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CATALOGUE NUMBER *for* 1946-1947

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

CATALOGUE NUMBER *for* 1946-1947

PASADENA · CALIFORNIA · SEPTEMBER, 1946

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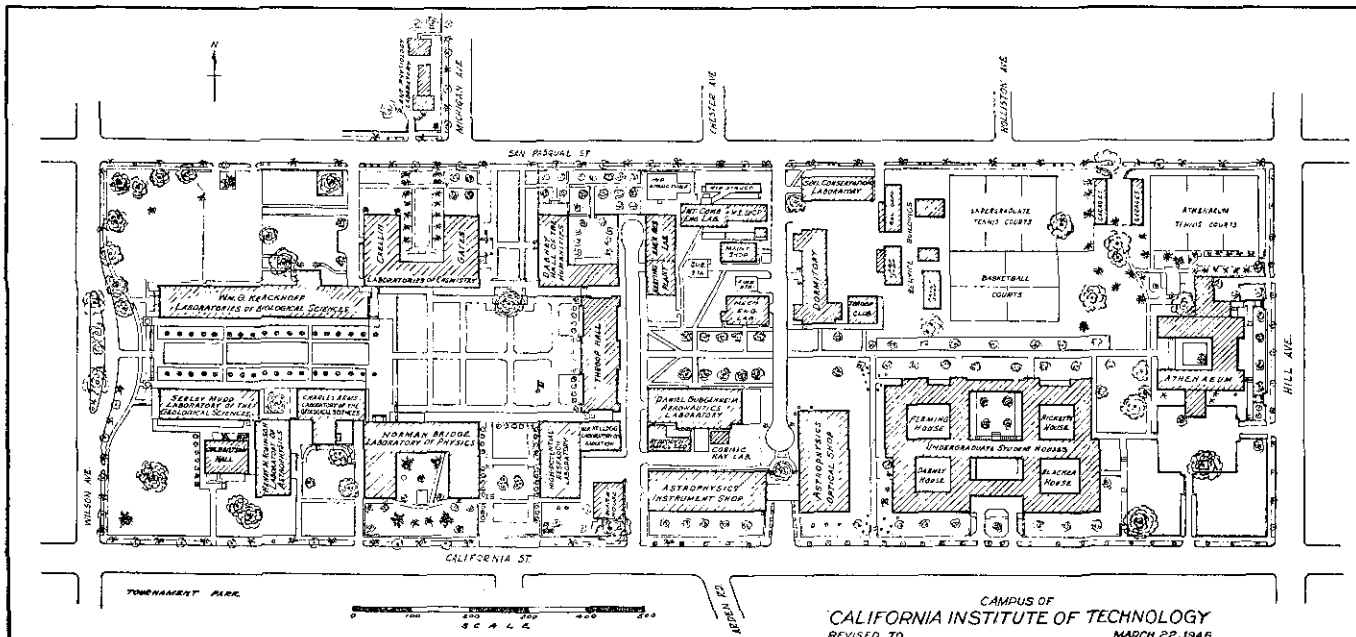

CAMPUS OF
CALIFORNIA INSTITUTE OF TECHNOLOGY
REVISED TO MARCH 22, 1946

CALENDAR

1946

JANUARY

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28	29	30	31			

CALENDAR

SECOND SEMESTER, 1946

July 1	Registration of all students—9:00 A.M. to 3:00 P.M.
July 2	Beginning of instruction—8:00 A.M.
July 8	Registration for refresher courses preparing for September examinations for upper class admission.
July 20	Last day for adding courses.
July 27	Examinations for the removal of conditions and incompletes.
August 3 and 10	Examinations for admission to the freshman class, October, 1946.
August 10	Mid-Semester.
August 23	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
September 7	Last day for final oral examinations and presenting of theses for the degree of Doctor of Philosophy.
September 12	Refresher courses terminate.
September 13 and 14	Examinations for admission to upper classes, October 1946.
September 16-21	Final examinations—Second Semester 1946.
September 21	End of Second Semester 1946—12 M.
September 25	Faculty meeting—2:00 P.M.
September 27	Meeting of Freshman Registration Committee.
September 28	Meeting of Upperclass Registration Committee.

FIRST TERM, 1946-47

October 4	Registration of entering freshmen—1:30 P.M.
October 7	Registration of students transferring from other colleges—9:00 A.M.
October 7	General registration—9:00 a.m. to 3:00 p.m.
October 8	Beginning of instruction—8:00 A.M.
October 26	Examinations for the removal of conditions and incompletes.
October 26	Last day for adding courses.
November 9	Mid-Term.
November 16	Last day for dropping courses.
November 22	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
Nov. 25-Dec. 14	Pre-registration for 2nd term 1946-47.
Nov. 28-Dec. 1	Thanksgiving Recess.
December 16-21	Final examinations—1st term 1946-47.
December 21	Last day for filing application for candidacy for the degree of Doctor of Philosophy in June 1947.
December 21	End of 1st term 1946-47—12M.
Dec. 22-Jan. 5	Christmas Vacation.
December 30	Meeting of Freshman Registration Committee.
December 31	Meeting of Upperclass Registration Committee.

SECOND TERM, 1946-47

January 6	General registration—9:00 A.M. to 3:00 P.M.
January 7	Beginning of instruction—8:00 A.M.
January 25	Examinations for the removal of conditions and incompletes.
January 25	Last day for adding courses.
February 8	Mid-Term.
February 15	Last day for dropping courses.

February 21	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
Feb. 24-March 15	Pre-registration for 3rd term 1946-47.
March 8 and 15	Examinations for admission to the freshman class, September, 1947.
March 17-22	Final examinations—2nd term 1946-47.
March 22	End of 2nd term 1946-47—12M.
March 28	Meeting of Freshman Registration Committee.
March 29	Meeting of Upperclass Registration Committee.

THIRD TERM, 1946-47

March 31	General registration—9:00 A.M. to 3:00 P.M.
April 1	Beginning of instruction—8:00 A.M.
April 19	Examinations for the removal of conditions and incompletes.
April 19	Last day for adding courses.
May 3	Mid-Term.
May 10	Last day for dropping courses.
May 16	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
May 19-June 7	Pre-registration for 1st term 1947-48.
May 31	Last day for final oral examinations and presenting of theses for the degree of Doctor of Philosophy.
June 2-7	Final examinations for senior and graduate students—3rd term 1946-47.
June 9-14	Final examinations for undergraduate students—3rd term 1946-47.
June 11	Meetings of Committees on Course in Science and Engineering —10:00 A.M.
June 11	Faculty meeting—2:00 P.M.
June 12	Class Day.
June 13	Commencement.
June 13 and 14	Examinations for admission to upper classes, September 1947.
June 14	End of 3rd term 1946-47—12 M.
June 20	Meeting of Freshman Registration Committee.
June 21	Meeting of Upperclass Registration Committee.

FIRST TERM 1947-48

September 5 and 6	Examinations for admission to upper classes, September, 1947.
September 23	Registration of entering freshmen—1:30 P.M.
September 25	Registration of students transferring from other colleges—9:00 A.M.
September 26	General Registration—9:00 A.M. to 3:00 P.M.
September 29	Beginning of instruction—8:00 A.M.

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SAFETY DIRECTOR ..... Lt. Col. Charles L. Wyman
DIRECTOR OF RESIDENCE HALLS ..... Bessie K. Little

*On leave of absence from the University of California.

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July 1, 1945 to June 30, 1946

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CHAIRMAN OF THE FACULTY BOARD AND CURRICULUM COMMITTEE—Watson
SECRETARY OF THE FACULTY—Martel

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FACULTY BOARD AND CURRICULUM COMMITTEE—*Watson,* Bates, Buwalda, Daugherty, Gray, Jones, Judy, Lacey, Martel (Secretary), Michael, C. B. Millikan, Pauling, Ruch, Smythe, Sorensen, Sterling, Strong, A. H. Sturtevant, Thomas, Tolman, Ward.

ALUMNI RELATIONS—*Clark,* Hertenstein, Huse, Munro, Sorensen, Thomas, Veysey.

ASSEMBLY—*Judy,* Craig, Daugherty, Eagleson, Thomas.

COMMENCEMENT EXERCISES—*Eagleson,* Clark, Craig, Hertenstein, Huse, Jones, Maxstadt, Musselman.

COURSE IN ENGINEERING—*Michael,* Converse, Daugherty, Gray, Hudson, Jones, MacMinn, Maxstadt, Sechler.

COURSE IN SCIENCE—*Smythe,* Buwalda, Lacey, Pickering, Stanton, Swift, Tyler, Wear.

FRESHMAN ADMISSION AND REGISTRATION—*Jones,* C. D. Anderson, Ian Campbell, Dilworth, Dunn, Eagleson, Lindvall, Neher, Niemann, Stewart, Stock, Strong, Untereiner, Watson.

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Members: E. G. Anderson, J. A. Anderson, Badger, E. T. Bell, Borsook, Bowen, Bowerman, Dan Campbell, Daugherty, Epstein, Goetz, Gray, Gutenberg, Haagen-Smit, Knapp, Lacey, Lucas, Mackeown, Michal, C. B. Millikan, Oppenheimer, Potapenko, Ruch, Sage, Smythe, Sorensen, Stock, Sturdivant, Thomas, von Karman, Ward, Went, Yost, Zechmeister, Zwicky.

HONOR STUDENTS—*Ward,* Buwalda, *Jones, Pauling, Strong,* Swift, *Thomas,* Untereiner, Watson, Wear.

LECTURES AND VISITS FOR OUTSIDE ORGANIZATIONS—*Gilbert,* Craig, Hertenstein, Laing, Michael, Sterling.

LIBRARY—*Sterling,* Bates, E. T. Bell, Borsook, Lund, Sechler, Stock, Watson, Zwicky.

MUSICAL ACTIVITIES—*Thomas,* Epstein, Goetz, Gutenberg, Stone, Wear.

PHYSICAL EDUCATION—*Sorensen,* J. M. Anderson, Craig, Jones, Mackeown, Musselman, Sterling, Thomas.

PUBLICATIONS AND PUBLICITY—*Thomas,* Barrett, Bowerman, Huse, Jones, MacMinn, Michael, Sechler.

STUDENT AID—*Thomas,* Barrett, Jones, Sorensen, Untereiner, Ward, Watson.

STUDENT BODY FINANCE—*Stott,* Sorensen, Vanoni, Youtz.

STUDENT HEALTH—*Borsook,* Barret, Kremers, Sorensen, Thomas, Untereiner, Wyman.

STUDENT RELATIONS—*Eagleson,* Clark, Craig, Gray, Jones, Sechler, Sorensen, Strong, Thomas, Untereiner.

STUDENT SOCIAL FUNCTIONS—*Craig,* Bowerman, Eagleson, Laing, Trabant.

UPPER CLASS ADMISSION AND REGISTRATION—*Jones,* Bates, Converse, Hudson, Martel, Maxstadt, Pickering, Sechler, Smythe, Stanton, Strong, Swift, Thomas, Wear.

STAFF OF INSTRUCTION AND RESEARCH

LEE A. DUBRIDGE, PH.D., SC.D.

President

A.B., Cornell College (Iowa), 1922; Sc.D., 1940. A.M., University of Wisconsin, 1924; Ph.D., 1926. Instructor in Physics, University of Wisconsin, 1925-26; National Research Fellow, California Institute, 1926-28; Assistant Professor, Washington University (Missouri) 1928-33; Associate Professor, 1933-34. Professor and Chairman of Department of Physics, University of Rochester, 1934-46; Dean of Faculty of Arts and Sciences, 1938-46. California Institute, 1946-

NORMAN S. B. ABRAHAMSEN, PH.D.

Research Fellow in Chemistry

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

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B.S., California Institute, 1922; M.S., 1924; Ph.D., 1926. Research Fellow, Harvard Medical School, 1927-28; Lecturer in Pharmacology, University of California Medical School, 1932-. Research Associate, California Institute, 1939-

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

Professor of Physics

B.S., California Institute, 1927; Ph.D., 1930. Sc.D., Colgate University, 1937. Assistant and Teaching Fellow in Physics, California Institute, 1927-30; Research Fellow, 1930-33; Assistant Professor, 1933-37; Associate Professor, 1937-39; Professor, 1939-

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ERNEST GUSTAF ANDERSON, PH.D.

Associate Professor of Genetics

B.S., University of Nebraska, 1915; Ph.D., Cornell University, 1920. Research Associate, Carnegie Institution, 1920-22; Instructor in Biology, College of the City of New York, 1922-23. National Research Fellow, University of Michigan, 1923-28. California Institute, 1928-

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JAMES MASON ANDERSON, B.S.

Instructor in Physical Education

B.S., West Texas State College, 1927. Instructor of Mathematics and football coach, high school, Trinidad, Colorado, 1927-36; high school, Colorado Springs, Colorado, 1936-41; Physical Education Instructor in Training Division, U. S. Navy, 1942-45. California Institute, 1945-

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Executive Officer of the Observatory Council

B.S., Valparaiso College, 1900; Ph.D., Johns Hopkins University, 1907. Associate Professor of Astronomy, Johns Hopkins University, 1908-16; Physicist, Mount Wilson Observatory, 1916-43. California Institute, 1928-

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Professor of Chemistry

B.S., California Institute, 1921; Ph.D., 1924. Teaching Fellow, 1922-24; Assistant in Chemistry, California Institute, 1924; Research Fellow, 1924-28; International Research Fellow in Chemistry, Universities of Göttingen and Bonn, Germany, 1928-29; Assistant Professor of Chemistry, California Institute, 1929-38; Lecturer in Chemistry, University of California, 1931. Associate Professor of Chemistry, California Institute, 1938-45; Professor, 1945-

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ARTHUR PERRY BANTA, M.S.

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A.B., Stanford University, 1926; M.S., California Institute, 1928. Teaching Fellow in Engineering, California Institute, 1926-27; Assistant Professor of Sanitary Engineering, California Institute, 1938-41; Associate Professor, 1945-

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A.B., University of Denver, 1894; Graduate in the School of Astronomy, University of Virginia, 1896; Ph.D., Cornell University, 1898. Instructor in Physics and Biology, University of Denver, 1894-95; Assistant in Astronomical Observatory, University of Virginia, 1895-96; Fellow in Physics, Cornell University, 1896-98; Instructor, Assistant Professor, and Professor of Physics, Colorado College, 1898-1900; Stanford University, 1900-05; Tulane University of Louisiana, 1905-11; Ohio State University, 1911-18; University of California, 1926-44; Professor emeritus since 1944. Aid and Magnetic Observer, U.S.C. & G.S., 1902-04; Physicist, Carnegie Institution of Washington, 1918-26; (Department of Terrestrial Magnetism, 1918-24; Research Associate, 1924-26). California Institute, 1924-

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Comptroller
Secretary of the Board of Trustees
Secretary of the Executive Committee

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ERIC TEMPLE BELL, PH.D.

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A.B., Stanford University, 1904; A.M., University of Washington, 1908; Ph.D., Columbia University, 1912. Instructor, Assistant Professor, Associate Professor, Professor, University of Washington, 1912-26; Professor, University of Chicago, summer quarter, 1924-28; Visiting Lecturer, Harvard University, first half 1926. California Institute, 1926-

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RICHARD WILLIAM BELL, A.E.

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B.A., Oberlin College, 1939; Ae.E., California Institute, 1941. California Institute, 1946-

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HUGO BENIOFF, PH.D.

Associate Professor of Seismology

B.A., Pomona College, 1921; Ph.D., California Institute, 1935. Research Assistant, Mount Wilson Observatory, summers 1917-21; Research Assistant, Lick Observatory, 1923-24; Research Assistant in Seismology, Carnegie Institution of Washington, 1924-37. Assistant Professor, California Institute, 1937; Associate Professor, 1937-

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Assistant Professor of Mathematics

A.B., Hope College, 1899; M.A., Colorado College, 1905. Instructor, Colorado College, 1905 and 1907; Instructor in Physics, University of Southern California, summer session, 1916. Instructor, California Institute, 1918-31; Assistant Professor, 1931-

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STEPHEN ERROL BLEWETT, M.S.

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2822 Grandeur Avenue, Altadena

JAMES FREDERICK BONNER, PH.D.

Associate Professor of Plant Physiology

A.B., University of Utah, 1931; Ph.D., California Institute, 1934. National Research Fellow, 1934-35 (Utrecht, Leiden, Zurich). Research Assistant, California Institute, 1935-36; Instructor, 1936-38; Assistant Professor, 1938-42; Associate Professor, 1942-

424 South Chester Avenue

HENRY BORSOOK, PH.D., M.D.

Professor of Biochemistry

Ph.D., University of Toronto, 1924; M.B., 1927; M.D., 1940. Teaching Fellow, University of Toronto, 1921-24; Research Fellow, 1927; Lecturer, 1929. Assistant Professor, California Institute, 1929-35; Professor, 1935-

1121 Constance Street

IRA SPRAGUE BOWEN, PH.D.

Research Associate in Astrophysics

A.B., Oberlin College, 1919; Ph.D., California Institute, 1926. Instructor in Physics, California Institute, 1921-26; Assistant Professor, 1926-28; Associate Professor, 1928-31; Professor, 1931-45. Director, Mount Wilson Observatory of the Carnegie Institution of Washington, 1946-. California Institute, 1921-

2388 North Foothill Boulevard, Altadena

WILLIAM HAROLD BOWEN, M.S.

Superintendent, Guggenheim Aeronautical Laboratory

B.S., University of California, 1928; M.S. (M.E.), California Institute, 1932; M.S. (A.E.), 1938. California Institute, 1929-

2067 Paloma Street

PAUL BOWERMAN, A.M.

Assistant Professor of Modern Languages

A.B., Dartmouth College, 1920; A.M., University of Michigan, 1936. Teaching Assistant in English, University of Southern California, 1938-45. Instructor in English, California Institute, 1942-45; Assistant Professor of Modern Languages, 1945-

1151 Fifth Avenue, Los Angeles

GILBERT BRIGHOUSE, PH.D.

Lecturer in Psychology

Ph.B., University of Chicago, 1931; Ph.D., University of Iowa, 1936. Instructor in Psychology, University of Illinois, 1936-38; Associate Professor of Psychology, Occidental College, 1938-42; Professor of Psychology, 1942. California Institute, 1943-

4689 Eagle Rock Boulevard, Los Angeles

EDWIN R. BUCHMAN, D.PHIL.

Research Associate in Organic Chemistry

Ch.E., Rensselaer Polytechnic Institute, 1922; S.M., Massachusetts Institute of Technology, 1925; D. Phil., Nat. University of Frankfurt, 1933. Columbia University, 1933-35; Johns Hopkins University, 1936-37. Research Fellow, California Institute, 1937-38; Research Associate, 1938-

2645 Lambert Drive

JOHN PETER BUWALDA, PH.D.

Professor of Geology
Chairman of the Division of Geological Sciences

B.S., University of California (Berkeley), 1912; Ph.D., 1915. Instructor, University of California (Berkeley), 1915-17; Assistant Professor of Geology, Yale University, 1917-21; Associate Professor of Geology, University of California (Berkeley), 1921-25; Professor of Geology, 1925. California Institute, 1925-

2103 San Pasqual Street

DAN HAMPTON CAMPBELL, PH.D.

Associate Professor of Immunochemistry

A.B., Wabash College, 1930; M.S., Washington University, 1932; Ph.D., University of Chicago, 1936. Research Fellow, University of Chicago, 1936-38; Instructor in Bacteriology, 1938-39; Assistant Professor of Immunochemistry, 1939-42. Assistant Professor of Immunochemistry, California Institute, 1942-45; Associate Professor, 1945-

1154 Mount Lowe Drive, Altadena

IAN CAMPBELL, PH.D.

Associate Professor of Petrology

A.B., University of Oregon, 1922; A.M., 1924. Ph.D., Harvard University, 1931. Assistant Professor of Geology, Louisiana State University, 1925-28; Instructor in Mineralogy and Petrography, Harvard University, 1928-31. Assistant Professor of Petrology, California Institute, 1931-35; Associate Professor, 1935-

405 South Bonnie Avenue

JOSEPH VINCENT CHARYK, M.S.

Instructor in Aeronautics

B.Sc., University of Alberta, 1942; M.S., California Institute, 1943. Graduate Assistant, California Institute, 1942-45; Instructor, 1946-

615 South El Molino Avenue

DONALD SHERMAN CLARK, PH.D.

Associate Professor of Mechanical Engineering
Director of Placements

B.S., California Institute, 1929; M.S., 1930; Ph.D., 1934. Assistant and Teaching Fellow, California Institute, 1929-34; Instructor, 1934-37; Assistant Professor, 1937-45; Associate Professor, 1945-

665 Canterbury Road, San Marino

FREDERICK JAMES CONVERSE, B.S.

Associate Professor of Civil Engineering

B.S., (M.E.), University of Rochester, 1914. Instructor in Applied Mechanics, University of Rochester, 1916-18. Instructor, California Institute, 1921-33; Assistant Professor, 1933-39; Associate Professor, 1939-

2167 Lambert Drive

ROBERT BRAINARD COREY, PH.D.

Senior Fellow in Structural Chemistry

B.Chem., University of Pittsburgh, 1919; Ph.D., Cornell University, 1924. Assistant in Inorganic Chemistry, Cornell University, 1919-22; Chemical Spectroscopy, 1922-23; Instructor in Analytical Chemistry, 1923-28; Assistant of the Rockefeller Institute for Medical Research, 1928-30; Associate, 1930-37. California Institute, 1937-

352 South Parkwood Avenue

STANLEY CORRSIN, A.E.

Instructor in Aeronautics

B.S., University of Pennsylvania, 1940; M.S., California Institute, 1942; A.E., 1942. Graduate Assistant in Aeronautics, California Institute, 1940-46; Instructor, 1946-

1509 Ramona Avenue, South Pasadena

HARDIN CRAIG, JR., PH.D.

Assistant Professor of History

A.B., Princeton University, 1929; A.M., Harvard University, 1931; Ph.D., 1937. Instructor in History, Hobart College, 1931-33. California Institute, 1937-

1755 Orangewood Street

JAMES WALLACE DAILY, PH.D.

Instructor in Mechanical Engineering

A.B., Stanford University, 1935; M.S., California Institute, 1937; Ph.D., 1945. Graduate Assistant, California Institute, 1936-38; Research Assistant, 1938-39; Research Fellow, 1939-40; Instructor, 1940-

350 South Greenwood Avenue

ROBERT LONG DAUGHERTY, M.E.

Professor of Mechanical and Hydraulic Engineering

A.B., (M.E.) Stanford University, 1909; M.E., 1914. Instructor in Mechanical Engineering, Stanford University, 1909-10; Assistant Professor of Hydraulics, Cornell University, 1910-16; Professor of Hydraulic Engineering, Rensselaer Polytechnic Institute, 1916-19. California Institute, 1919-

373 South Euclid Avenue

WILLIAM HENRY DAVENPORT, PH.D.

Lecturer in English

A.B., Dartmouth College, 1929; A.M., Tufts College, 1931; Ph.D., Yale University, 1938. Teaching Fellow in English, Tufts College, 1929-31; Instructor in English, Carnegie Institute of Technology, 1931-35; Instructor in English, Smith College, 1938; Assistant Professor and Associate Professor of English, University of Southern California, 1938-. California Institute, 1943-

297 North Duane Avenue, San Gabriel

GODFREY DAVIES, B.A.

Associate in History

B.A., Honour School of Modern History, Oxford University, 1914. Secretary to Regius Professor of Modern History, Oxford University, 1914-16; Tutor and Lecturer in the School of Modern History, 1919-24; Assistant Professor of History, University of Chicago, 1925-30; Visiting Scholar of the Huntington Library, 1930-31; Member of Research Staff, 1931-. California Institute, 1930-

395 South Bonnie Avenue

LEVERETT DAVIS, JR., PH.D.

Assistant Professor of Physics

B.S., Oregon State College, 1936; M.S., California Institute of Technology, 1938; Ph.D., 1941. Graduate Assistant in Physics, California Institute, 1936-39; Teaching Fellow in Physics, 1939-40; Fellow of the Rockefeller Institute for Medical Research, 1940-41. Instructor in Physics, California Institute, 1941-46; Assistant Professor, 1946-

957 East California Street

ALBERT O. DEKKER, PH.D.

Research Fellow in Chemistry

B.S., California Institute, 1935; Ph.D., 1940. Associate Professor of Chemistry, Berea College, 1939. California Institute, 1942-

405 South El Molino Avenue

ROBERT PALMER DILWORTH, PH.D.

Associate Professor of Mathematics

B.S., California Institute, 1936; Ph.D., 1939. Teaching Fellow, California Institute, 1936-39; Sterling Research Fellow, Yale University, 1939-40; Instructor, Yale University, 1940-43. Assistant Professor, California Institute, 1943-45; Associate Professor, 1945-

2072 Loma Vista Street

RICHARD W. DODSON, PH.D.

Assistant Professor of Chemistry

B.S., California Institute, 1936; Ph.D., Johns Hopkins University, 1939. Research Assistant, Johns Hopkins University, 1939-40. National Research Fellow, California Institute, 1940-41; Assistant Professor, 1946-

195 South Grand Avenue

ROBERT ELMORE DORLAND, B.S.

Research Fellow in Biology

B.S., University of Chicago, 1923. California Institute, 1945-

399 South Mentor Avenue

JACOB WILLIAM DUBNOFF, PH.D.

Research Fellow in Biology

A.B., University of California (Los Angeles), 1931; M.A., 1933. Ph.D., California Institute, 1944. California Institute, 1936-

1871 Brigden Road

LEE A. DUBRIDGE, PH.D., SC.D.

(See page 14)

JESSE WILLIAM MONROE DUMOND, PH.D.

Associate Professor of Physics

B.S., California Institute, 1916; M.S. (E.E.), Union College, 1918; Ph.D., California Institute, 1929. Teaching Fellow, California Institute, 1921-25; Research Fellow, 1925-31. Acting Associate Professor of Physics, Stanford University, 1931. Research Associate, California Institute, 1931-38; Associate Professor, 1938-

530 South Greenwood Avenue

LOUIS G. DUNN, PH.D.

Associate Professor of Aeronautics

B.S., California Institute, 1936; M.S. (M.E.), 1937; M.S. (A.E.), 1938; Ph.D., 1940. Research Assistant, California Institute, 1937-39; Research Fellow, 1939-40; Instructor, 1940-41; Assistant Professor, 1941-46; Associate Professor, 1946-

937 West Sierra Madre Avenue, Glendora

JOHN WYATT DURHAM, PH.D.

Associate Professor of Invertebrate Paleontology

B.S., University of Washington, 1933; A.M., University of California, 1936; Ph.D., 1941. Research Assistant, University of California, 1940. California Institute, 1946-

HARVEY EAGLESON, PH.D.

Associate Professor of English Language and Literature

B.A., Reed College, 1920; M.A., Stanford University, 1922; Ph.D., Princeton University, 1928. Instructor in English, University of Texas, 1922-26. Assistant Professor, California Institute, 1928-38; Associate Professor, 1938-

1706 Fair Oaks Avenue, South Pasadena

PAUL CONANT EATON, A.M.†

Visiting Lecturer in English

S.B., Massachusetts Institute of Technology, 1927; A.M., Harvard University, 1930. Instructor in English, Phillips Exeter Academy, 1927-29; Instructor and Assistant Professor of English, Massachusetts Institute of Technology, 1930-. California Institute, 1946-

139 South Camden Drive, Beverly Hills

ROBERT DUNSHEE ELLIOTT, M.S.

Assistant Professor of Meteorology

B.S., California Institute, 1936; M.S., 1937. Instructor, California Institute, 1940-42; Assistant Professor, 1942-

Wrightwood

STERLING EMERSON, PH.D.

Professor of Genetics

B.Sc., Cornell University, 1922; M.A., University of Michigan, 1924; Ph.D., 1928. Instructor in Botany, University of Michigan, 1924-28. Assistant Professor of Genetics, California Institute, 1928-37; Associate Professor, 1937-46; Professor, 1946-

1207 Morada Place, Altadena

PAUL SOPHUS EPSTEIN, PH.D.

Professor of Theoretical Physics

B.Sc., Moscow University, 1906; M.Sc., 1909. Ph.D., University of Munich, 1914. Assistant in Physics, Moscow Institute of Agriculture, 1906-07; Assistant in Physics, Moscow University, 1907-09; Privatdozent, Moscow University, 1909-13; Privatdozent, University of Zurich, 1919-22; Exchange Professor, Aachen Institute of Technology, 1927 and 1929. California Institute, 1921-

1484 Oakdale Street

PHILIP SHEARER FOGG, M.B.A.*

Associate Professor of Business Economics

A.B., Stanford University, 1925; M.B.A., Harvard University, 1929. Instructor, American Institute of Banking, 1932-38; Instructor in Economics, California Graduate School of Design, 1937-. Assistant Professor of Business Economics, California Institute, 1930-38; Associate Professor, 1938-

1977 Midlothian Drive, Altadena

WILLIAM ALFRED FOWLER, PH.D.

Professor of Physics

B.Eng. (Physics), Ohio State University, 1933; Ph.D., California Institute, 1936. Research Fellow, California Institute, 1936-39; Assistant Professor, 1939-42; Associate Professor, 1942-46; Professor, 1946-

1108 Lura Street

WILLIAM DEAN FRASER, PH.D.

Research Fellow in Biology

B.S., Harvard University, 1938; M.S., University of Illinois, 1939; Ph.D., 1941. Research Fellow, California Institute, 1946-

245 Wallis Street

CH'ENG-YI FU, PH.D.

Research Fellow in Geophysics

B.S., National Tsing-Hua University, Peiping, China, 1933; M.Sc., McGill University, Canada, 1941; Ph.D., California Institute, 1944. Assistant and Instructor in Physics, Tsing-Hua University, 1934-39. Research Fellow, California Institute, 1944-

281 South Chester 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, 1926-28; Instructor in Business Economics, Harvard University, 1928-29. Assistant Professor of Business Economics, California Institute, 1929-30; Associate Professor, 1930-

385 South Bonnie Avenue

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†On leave from Massachusetts Institute of Technology.

*On leave of absence.

ALEXANDER GOETZ PH.D.

Associate Professor of Physics

Ph.D., University of Göttingen, 1921; Habilitation, 1923. Privatdozent and A.O. Professor, University of Göttingen, 1923-30; Rockefeller Fellow at California Institute, 1927-28; Guest Professor, University of Japan, Tsing-Hua, University of China, 1929-30. Associate Professor of Physics, California Institute, 1930-

1317 Boston Street, Altadena

E. C. GOLDSWORTHY, PH.D.

Master of the Student Houses
*Assistant Professor of Mathematics**

A.B., University of California, 1923; Ph.D., 1928. Instructor and Assistant Professor of Mathematics, University of California, 1923-. California Institute, 1946-

1245 Arden Road

ROBERT D. GRAY, B.S.

Professor of Economics and Industrial Relations
Director of Industrial Relations Section

B.S., (Economics), Wharton School of Finance and Commerce, University of Pennsylvania, 1930. Research Assistant, Industrial Research Department, University of Pennsylvania, 1927-36; Research Associate, 1936-39; Instructor in Geography and Industry, Wharton School of Finance and Commerce, 1934-37; Assistant Professor of Economics, University of Connecticut, 1937-40; Adviser, Division of Business and Commerce, 1939-40. Associate Professor, California Institute, 1940-42; Professor, 1942-

262 South Allen Avenue

HARRY R. GREENE, M.A.

Visiting Lecturer in Industrial Design

A.B., San Diego State College, 1939; M.A., California Graduate School of Design, 1941. Visiting Lecturer, California Institute, 1945-

745 East California Street

BENO GUTENBERG, PH.D.

Professor of Geophysics

Ph.D., University of Göttingen, 1911. Research Assistant Zentralbüro Internat. Seismolog. Vereinigung, Strassburg, 1913-14; Reichszentrale für Erdbebenforschung, Strassburg, 1914-19; Privatdozent für Geophysik, Frankfurt a/M, 1924-26; A.O. Professor, 1926-30. California Institute, 1930-

399 Ninita Parkway

ARIE JAN HAAGEN-SMIT, PH.D.

Professor of Bio-organic Chemistry

A.B., University of Utrecht, 1922; A.M., 1926; Ph.D., 1929. Head Assistant, Department of Organic Chemistry, Utrecht, 1929-34; Lecturer in Organic Chemistry, Utrecht, 1934-36; Lecturer in Biological Chemistry, Harvard University, 1936-37. Associate Professor, California Institute, 1937-40; Professor, 1940-

416 South Berkeley Avenue

FLOYD LUTHER HANES, D.O.

Track Coach, Physical Trainer and Cross Country Coach

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

2141 Layton Street

ANTHONIE VAN HARREVELD, M.D.

Associate Professor of Physiology

B.A., Amsterdam University, 1925; M.A., 1929; M.D., 1929. Assistant in Physiology, Amsterdam University, 1926-32; Chief Assistant in Physiology, Utrecht University, 1932-34. Research Assistant, California Institute, 1934-35; Instructor, 1935-40; Assistant Professor, 1940-42; Associate Professor, 1942-

764 South Oakland Avenue

ELDRED WILSON HOUGH, PH.D.

Senior Fellow in Chemical Research

B.S. (Engineering Physics), University of Illinois, 1939; M.S. (Physics), California Institute, 1941; Ph.D. (Physics), 1943. Research Assistant, California Institute, 1941-46; Senior Fellow, 1946-

365 South Wilson Avenue

GEORGE WILLIAM HOUSNER, PH.D.

Assistant Professor of Applied Mechanics

B.S., University of Michigan, 1933; M.S., California Institute, 1934; Ph.D., 1941. Teaching Fellow, California Institute, 1939-41; Assistant Professor, 1945-

4084 Chevy Chase Drive, Flintridge

*On leave of absence from the University of California.

DONALD ELLIS HUDSON, PH.D.

Assistant Professor of Mechanical Engineering

B.S., California Institute, 1938; M.S., 1939; Ph.D., 1942. Instructor, California Institute, 1941-43; Assistant Professor, 1943-

640 North Chester Avenue

RUDOLF VON HUENE, B.S.

Technician, Geological Sciences

B.S., California Institute, 1934. California Institute, 1936-

865 North Mentor Avenue

WILLIAM HUSE, M.A.

Associate Professor of English Language and Literature

A.B., Stanford University, 1921; M.A., Princeton University, 1928. Instructor in English, Washington University, 1921-23; Instructor in English, Princeton University, 1923-24; Assistant Professor of English, University of Kansas, 1927-29. Assistant Professor, California Institute, *1929-38*; Associate Professor, *1938-*

3676 Yorkshire Road

HAROLD MILTON HUSTON, B.S.

Visiting Lecturer in Industrial Design

B.S., *California Institute, 1929. California Institute, 1945-*

426 Oaklawn Avenue, South Pasadena

RICHARD HENRY JAHNS, PH.D.

Assistant Professor of Geology

B.S., California Institute, 1935; M.S., Northwestern University, 1937; Ph.D., California Institute, 1943. Junior Geologist, U. S. Geological Survey, 1937-40; Assistant Geologist, 1940-42; Associate Geologist, 1942-44; Geologist, 1944-. California Institute, 1946-

207 North Marguerita Avenue, Alhambra

JOSEF JEROME JOHNSON, PH.D.

Research Associate in Astrophysics

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

1030 San Pasqual Street

LOUIS WINCHESTER JONES, A.B.

Associate Professor of English Language and Literature
Registrar
Associate Dean for Upper Classmen

A.B., Princeton University, 1922. Instructor, California Institute, 1925; Assistant Professor, 1937; Associate Professor, 1943-

351 California Terrace

CLINTON KELLY JUDY, A.M.

Professor of English Language and Literature
Chairman of the Division of Humanities

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

1325 Woodstock Road, San Marino

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

Professor of Aeronautics
Director of the Daniel Guggenheim Laboratory

M.E., *Budapest, 1902*; Ph.D., *Göttingen, 1908*. Doctor of Engineering, University of Berlin, 1929; Doctor of Science, University of Brussels, 1937. Privatdozent, Göttingen, 1910-13; Professor of Mechanics and Aerodynamics, Director of the Aerodynamical Institute, University of Aachen, 1913-34; Rouse-Ball Lecturer at the University of Cambridge, 1937; C.R.B. Lecturer in Belgium, 1937; Wilbur Wright Lecturer of the Royal Aeronautical Society, 1937; Josiah Willard Gibbs Lecturer of the American Mathematical Society, 1939. California Institute, 1928-

1501 South Marengo Avenue

GEOFFREY LORRIMER KEIGHLEY, PH.D.

Instructor in Biology

B.A., University of Toronto, *1926*; M.S., *California Institute, 1940*; *Ph.D., 1944*. Research Assistant, California Institute, 1930-43; Instructor, 1943-

237 West Las Flores Drive, Altadena

ARTHUR LOUIS KLEIN, PH.D.

Associate Professor of Aeronautics

B.S., California Institute, 1921; M.S., 1924; Ph.D., 1925. Teaching Fellow in Physics, California Institute, 1921-25; Research Fellow in Physics and in Aeronautics, 1927-29; Assistant Professor, 1929-34; Associate Professor, 1934-

2771 Glendower Avenue, Los Angeles

ROBERT TALBOT KNAPP, PH.D.

Associate Professor of Hydraulic Engineering

B.S., Massachusetts Institute of Technology, 1920; Ph.D., California Institute, 1929. Instructor, California Institute, 1922-30; Assistant Professor of Mechanical Engineering, 1930-36; Associate Professor of Hydraulic Engineering, 1936-

1801 North Country Lane

JOSEPH BLAKE KOEPFLI, D.PHIL.

Research Associate in Chemistry

A.B., Stanford University, 1924; M.A., 1925; D. Phil., Oxford University, 1928. Research Fellow in Organic Chemistry, California Institute, 1928-29; Instructor in Pharmacology, Johns Hopkins University School of Medicine, 1929-31; Research Associate, California Institute, 1932-

955 Avondale Road, San Marino

KARL JOHN KORPI, PH.D.

Research Fellow in Chemical Engineering

B.S., Northwestern University, 1927; Ph.D., University of California (Berkeley), 1930. Teaching Fellow and Instructor, University of California, 1927-30; Research Associate, University of California, 1933-36. California Institute, 1943-

4518 Gateside Drive, Los Angeles

EDWARD DUNSTER KREMERS, M.D.

Consulting Physician; Director of Student Health

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

2125 Mar Vista Avenue, Altadena

MARSHALL YATES KREMERS, M.D.

Assistant to the Consulting Physician

A.B., Occidental College, 1930; M.A., University of California, 1932; M.D., 1935. California Institute, 1936-

1946 Midlothian Drive, Altadena

IRVING PARKHURST KRICK, PH.D.*

Professor of Meteorology

A.B., University of California, 1928; M.S., California Institute, 1933; Ph.D., 1934. Teaching Fellow, California Institute, 1932-33; Instructor, 1933-35; Assistant Professor, 1935-38; Associate Professor, 1938-43; Professor, 1943-

YUNG HUAI KUO, PH.D.

Research Fellow in Aeronautics

B.A., National Peking University, 1935; Ph.D., California Institute, 1945. California Institute, 1945-

629 South Catalina Avenue

PETER RUDOLF KYROPOULOS, M.S.

Instructor in Mechanical Engineering

B.S., University of Göttingen, 1936; M.S., California Institute, 1938. California Institute, 1943-

1938 Mill Road, South Pasadena

WILLIAM NOBLE LACEY, PH.D.

Professor of Chemical Engineering

A.B., Stanford University, 1911; Ch.E., 1912. M.S., University of California, 1913; Ph.D., 1915. Assistant in Chemistry, Stanford University, 1911-12; Assistant in Chemistry, University of California, 1912-15; Research Associate, Massachusetts Institute of Technology, 1916. Instructor, California Institute, 1916-17; Assistant Professor, 1917-19; Associate Professor, 1919-31; Professor, 1931-

2024 Minoru Drive, Altadena

*On leave of absence.

GRAHAM ALLAN LAING, M.A.

Professor of Economics and Business Administration

B.A., University of Liverpool, 1908; M.A., 1909. Workers' Educational Association Lecturer in Economic History for Liverpool University, 1909-13; Secretary, Department of Education, Government of British Columbia, 1913-14; Director of Technical Education, Vancouver, B.C., *1914-17; Instructor in Economics and History, University of California, 1917-18;* Assistant Statistician, United States Shipping Board, 1918-19; Assistant Professor of Social Science, University of Arizona, 1919-21. California Institute, 1921-

1642 Pleasant Way

CHARLES CHRISTIAN LAURITSEN, PH.D.

Professor of Physics

Graduate, Odense Tekniske Skole, 1911; Ph.D., California Institute, 1929. Assistant in Physics, California Institute, 1927-30; Assistant Professor, 1930; Associate Professor, 1931; Professor, 1935-

1444 Blanche Street

THOMAS LAURITSEN, PH.D.

Assistant Professor of Physics

B.S., California Institute, 1936; Ph.D., 1939. Rockefeller Fellow at University of Copenhagen, 1940. Senior Research Fellow, California Institute, 1941; Assistant Professor, 1946-

1444 Blanche Street

EDWARD BUTTS LEWIS, PH.D.

Instructor in Genetics

B.A., University of Minnesota, *1939;* Ph.D., California Institute, *1942. California Institute, 1946-*

Athenaeum

HANS WOLFGANG LIEPMANN, PH.D.

Associate Professor of Aeronautics

Ph.D., University of Zurich, 1938. Research Fellow, University of Zurich, 1938. Assistant *Professor, California Institute, 1939-46;* Associate Professor, 1946-

2595 Lambert Drive

FREDERICK CHARLES LINDVALL, PH.D.

Professor of Electrical and Mechanical Engineering
Chairman of the Division of Civil and Mechanical Engineering and Aeronautics
Member of the Executive Committee

B.S., University of Illinois, 1924; Ph.D., California Institute, 1928. Teaching Fellow, California Institute, 1925-28; Instructor in Electrical Engineering, 1930-31; Assistant Professor of Electrical Engineering, 1931-37; Associate Professor of Electrical and Mechanical Engineering, 1937-42; Professor of Electrical and Mechanical Engineering, 1942-

2006 Skyview Drive, Altadena

WILLIAM NUNN LIPSCOMB, JR., B.S.

Research Fellow in Chemistry

B.S. (Industrial Chemistry), University of Kentucky, 1941. California Institute, 1941-

1551 Mar Vista Avenue

PAUL EUGENE LLOYD, PH.D.

Research Fellow in Physics

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

620 Burleigh Drive

HOWARD JOHNSON LUCAS, M.A.

Professor of Organic Chemistry

B.A., Ohio State University, 1907; M.A., 1908. Instructor in Chemistry, California Institute, 1913-15; Associate Professor of Organic Chemistry, 1915-40; Professor of Organic Chemistry, 1940.

95 North Holliston Avenue

JOHN J. LUND, PH.D.

Director of Institute Libraries

A.B., University of California (Berkeley), *1928;* Ph.D., *University of Chicago, 1932. Librarian,* Duke University, 1938-43. California Institute, 1945-

354 South Catalina Avenue

WERNER KARL MAAS, A.B.

Gosney Fellow in Biology

A.B., Harvard University, *1943. California Institute, 1946-*

JOHN ROBERTSON MACARTHUR, PH.D.

Professor of Languages, Emeritus

B.A., University of Manitoba, 1892; Ph.D., University of Chicago, 1903. Lecturer in Modern Languages, Manitoba College, 1893-98; Professor of English, New Mexico Agricultural College, 1903-10, 1911-13; Professor of English, Kansas State Agricultural College, 1914-20. Associate Professor, California Institute, 1920-23; Dean of Freshmen, 1923-37; Professor of Languages, 1923-

GEORGE EBER MACGINITIE, M.A.

Associate Professor of Biology
Director of William G. Kerckhoff Marine Laboratory

A.B., Fresno State College, 1925; M.A., Stanford University, 1928. Instructor in Biology, Fresno State College, 1925-28; Instructor in Zoology, Hopkins Marine Station of Stanford University, 1928-29; Assistant Professor of Zoology, 1929-32. Assistant Professor, California Institute, 1932-46; Associate Professor, 1946-

Corona Del Mar

SAMUEL STUART MACKEOWN, PH.D.

Professor of Electrical Engineering

A.B., Cornell University, 1917; Ph.D., 1923. Instructor in Physics, Cornell University, 1920-23. National Research Fellow in Physics, California Institute, 1923-26; Assistant Professor, 1926-31; Associate Professor, 1931-42; Professor, 1942-

1240 Arden Road

GEORGE RUPERT MACMINN, A.B.

Professor of English Language and Literature

A.B., Brown University, 1905. Instructor in English, Brown University, 1907-09; Iowa State College, 1909-10; University of California, 1910-18. Associate Professor, California Institute, 1918-45; Professor, 1945-

255 South Bonnie Avenue

FRANK JOSEPH MALINA, PH.D.

Assistant Professor of Aeronautics

B.S., Texas Agricultural and Mechanical College, 1934; M.S., California Institute, 1935 (M.E.) and 1936 (A.E.); Ph.D., 1940. Assistant and Teaching Fellow, California Institute, 1934-39; Research Assistant, 1939-40; Research Fellow, 1940-42; Assistant Professor, 1942-

800 South Hudson Avenue

KLAUS JOACHIM MAMPELL, PH.D.

Research Fellow in Biology

A.B., University of Southern California, 1939; Ph.D., California Institute, 1943. California Institute, 1943-

1520 Blanche Street

ROMEO RAOUL MARTEL, S.B.

Professor of Structural Engineering

S.B., Brown University, 1912. Instructor in Civil Engineering, Rhode Island State College, 1913-14; Instructor in Civil Engineering, Mechanics Institute, 1914-15. Instructor, California Institute, 1918-20; Assistant Professor, 1920-21; Associate Professor, 1921-30; Professor, 1930-

690 South Mentor Avenue

HAROLD CLIFFORD MARTIN, M.S.

Instructor in Aeronautics

B.S. (Mechanical Engineering), New York University, 1934; M.S., 1937. Instructor in Aeronautics, Princeton University, 1942-44. Assistant in Aeronautics, California Institute, 1944-46; Instructor, 1946-

244 North Ivy Street, Monrovia

WALTER MARX, PH.D.

Research Fellow in Biology

Dipl. Ing. (M.A.), Institute of Technology, Karlsruhe, Germany, 1931; Dr. Ing. (Ph.D.), 1933. Research Fellow, Kaiser Wilhelm Institute of Medical Research, Heidelberg, Germany, 1933-34; Research Fellow, Mt. Sinai Hospital, New York, 1934-37; Research Associate, Duke University Medical School, 1937-39; Research Associate, University of California (Berkeley), 1939-44; Assistant Professor of Experimental Medicine, University of Southern California, 1945. California Institute, 1945-

1049 South Norton Avenue, Los Angeles

EDMUND BLAKE MASKE, JR., B.S.

Research Assistant in Aeronautics

B.S., Louisiana State University, 1942. California Institute, 1942-

150 North Oakland Avenue

MAX MASON, PH.D., LL.D., SC.D.

Chairman of the Observatory Council
Member of the Board of Trustees

B.L., University of Wisconsin, 1898; Ph.D., University of Göttingen, 1903. Instructor in Mathematics, Massachusetts Institute of Technology, 1903-04; Assistant Professor of Mathematics, Yale University, 1904-08; Associate Professor of Mathematics, University of Wisconsin, 1908; Professor of Mathematical Physics, 1910-25; President, University of Chicago, 1925-28; President of the Rockefeller Foundation, 1928-36. LL.D., University of Wisconsin, 1926; Yale University, 1926; Dartmouth College, 1927; Pomona College, 1937; Sc.D., Columbia University, 1926. Colloquium Lecturer, American Mathematical Society, 1906; Visiting Lecturer, Mathematical Physics, Harvard University, 1911-12. California Institute, 1936-

1035 Harvard Avenue, Claremont

JOHN HAVILAND MAXSON, PH.D.

Assistant Professor of Geology

B.S., California Institute, 1927; M.S., 1928; Ph.D., 1931. Instructor, California Institute, 1931-37; Assistant Professor, 1938-

1275 North Craig Avenue

FRANCIS WILLIAM MAXSTADT, PH.D.

Assistant Professor of Electrical Engineering

M.E. (Electrical Engineering), Cornell University, 1916; M.S., California Institute, 1925; Ph.D., 1931. Instructor, California Institute, 1919-33; Assistant Professor, 1933-

1626 North Grand Oaks Avenue

SALVTORE MERENDINO, M.A.

Visiting Lecturer in Industrial Design

A.B., San Jose State College, 1938; M.A., California Graduate School of Design, 1940. California Institute, 1945-

562 South Oak Knoll Avenue

WILLIAM W. MICHAEL, B.S.

Associate Professor of Civil Engineering

B.S. (Civil Engineering), Tufts College, 1909. Instructor, Department of Drawing and Design, Michigan Agricultural College, 1914; Chief of Surveys, 200-inch Telescope, Palomar Mt. Summer, 1935. California Institute, 1918-

388 South Oak Avenue

ARISTOTLE DEMETRIUS MICHAL, PH.D.

Professor of Mathematics

A.B., Clark University, 1920; A.M., 1921. Ph.D., The Rice Institute, 1924. Teaching Fellow and Instructor of Mathematics, The Rice Institute, 1921-25; Instructor of Mathematics, University of Texas, Summer 1924; National Research Fellow in Mathematics, University of Chicago, Harvard University, and Princeton University, 1925-27; Assistant Professor of Mathematics, Ohio State University, 1927-29. California Institute, 1929-

830 Hillside Terrace

CLARK BLANCHARD MILLIKAN, PH.D.

Professor of Aeronautics
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Ph.B., Yale University, 1924; Ph.D., California Institute, 1928. Teaching Fellow, California Institute, 1925-28; Assistant Professor, 1928-34; Associate Professor, 1934-40; Professor, 1940-

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Professor of Physics, Emeritus
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A.B., Oberlin College, 1891; A.M., 1893; Ph.D., Columbia University, 1895. Instructor in Physics, University of Chicago, 1895-1902; Assistant Professor, 1902-07; Associate Professor, 1907-19; Professor, 1919-21. Professor of Physics and Director of the Norman Bridge Laboratory of Physics, California Institute, 1921-45; Chairman of the Executive Council, 1921-45; Vice-President of the Board of Trustees and Professor of Physics, Emeritus, 1945-

1640 Oak Grove Avenue, San Marino

HENRY BAYARD MILNE, PH.D.

Research Fellow in Chemistry

M.S., Northwestern University, 1939; Ph.D., 1941. Instructor in Organic Chemistry, University of Idaho, 1941-42. California Institute, 1945-

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B. W. MORANT

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California Institute, 1941- 567 North Oakland Avenue

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Research Fellow in Astrophysics

Ph.D., University of Utrecht, 1934. Associate Professor of Physics, Occidental College, 1945. California Institute, 1946- 5363 College View Avenue, Los Angeles

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B.A., Queens University, 1895; M.A., 1896; LL.B., 1898; M.A., Harvard University, 1899; Ph.D., 1900; M.A. (hon.) Williams College, 1904; LL.D., Queens University, 1912; Litt.D., University of Southern California, 1930; LL.D., Mills College, 1931. Instructor in History and Political Science, Williams College, 1901-04; Instructor in Government, Harvard University, 1904-06; Assistant Professor of Government, 1906-12; Professor of Municipal Government, 1912-25; Jonathan Trumbull Professor of American History and Government, 1925-30; Chairman, Division of History, Economics and Government, Harvard University, 1920-28. California Institute, 1925- 268 Bellefontaine Street

HAROLD Z. MUSSELMAN, A.B.

Director of Physical Education

A.B., Cornell College, 1920. Athletic Director, Sterling (Illinois) High School, 1920-21. Instructor, California Institute, 1921-24; Manager of Athletics, 1924-25; Assistant Director of Physical Education and Manager of Athletics, 1935-42; Acting Director of Physical Education, 1942-43; Director of Physical Education and Manager of Athletics, 1943- 1080 North Holliston Avenue

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University of Manitoba, 1919. Chief Accountant, California Institute, 1922-35; Assistant Secretary, 1935- 1005 Cornell Road

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A.B., Pomona College, 1926; Ph.D., California Institute, 1931. Instructor and Assistant Professor of Physics, California Institute, 1933-40; Associate Professor of Physics, 1940-44; Professor of Physics, 1944- 885 North Holliston Avenue

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Professor of Organic Chemistry

B.S., University of Wisconsin, 1931; Ph.D., 1934. Research Assistant, University of Wisconsin, 1929-31; Fellow, 1931-34; Research Associate, 1934-35. Fellow of the General Education Board at the Rockefeller Institute for Medical Research, 1935-36; Assistant in Chemistry, 1936-37; Fellow of the Rockefeller Foundation at the University College Hospital Medical School, 1937-38. Assistant Professor, California Institute, 1937-43; Associate Professor, 1943-45; Professor, 1945- 400 South Berkeley Avenue

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Research Fellow in Chemistry

A.B., Harvard University, 1939; Ph.D., California Institute, 1942. Instructor, California Institute, 1942-44; Research Fellow, 1944- 961 Cornell Road

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Professor of Theoretical Physics

B.A., Harvard University, 1925; Ph.D., University of Göttingen, 1927. Associate Professor of Physics, University of California, 1930-36; Professor, 1936-. Assistant Professor, California Institute, 1928-34; Associate Professor, 1934-37; Professor, 1937- 1308 East California Street

WILLIAM JOHN PETER OTTO

Sculptor and Preparator in Vertebrate Paleontology

California Institute, 1941- 184 South El Molino Avenue

RAY D. OWEN, PH.D.

Gosney Fellow in Biology

B.S., Carroll College, 1937; A.M., University of Wisconsin, 1938; Ph.D., 1941. Assistant Professor of Genetics, University of Wisconsin. California Institute, 1946-

LINUS PAULING, PH.D., SC.D.

Professor of Chemistry
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B.S. (Ch.E.), Oregon State College, 1922; Ph.D., California Institute, 1925; Sc.D. Oregon State College, 1933; Sc.D., University of Chicago, 1941. National Research Fellow in Chemistry, 1925-26. Fellow of the John Simon Guggenheim Memorial Foundation, 1926-27. Lecturer in Physics and Chemistry, University of California, 1928-33; Massachusetts Institute of Technology, 1932; George Fisher Baker Lecturer, Cornell University, 1937-38. Assistant in Chemistry, California Institute, 1922-23; Teaching Fellow, 1923-25; Research Fellow, 1926-27; Assistant Professor, 1927-29; Associate Professor, 1929-31; Professor, 1931-

3500 East Fairpoint Street

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Research Fellow in Chemistry

B.A., Oregon State College, 1942; M.A., 1943; Ph.D., University of Wisconsin, 1945. California Institute, 1945-

741 West Washington Street

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Associate Professor of Electrical Engineering

B.S., California Institute, 1932; M.S., 1933; Ph.D., 1936. Lecturer in Physics, University of Southern California, 1938. Teaching Fellow, California Institute, 1932-36; Instructor, 1936-40; Assistant Professor, 1940-45; Associate Professor, 1945-

425 South Craig Avenue

WILLIS PARKISON POPENOE, PH.D.

Research Fellow in Geology

B.S., George Washington University, 1930; M.S., 1933; Ph.D., California Institute, 1936. Curator in Invertebrate Paleontology, California Institute, 1929-45; Curator in Geology and Lecturer in Paleontology, University of California (Los Angeles), 1945. Research Fellow, California Institute, 1945-

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GENNADY W. POTAPENKO, PH.D.

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C.Sc., University of Moscow, 1917; M.A., Ph.D. (Habil.), 1920. Docent, University of Moscow, 1920-32; Lecturer and Professor of Physics, Moscow School of Mines, 1919-32; Professor of Physics, Moscow School of Agriculture, 1929-31; Research Associate, University of Berlin, 1927; Visiting Lecturer, University of Göttingen, 1929. California Institute, 1930-

1718 Oakdale Street

HARLAN KELLEY PRATT, PH.D.

Research Fellow in Biology

B.S. (Agriculture), University of California (Los Angeles), 1939; Ph.D., 1944. Research Fellow, California Institute, 1944-

923 East California Street

DAVID PRESSMAN, PH.D.

Senior Fellow in Immunochemistry

B.S., California Institute, 1937; M.A., University of California (Los Angeles), 1938; Ph.D., California Institute, 1940. Research Fellow, California Institute, 1940-42; Senior Fellow, 1942-

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B.S., Harvard University, 1939; M.S., Graduate School of Engineering, Harvard University, 1941. Research Assistant, California Institute, 1941-45; Instructor, 1946-

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B.S., Illinois Institute of Technology, 1941; M.S., California Institute, 1944. Instructor in Aeronautics, California Institute, 1946-

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WILLIAM HERBERT REMPEL, M.S.

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B.A., Montana State University, 1939; M.S., California Institute, 1941. Instructor, California Institute, 1940-42; Assistant Professor of Meteorology, 1943-

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Assistant Professor of Seismology

A.B., Stanford University, 1920; Ph.D., California Institute, 1928. Research Assistant, Seismological Laboratory, Carnegie Institution of Washington, 1928-36. California Institute, 1937-

1820 Kenneth Way

HERSCHEL K. ROMAN, PH.D.

Gosney Fellow in Biology

Ph.D., University of Missouri, 1941. California Institute, 1946-

PAUL E. RUCH, M.S.

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B.S., Massachusetts Institute of Technology, 1928; M.S., California Institute, 1939. Instructor, California Institute, 1938-42; Associate Professor, 1942-

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Professor of Chemical Engineering

B.S., New Mexico State College, 1929; M.S., California Institute, 1931; Ph.D., 1934. Teaching Fellow, California Institute, 1930-34; Research Fellow, 1934-35; Senior Fellow in Chemical Research, 1935-37; Assistant Professor, 1937-39; Associate Professor, 1939-44; Professor, 1944-

1604 Kenneth Way

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Institute of International Education Fellow in Chemistry

Chemist, University of Mexico. Assistant, Institute of Chemistry, University of Mexico, 1942-44. California Institute, 1944-

532 El Dorado Street

VERNER F. H. SCHOMAKER, PH.D.

Assistant Professor of Chemistry

B.S. (Ch. Eng.), University of Nebraska, 1934; M.S., 1935; Ph.D., California Institute, 1938. George Ellery Hale Fellow, California Institute, 1938-40; Senior Fellow in Chemical Research, 1940-45; Assistant Professor, 1945-

418 South Michigan Avenue

WALTER A. SCHROEDER, PH.D.

Research Fellow in Chemistry

B.Sc., University of Nebraska, 1939; M.A., 1940; Ph.D., California Institute, 1943. Graduate Assistant, University of Nebraska, 1939-40. Graduate Assistant, California Institute, 1940-42; Research Assistant, 1942-43; Research Fellow, 1943-

406 South Chester Avenue

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Instructor in History

A.B., University of California (Los Angeles), 1942; M.A., 1943; Ph.D., 1945. Instructor in History, California Institute, 1945-

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A.B., Princeton University, 1941; Ph.D., California Institute, 1946. California Institute, 1941-

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Professor of Aeronautics

B.S., California Institute, 1928; M.S., 1929; Ph.D., 1933. Assistant in Engineering, California Institute, 1928-30; Instructor, 1930-37; Assistant Professor, 1937-40; Associate Professor, 1940-46; Professor, 1946-

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Instructor in English

A.B., Stanford University, 1939; M.A., 1940. Instructor in English, California Institute, 1945-

1770 Oakdale Street

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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, 1921-23. National Research Fellow, California Institute, 1923-26; Research Fellow, 1926-27; Assistant Professor, 1927-34; Associate Professor, 1934-40; Professor, 1940-

674 Manzanita Avenue, Sierra Madre

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Chairman of the Division of Physical Education

B.S. (E.E.), University of Colorado, *1905*; E.E., *1928*; D.Sc., *1938*. Associate Professor, Throop College, 1910-11; Professor, Throop College and California Institute, 1911-

384 South Holliston Avenue

FRANCES HALSEY SPINING

Librarian

California Institute, 1914-

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ROGER FELLOWS STANTON, PH.D.

Assistant Professor of English Language and Literature

B.S., Colgate University, 1920; M.A., Princeton University, 1924; Ph.D., 1931. Instructor, Colorado College, 1924-25. Instructor, California Institute, 1925-31; Assistant Professor, 1931-

Athenaeum

J. E. WALLACE STERLING, PH.D.

Edward S. Harkness Professor of History and Government

Member of the Executive Committee

B.A., University of Toronto, 1927; M.A., University of Alberta, 1930; Ph.D., Stanford University, 1938. Lecturer in History, Regina College, 1927-28; Assistant in History and Director of Physical Education, University of Alberta, 1928-30; Research Staff, Hoover War Library, 1932-37; Instructor in History, Stanford University, 1935-37. Assistant Professor of History, California Institute, 1937-40; Associate Professor, 1940-42; Professor, 1942-

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Associate Professor of Aeronautics and Meteorology

B.AeroE., University of Minnesota, 1936; Ph.D., California Institute, 1940. Wind Tunnel Assistant, California Institute, 1936; Instructor, 1938-42; Assistant Professor, 1942-46; Associate Professor, 1946-

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CHESTER STOCK, PH.D.

Professor of Paleontology

B.S., University of California, 1914; Ph.D., 1917. Research Assistant, Department of Paleontology, University of California, 1917-19; Instructor, 1919-21; Assistant Professor, Department of Geological Sciences, 1921-25. Research Associate, Carnegie Institution of Washington; Senior Curator of Vertebrate Paleontology, Los Angeles Museum; Fellow of the John Simon Guggenheim Memorial Foundation, 1939-40; 1940-41. California Institute, 1926-

1420 San Pasqual Street

NEWTON C. STONE, M.S.

Assistant Professor of Meteorology

B.Ed., Southern Illinois Teachers College, 1934; M.S., University of Illinois, 1935; B.S., California Institute, 1940; M.S., 1941. Head of Mathematics Department, Amboy Township High School, 1935-39. Instructor, California Institute, 1940-42; Assistant Professor, 1943-

214 South Wilson Avenue

AUDRE L. STONG, M.S.

Director of Institute Band

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

258 South Hudson Avenue

WILLIAM RICHARD STOTT, M.B.A.

Assistant Comptroller

B.A., Pomona College, 1931; M.B.A., Stanford University, 1940. Project Comptroller, California Institute, 1942; Assistant Comptroller, 1943-

2470 Morsley Road, Altadena

ARTHUR G. R. STRICKLAND, PH.D.

Research Fellow in Biology

Dipl. Ing., Eidgen. Politechnikum, Zurich, 1908. Ph.D., Stanford University, 1939. Research Assistant in Biology, Stanford University, 1935-39. California Institute, 1939-

664 South Oak Knoll Avenue

THOMAS FOSTER STRONG, M.S.

Assistant Professor of Physics
Associate Dean for Freshmen

B.S., University of Wisconsin, 1922; M.S., California Institute, 1937. Assistant Professor, California Institute, 1943-

1791 East Mendocino Street, Altadena

JAMES HOLMES STURDIVANT, PH.D.

Associate Professor of Chemistry

B.A., University of Texas, 1926; M.A., 1927; Ph.D., California Institute, 1930. Instructor, University of Texas, 1926-27. Teaching Fellow, California Institute, 1927-30; Research Fellow, 1930-35; Senior Fellow in Research, 1935-38; Assistant Professor, 1938-45; Associate Professor, 1945-

Athenaeum

ALFRED HENRY STURTEVANT, PH.D.

Professor of Genetics

A.B., Columbia University, 1912; Ph.D., 1914. Research Assistant, Carnegie Institution of Washington, 1915-28. California Institute, 1928-

1244 Arden Road

C. GARDNER SWAIN, PH.D.

National Research Council Postdoctoral Fellow in Chemistry

A.B., Harvard University, 1940; Ph.D., 1944. Teaching Fellow, Harvard University, 1941-42; Research Associate, 1942-44; Pittsburgh Plate Glass Fellow, 1944-45. California Institute, 1946-

48 North Catalina Avenue

ERNEST HAYWOOD SWIFT, PH.D.

Professor of Analytical Chemistry

B.S., University of Virginia, 1918; M.S., California Institute, 1920; Ph.D., 1924. Teaching Fellow, California Institute, 1920; Instructor, 1920-28; Assistant Professor, 1928-39; Associate Professor, 1939-43; Professor, 1943-

3140 East California Street

STANLEY MORSE SWINGLE, PH.D.

Instructor in Chemistry

B.S., Montana State College, 1939; Ph.D., California Institute, 1943. California Institute, 1944-

1099 Steuben Street

FRANKLIN THOMAS, C.E.

Professor of Civil Engineering
Dean of Students

B.E., University of Iowa, 1908; C.E., 1913. Instructor in Descriptive Geometry, University of Michigan, 1910-12. Associate Professor of Civil Engineering, California Institute, 1913-15; Professor, 1915-

685 South El Molino Avenue

RICHARD CHASE TOLMAN, PH.D., SC.D.

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

S.B., in Chemical Engineering, Massachusetts Institute of Technology, 1903; Ph.D., 1910; Sc.D., Princeton University, 1945. Dalton Fellow, Instructor in Theoretical Chemistry, and Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1905-10; Instructor in Physical Chemistry, University of Michigan, 1910-11; Assistant Professor of Physical Chemistry, University of Cincinnati, 1911-12; Assistant Professor of Chemistry, University of California, 1912-16; Professor of Physical Chemistry, University of Illinois, 1916-18; Chief, Dispersoid Section, Chemical Warfare Service, 1918; Associate Director and Director, Fixed Nitrogen Research Laboratory, Department of Agriculture, 1919-21; Vice-Chairman, National Defense Research Committee, 1940-45. California Institute, 1921-

345 South Michigan Avenue

Hsue-shen Tsien, Ph.D.

Associate Professor of Aeronautics

B.S., Chiao-tung University, 1934; M.S., Massachusetts Institute of Technology, 1936; Ph.D., 1939. Research Fellow, California Institute, 1939-43; Assistant Professor, 1943-45; Associate Professor, 1945-
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Associate Professor of Embryology

A.B., Columbia University, 1927; M.A., 1928; Ph.D., California Institute, 1929. Assistant in Zoology, Columbia University, 1927-28; National Research Council Fellow in Biology at Berlin and Naples; 1932-33. Teaching Fellow, California Institute, 1928-29; Instructor, 1929-38; Assistant Professor, 1938-46; Associate Professor, 1946-
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Hixon Fellow in Biology

A.B., University of Southern California, 1933; Ph.D., 1937. Lecturer, Medical School, University of Southern California, 1932. California Institute, 1939-
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Assistant Professor of Mechanical Engineering and Engineering Drafting

B.S., Massachusetts Institute of Technology, 1920. Assistant Instructor in Thermodynamics, Massachusetts Institute of Technology, 1920-21. California Institute, 1936-
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Professor of History and Economics

A.B., University of Redlands, 1920; M.A., Harvard University, 1921; J.D., Mayo College of Law, 1925; Ph.D., Northwestern University, 1932. Instructor in Economics, Harvard University, 1921-23; Professor of Public Speaking, Huron College, 1923-24; Lecturer in Economics, Northwestern University, 1924-25. California Institute, 1925-
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Assistant Professor of Hydraulics

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B.S., California Institute, 1936; M.B.A., Harvard University, 1938. Instructor and Research Assistant, California Institute, 1938-40; Teaching Assistant, Stanford University, 1940-41. Assistant Professor, California Institute, 1941-
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B.S. (C.E.), Washington State College, 1934; M.S., University of Michigan, 1936; Ph.D., California Institute, 1945. Teaching Fellow, California Institute, 1936-39; Assistant Professor and Associate Professor of Civil Engineering, University of Nevada, 1939-41. California Institute, 1945-
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Morgan Ward, Ph.D.

Professor of Mathematics

A.B., University of California, 1924; Ph.D., California Institute, 1928. Research Worker in Mathematics, Institute for Advanced Study, 1934-35. Assistant in Mathematics, California Institute, 1925-26; Teaching Fellow, 1926-28; Research Fellow, 1928-29; Assistant Professor, 1929-35; Associate Professor, 1935-40; Professor, 1940-
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Ph.D., California Institute, 1944. California Institute, 1942-

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Acting Chairman of the Division of Physics, Mathematics and Electrical Engineering

Ph.B., Lafayette College, 1914. Assistant in Physics, University of Chicago, 1914-17. Assistant Professor, California Institute, 1919-20; Associate Professor, 1920-30; Professor, 1930-

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LUTHER EWING WEAR, PH.D.

Associate Professor of Mathematics

A.B., Cumberland University, 1902; Ph.D., Johns Hopkins University, 1913. Professor of Mathematics, Trinity University (Texas), 1904-08; Dean, 1907-08; Instructor, University of Washington, 1913-18. Associate Professor, California Institute, 1918-

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Instructor in Industrial Design and Engineering Drafting

A.B. (M.E.), Stanford University, 1941; Industrial Designer, California Institute, 1943. California Institute, 1943-

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Professor of Plant Physiology

A.B., University of Utrecht, 1922; M.S., 1925; Ph.D., 1927. Botanist, Botanic Gardens, Buitenzorg, Java, 1928-30; Director, Foreigners' Laboratory, Buitenzorg, Java, 1930-32. California Institute, 1933-

485 South Madison Avenue

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B.A., University of Leiden, 1926; M.A., University of Utrecht, 1929; Ph.D., 1933. Assistant in Comparative Physiology, University of Utrecht, 1929, 1931; Dondersfonds Research Fellow, 1930-31; Chief Assistant in Medical Physiology, University of Utrecht, 1932-34. California Institute, 1934-

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Instructor in Engineering Drafting

A.B., Harvard University, 1917; A.B., School of Fine Arts (Boston), 1924. Associate Professor of Design, Syracuse University, 1925-29. California Institute, 1932-

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B.A., Oregon State College, 1939; Ph.D., University of Michigan, 1942. California Institute, 1945-

330 South Wilson Avenue

DAVID P. WILLOUGHBY

Scientific Illustrator in Vertebrate Paleontology

Medical Artist and Illustrator in Vertebrate Paleontology, 1929-36; Scientific Artist, Federal Art Project, Los Angeles County Museum, 1936-37. California Institute, 1938-

1462 Blanche Street

ERNEST B. WRIGHT, PH.D.

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B.S., Yale University, 1938; Ph.D., California Institute, 1945. California Institute, 1945-

785 South El Molino Avenue

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Senior Fellow in Immunochemistry

A.B., Olivet College, 1936; Ph.D., University of Chicago, 1941. Instructor in Immunology, University of Chicago, 1941-42. Research Fellow, California Institute, 1942-43; Senior Fellow in Research in Immunochemistry, 1943-

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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, 1925-27; Johnston Research Scholar, Johns Hopkins University, 1927-28; Fellow of the John Simon Guggenheim Memorial Foundation, 1928-29; Visiting Professor, Emory University, winter quarter, 1929; Visiting Professor, University of Michigan, summer, 1935; Assistant Professor of English, University of North Carolina, 1929-30; Associate Professor, 1930-32. Visiting Scholar of the Huntington Library, 1931-32; Member of the Research Staff, 1932-. California Institute, 1931-

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Oliver Reynolds Wulf, Ph.D.

Research Associate in Chemistry

B.S., Worcester Polytechnic Institute, 1920; M.S., American University, 1922; Ph.D., California Institute, 1926. Research Associate, University of Chicago (Member of U.S. Weather Bureau), 1941-45. California Institute, 1945-

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Arthur Howland Young

Visiting Lecturer on Industrial Relations

Vice-President, U.S. Steel Corporation, 1934-37; Lecturer on Industrial Relations, Harvard Graduate School of Business Administration, 1929-31; and Wharton School of Commerce and Industry, 1930-37; Consulting Professor of Industrial Relations, Stanford University, 1937-. California Institute, 1939-

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Administrative Assistant

B.S. (E.E.) (TCT), California Institute, 1917; M.S. (E.E.), Union College, 1919. California Institute, 1932-

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László Zechmeister, Dr. Ing.

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Diploma of Chemist, 1911; Dr. Ing., 1913; Eidgenossische Technische Hochschule, Zurich, Switzerland. Assistant and Chief Assistant, Kaiser Wilhelm Institut für Chemie, 1912-14; Instructor, Danish Royal Veterinary and Agricultural Academy, Copenhagen, 1921-23; Professor of Chemistry and Director of the Chemical Laboratory, Medical School of the University of Pecs, Hungary, 1923-40. California Institute, 1940-

Athenaeum

Fritz Zwicky, Ph.D.

Professor of Astrophysics

B.S., Federal Institute of Technology, Zurich, Switzerland, 1920; Ph.D., 1922. Research Assistant, Federal Institute of Technology, Zurich, 1920-25. Research Fellow, International Education Board, California Institute, 1925-27; Assistant Professor of Theoretical Physics, California Institute, 1927-29; Associate Professor of Theoretical Physics, 1929-41; Professor of Astrophysics, 1942-

212 West California Street

FELLOWS AND ASSISTANTS

**RAYMOND VOILES ADAMS, JR. ..... Physics
B.S., Kansas State College, 1941

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B.S., California Institute, 1942

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*HARRY ISRAEL ASHKENAS ..... Aeronautics
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HISTORICAL SKETCH

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

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

The possibility which he envisaged fired the enthusiasm and enlisted the support of a number of outstanding citizens of the community, notably Messrs. Arthur H. Fleming, Norman Bridge, Henry M. Robinson, James A. Culbertson, Charles W. Gates, and Hiram and John Wadsworth. Mr. Fleming and his daughter, Marjorie, presented the institution with twenty-two acres of land which, with the addition of eight acres later, comprise the present campus. The Flemings were also largely instrumental in providing the first building to be erected on the new site, the present Throop Hall. In 1910, under the presidency of Dr. James A. B. Scherer, the institute moved to its new quarters. A few years earlier the elementary school had been set up as a separate institution, the present Polytechnic Elemen-

tary School; and by 1911 the normal school and the academy had been discontinued.

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

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

Nineteen hundred and twenty-one was marked by developments which made it one of the most important years in the history of the Institute. When a laboratory of physics was assured by Dr. Norman Bridge, Dr. Millikan severed his connection with the University of Chicago to become director of the laboratory and Chairman of the Executive Council of the Institute.

In the same year, 1921, financial stability was assured by Mr. Arthur H. Fleming's agreement to give the California Institute his personal fortune as permanent endowment. In November of that year, the Board of Trustees formulated in the "Educational Policies of the Institute" an explicit statement of the principles which were to govern the present conduct of the Institute and its future development. Recognition by the Southern California community of the value of these aims has resulted in a steady growth of the physical facilities and has made possible the addition of work in geology,

biology, aeronautics, meteorology and industrial design. There has been also, during the past fifteen years, a steady growth in enrollment, both in the undergraduate and graduate groups. But all of these developments have involved no changes of fundamental purpose; they have, in fact, only enabled that purpose to be fulfilled more completely.

Beginning in the summer of 1941, the Institute devoted a large part of its personnel and facilities to the furthering of national defense and the war effort. In addition to carrying a wide variety of projects involving research on and development of the instrumentalities of war, the Institute set up a number of special instructional programs for members of the armed forces, including Army Meteorology Cadets, Navy V-12 Engineering Specialists, and advanced work in aeronautics and ordnance for officer personnel. Between 1941 and 1946 these programs included more than 2000 students.

EDUCATIONAL POLICIES

In pursuance of the plan of developing an institute of science and technology of the highest grade, the Trustees in 1921 adopted the following statement of policies:

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

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

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

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

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

(6) Throughout the period of undergraduate study every effort shall be made to develop the character, ideals, breadth of view, general culture, and physical well-being of the students of the Institute. To this end the literary, historical, economic, and general scientific subjects shall continue to be taught by a permanent staff of men of mature judgment and broad experience; the regular work in these subjects shall be supplemented by courses of lectures given each year by men of distinction from other institutions. Moderate participation of all students in student activities of a social, literary, or artistic character, such as student publications, debating and dramatic clubs, and musical clubs, shall be encouraged; and students shall be required to take regular exercise, preferably in the form of intramural games or contests affording recreation.

(7) In all the scientific and engineering departments of the Institute research shall be strongly emphasized, not only because of the

importance of contributing to the advancement of science and thus to the intellectual and material welfare of mankind, but also because research work adds vitality to the educational work of the Institute and develops originality and creativeness in its students.

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

BUILDINGS AND FACILITIES

THROOP HALL, 1910.

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

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

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

CULBERTSON HALL, 1922.

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

NORMAN BRIDGE LABORATORY OF PHYSICS: first unit, 1922; second unit, 1924; third unit, 1925.

The gift of the late Dr. Norman Bridge.

HIGH-POTENTIAL RESEARCH LABORATORY, 1923.

Erected with funds provided by the Southern California Edison Company Ltd.

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

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

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

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

WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES: first unit, 1929; second unit, 1938.
The gift of the late Mr. William G. Kerckhoff and Mrs. Kerckhoff, of Los Angeles.

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

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

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

ATHENÆUM, 1930.
The gift of the late Mr. and Mrs. Allan C. Balch, of Los Angeles. A clubhouse for the use of the Staffs of the California Institute, the Huntington Library, the Mt. Wilson Observatory, and the California Institute Associates.

STUDENT HOUSES, 1931.

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

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

Fleming House.

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

Ricketts House.

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

ASTROPHYSICAL INSTRUMENT SHOP, 1931.

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

W. K. KELLOGG LABORATORY OF RADIATION, 1932.

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

HENRY M. ROBINSON LABORATORY OF ASTROPHYSICS, 1932.

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

HYDRAULIC STRUCTURES LABORATORY, 1932.

ASTROPHYSICAL OPTICAL SHOP, 1933.

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

SOIL CONSERVATION LABORATORY, 1936.

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

CHARLES ARMS LABORATORY OF THE GEOLOGICAL SCIENCES, 1938.

The gift of the late Mr. and Mrs. Henry M. Robinson, of Pasadena, in memory of Mrs. Robinson's father, the late Mr. Charles Arms.

SEELEY W. MUDD LABORATORY OF THE GEOLOGICAL SCIENCES, 1938.

The gift of the late Mrs. Seeley W. Mudd, of Los Angeles, in memory of her husband.

SHIPPING, RECEIVING AND STORAGE BUILDING, 1944.

HYDRODYNAMICS LABORATORY, 1944.

MECHANICAL ENGINEERING LABORATORY, 1945.

TEMPORARY BUILDINGS

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

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

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

LIBRARIES

The libraries of the Institute offer students and staff members a comprehensive and well selected collection of books, periodicals, and other printed materials for study and research. The General Library, in the Norman Bridge Laboratory of Physics, contains a general reference collection and also covers the fields of mathematics and of civil, mechanical, and electrical engineering. The Humanities Library, in Dabney Hall of the Humanities, provides materials in literature, history, and the other non-technical fields, and offers additional books for general cultural and recreational reading. The separate libraries for physics, chemistry, biology, geology, aeronautics, industrial design, and industrial relations provide books and periodicals in their respective fields.

STUDENT LIFE

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

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

The completion of this group of four residence halls marks the initial step in a plan to meet the housing and living problems of undergraduate students. The plan calls eventually for eight residence halls. Each of the four present houses has its own elected officers and is given wide powers in the matter of arranging its own social events, preserving its own traditions, and promoting the general welfare of the house. The houses are under the general supervision and control of a member of the Faculty known as the Master of the Student Houses.

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

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

bership in the Throop Club greatly facilitates participation in undergraduate social life and intramural sports.

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

Associated Student Body. The undergraduate students are organized as the "Associated Students of the California Institute of Technology, Incorporated." All students who pay their student body fees are automatically members of this organization, which deals with affairs of general student concern and with such matters as may be delegated to it by the faculty. Membership in the corporation entitles each student to (a) admission to all regular athletic or forensic contests in which Institute teams participate, (b) a subscription to The California Tech, (c) one vote in each corporate election, and (d) the right to hold a corporate office.

Board of Directors. The executive body of the corporation is the Board of Directors, which is elected by the members in accordance with the provisions of the By-Laws. The Board interprets the By-Laws, makes awards for athletic and extra-curricular activities, authorizes expenditures from the corporation funds, and exercises all other powers in connection with the corporation not otherwise delegated.

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

Faculty-Student Relations. Faculty-student coördination and coöperation with regard to campus affairs is secured through periodic

joint meetings of the Faculty Committee on Student Relations, and the Board of Directors and the Board of Control of the Student Body. These conferences serve as a clearing house for suggestions as to policy, organization, etc., originating with either students or faculty.

Athletics. The California Institute maintains a well-rounded program of athletics and schedules inter-collegiate events with various neighboring institutions.

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

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

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

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

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

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

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

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

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

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

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

STUDENT HEALTH AND PHYSICAL EDUCATION

PHYSICAL EDUCATION

All undergraduate students are required to participate in some form of physical training a minimum of three days per week. This requirement may be satisfied by engaging in organized sports, which include both intercollegiate and intramural athletics, or by regular attendance at physical training classes.

War veterans, and men whose twenty-fourth birthday has occurred by the opening of the term, may be excused from the required work by action of the Physical Education Committee.

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

HEALTH SERVICE

A. PHYSICAL EXAMINATION AND VACCINATION

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

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

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

B. SERVICES OF THE INSTITUTE PHYSICIAN

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

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

C. EMERGENCY HOSPITALIZATION FUND

In addition, in order to meet the hospital and certain other emergency medical and surgical expenses, incurred by students who develop serious illnesses which require immediate attention, or suffer accidents, an emergency hospitalization fee of four dollars ($4.00) per academic year is assessed against every undergraduate and every graduate student. This fee must be paid with the tuition charge for the first term of the academic year.

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

The following regulations have been established:

1. The funds derived from this fee will be deposited at interest in a special account known as the Emergency Hospitalization Fund. The Institute will be the

custodian of the fund. Money in this fund shall not be used for any other purpose than for the payment of surgical and medical expenses. Whether a case is an emergency or not will be decided by the Institute Physician. Whenever an emergency arises, the Institute Physician will decide whether hospitalization is necessary, and will then put into operation the provisions of the Emergency Hospitalization Fund.

Illnesses and injuries which are not emergencies do not come within the scope of the Fund. The Emergency Hospitalization Fund is not applicable to accidents away from the grounds of the Institute. This rule does not apply, i.e., the Fund is applicable, to accidents away from the Institute when these occur in authorized activities connected with regular curricular work.

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

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

4. Whenever the expenses for emergency care in any one fiscal year are less than the total collected in fees for that year, the balance of money remaining shall be kept in the Emergency Hospitalization Fund, and shall remain deposited at interest to increase for the benefit of the fund. A balance kept over from one year will be used to render emergency medical aid to the students in later years. It is probable that the plan can be liberalized by the building up of the Fund in this manner.

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

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

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

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

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

10. The Faculty Committee on Student Health supervises, and authorizes, expenditures by the Fund. All questions regarding the administration of this Fund are to be referred to this Committee. The Committee will review the facts of every emergency case, and may, if they feel it desirable, recommend an extension of payments in excess of the maximum amounts prescribed in Section 2 above for specific purposes cited by the Committee.

REQUIREMENTS FOR ADMISSION TO UNDERGRADUATE STANDING

Since July, 1943, the Institute has been on an accelerated program of two sixteen-week semesters to an academic year and three such semesters in a calendar year. Commencing in October, 1946, the former calendar will be resumed. This consists of three eleven-week terms in an academic year extending from late September until the middle of June. There will be no academic summer session after 1946. To give time for this final summer semester, the starting date of the 1946-47 academic year will be in October instead of September.

Undergraduates are admitted only once a year—in September.

I. ADMISSION TO THE FRESHMAN CLASS

Students are selected from the group of applicants on the basis of (a) high grades in certain required high school subjects, (b) satisfactory completion of entrance examinations in mathematics, physics, chemistry, and English, and (c) a personal interview. The specific requirements in each of these groups are described below.

HIGH SCHOOL CREDITS. Each applicant must be thoroughly prepared in at least fifteen units of preparatory work, each unit representing one year's work in a given subject in an approved high school at the rate of five recitations weekly. Each applicant must offer all of the units in Group A and at least five units in Group B.

Group A:	English	3
	Algebra	2
	Plane Geometry	1
	Solid Geometry	½
	Trigonometry	½
	Physics	1
	Chemistry	1
	United States History and Government	1
Group B:	Foreign Languages, Shop, additional English, Mathematics, Laboratory Science, History, Drawing, Commercial subjects, etc.	5

Applicants who offer for entrance a total of fifteen recommended units, but whose list of subjects is not in accord with this table, may be admitted at the discretion of the faculty, if they are successful in passing the general entrance examinations; but no applicant will be admitted whose preparation does not include English 2 units, algebra

1½ units, geometry 1 unit, trigonometry ½ unit, physics 1 unit. All entrance deficiencies must be made up before registration for the second year.

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

Each applicant is expected to show that he has satisfactorily completed the above-stated required preparation, by presenting a complete scholastic record from an approved school. This record must contain a list of courses in progress—if any—at the time the record is submitted.

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

For admission September 23, 1947, entrance examinations will be held at the Institute on March 8 (Engilsh and chemistry) and March 15 (physics and mathematics). The examinations run from 9:00 a.m. to 12 noon and from 1:00 to 4:00 p.m. on each day. Applicants who are eligible to take the examinations will be notified of the place and should report there not later than 8:30 a.m. No other freshman entrance examinations will be given in 1947.

For dates of the examinations for admission in October, 1946 see the calendar on page 7.

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

Entrance examinations whether taken at the Institute or in absentia must be taken on the dates specified. In fairness to all applicants no exceptions to this rule can be permitted.

PERSONAL INTERVIEW. A personal interview will, wherever possible, be arranged with each applicant unless the results of the entrance examinations show very definitely that he has not had sufficient preparation. These interviews will be held in the locality in which the applicant lives or is attending school. In some cases, applicants may be asked to travel short distances to a central point. Notices of interview appointments will be sent, and the applicant has no responsibility with regard to the interview until such notice is received.

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

Complete application blanks and high school records including courses that may be in progress must reach the Registrar's Office at least four weeks in advance of the first examination date.

Applicants living outside the continental limits of the United States must submit their credentials in time for them to be evaluated and for the examinations to be mailed in time to reach the supervisor by the date on which the first examination is given.

Final selections are ordinarily made and the applicants notified of their admission or rejection within 60 days after the last examination date. Upon receipt of a notice of admission an applicant should immediately send in the registration fee of $10.00 (which will be credited toward the first-term tuition). The registration fee is not required of those entering under Public Laws 16 or 346, but such men must notify the Registrar's Office immediately, in writing, of their intention to attend. Places in the entering class will not be held for more than ten days from the time an applicant could reasonably be expected to have received notice of acceptance. When the registration fee (or a letter in the case of veterans) has been received, each accepted applicant will be sent a registration card which will entitle him to register, provided his physical examination is satisfactory. The registration card should be presented at the Dabney Hall Lounge at 1:30 p.m. on the date of registration.

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

PHYSICAL EXAMINATION. Each applicant must pass a physical examination prior to admission to the Institute. These examinations will be conducted for the Institute by the staff of the Huntington Memorial Hospital. At the time of his registration each new student will be assigned an appointment for his examination. Registrations are tentative pending such examinations, and are subject to cancellation if the examinations are unsatisfactory. Students

living at a distance are advised to consult their family physicians before coming to Pasadena in order to avoid unnecessary expense if physical defects exist which would prevent successful scholastic work. Every student entering the Institute for the first time must be vaccinated upon admission or bring a certificate from a physician that he has been vaccinated not earlier than one month before admission. Those students who refuse to be vaccinated will be denied admission to the Institute.

II. ADMISSION TO UPPER CLASSES BY TRANSFER FROM OTHER INSTITUTIONS

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

A student who is admitted to the upper classes pursues a full course in one of the options in engineering or in science, leading to the degree of Bachelor of Science. The Institute has no special students. Men are admitted either as freshmen in accordance with the regulations set forth on pages 70 to 73 or as upper classmen in the manner described below. Those who have pursued college work elsewhere, but whose preparation is such that they have not had the substantial equivalent of any three of the following freshman subjects, English, mathematics, physics and chemistry, will be classified as freshmen and must be admitted as such. (See freshman admission requirements on pages 70 to 73.) They may, however, receive credit for the subjects which have been completed in a satisfactory manner.

A minimum residence at the Institute of one scholastic year is required of all candidates for the degree of Bachelor of Science. See page 89.

An applicant for admission must present a transcript of his record to date showing in detail the character of his previous training and the grades received both in high school and college. In addition, he should file an application for admission; the necessary blanks for this will be forwarded from the Registrar's office upon request. The transcript and application should be received at least one month before the date of the first examination he wishes to take. If the applicant is attending another college, a supplementary transcript covering the work in progress should be filed as soon as possible.

Before their admission to the upper classes of the Institute all students are required to take entrance examinations in mathematics, physics and chemistry covering the work for which they desire credit, except that the examination in chemistry is required only of those desiring to pursue the course in science. Students must offer courses, both professional and general, substantially the same as those required in the various years at the Institute (see pages 137 to 153) or make up their deficiencies as soon as possible after admission (see Special Arrangements for Veterans, page 76). 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.

It is not possible to answer general questions regarding the acceptability of courses taken elsewhere. The nature of the work at the Institute is such as to demand that all courses offered for credit be scrutinized individually. Even when a transcript of record is submitted it is not always possible to tell whether the courses taken are equivalent to our work. In case the standard of the work taken elsewhere is uncertain, additional examinations may be required before the question of credit is finally determined.

Applicants are advised to read the descriptions of the freshman and sophomore courses, particularly those in physics, mathematics, and chemistry, and to note that the work in freshman mathematics includes certain topics in differential and integral calculus. It is possible, however, for an able student to cover outside of class, the necessary work in integral calculus and thus prepare himself for the entrance examination and the sophomore course in mathematics.

Two examinations of a comprehensive character are offered in each of the three subjects, mathematics, physics and chemistry. One examination in each subject covers the work of the first year, the other examination that of the first and second years. Representative examination papers will be sent to approved applicants upon request. From a study of these, prospective students may judge for themselves which examinations they are prepared to take. Students are not required to take all of the examinations for admission to the classification of a given year as junior or sophomore, but may take examinations in one or more subjects for admission to one class and in others for admission to the work of another class. The Institute courses for which they will receive credit will be determined by the Committee on Admission to Upper Classes on the basis of their previous record and of the results of the examinations.

No fee is charged for the entrance examinations, but only those whose records are good will be permitted to write upon them.

Applicants should not come to the Institute expecting to be admitted to the examinations, without first receiving definite permission to take them.

The schedule for the three-hour examinations for admission to upper classes September 25, 1947 is as follows:

Mathematics	9:00 a.m.	June 13, 1947; September 5, 1947
Physics	9:00 a.m.	June 14, 1947; September 6, 1947
Chemistry	1:00 p.m.	June 14, 1947; September 6, 1947

Dates of examinations for admission to upper classes in October, 1946 are given in the calendar on page 7.

Applicants who have completed the substantial equivalent of the first three years, and wish to transfer to the senior class at the Institute, take the same examinations as are given to junior transfers. After they have been admitted, further examinations may be required if any doubt exists with regard to their previous preparation in any subject.

Applicants residing at a distance may take the 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.

The attention of students planning to transfer to junior or senior standing is called to the fact that, until they have satisfactorily completed three full terms of residence at the Institute, they are subject to the same scholastic requirements as are freshmen and sophomores. See pages 87 to 90. In addition, they should note that to be permitted to register for any science or engineering options during their junior and senior years they must meet the scholastic requirements of the divisions concerned. See page 88.

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

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

(The registration fee is not required of those entering under Public Laws 16 or 346.)

III. SPECIAL ADMISSION ARRANGEMENTS FOR VETERANS

It is recognized that veterans transferring to the Institute at the sophomore or junior level may not have had all courses required of regular Institute freshmen or sophomores. Such veteran transfers will be governed by the following regulations:

With the exception of requirements in Mathematics, Physics, and English Composition, and in addition Chemistry for Science Majors, the Institute curriculum requirements of the first year for an entering Sophomore, or of the first two years for an entering Junior—will be waived provided that (a) the transfer student has 32 acceptable college credits if a Sophomore or 64 if a Junior, the acceptability of such credits to be judged by the Engineering or Science Course Committees for engineers or scientists respectively; (b) he has satisfied all of the prerequisites of his option prior to the level at which he enters according to a list of such prerequisites selected from the curricula of the first two years at the Institute and certified to the Registrar by the head of each option; (c) if he is allowed credit for any courses of the year in which he enters or subsequent years, he may be required to complete his program by including such Institute courses of the year or years prior to his admission for which he may not have credit, as his adviser shall think wise. In any such requirement, courses prerequisite to the work in his option shall take precedence; (d) any department may prescribe the electives taken by the Transfer in its own department if it considers that his previous preparation has been lacking in a field under its jurisdiction. (For example, a transfer who had had no history might be required to take courses in history as his Senior Humanities elective.)

EXPENSES

The following is a list of student expenses at the California Institute of Technology for the academic year 1946-47, together with the dates on which the various fees are due. These charges are subject to change at the discretion of the Institute. In addition to the total amount given, approximately $50 a year should be allowed for books and supplies.

Date	*Fee*	*Amount*
Upon notification of admission	Registration Fee	$ 10.00[1]
At time contract for Student House reservation is signed	Student House Deposit	25.00[2]
October 4, 1946: Freshmen and transfer students October 7, 1946: Upperclassmen	Tuition, 1st term	168.00[3]
	1st installment of Board and Room, 21 meals per week	77.00[4]
	1st installment of Board and Room, 15 meals per week	75.50
	General Deposit	25.00
	Associated Student Body Dues, 1st term	4.45
	Emergency Hospitalization Fee, 1946-47	4.00
	Subscription to the California Tech, 1946-47	.55
	Locker Rent, 1st term	1.00[5]
	Parking Fee, 1st term	1.00[5]
	Student House Dues, 1st term	2.50
Nov. 9, 1946	2nd installment of Room and Board, 21 meals per week	90.00
	2nd installment of Room and Board, 15 meals per week	89.00
Jan. 6, 1947	Tuition, 2nd term	166.00
	3rd installment of Room and Board, 21 meals per week	77.00
	3rd installment of Room and Board, 15 meals per week	75.50
	Associated Student Body Dues, 2nd term	5.00
	Locker Rent, 2nd term	1.00[5]
	Parking Fee, 2nd term	1.00[5]
	Student House Dues, 2nd term	2.50
Feb. 9, 1947	4th installment of Room and Board, 21 meals per week	96.00
	4th installment of Room and Board, 15 meals per week	93.00

[1]This fee is paid by freshmen and transfer students and is automatically applied on the first term's tuition. Those entering under Public Laws 16 or 346 are not required to pay the Registration Fee.

[2]This deposit is automatically applied on the first installment of room and board.

[3]For those who have paid the registration fee, the balance due is $118.

[4]For those who have paid the deposit, the balance due is $52.

[5]Optional.

March 31, 1947	Tuition, 3rd term	166.00
	5th installment of Room and Board,	
	21 meals per week	77.00
	15 meals per week	75.50
	Associated Student Body Dues, 3rd term	5.00
	Locker Rent, 3rd term	1.00[5]
	Parking Fee, 3rd term	1.00[5]
	Student House Dues, 3rd term	2.50
May 4, 1947	6th installment of Room and Board,	
	21 meals per week	96.00
	15 meals per week	93.00

Total for academic year
(Less Registration Fee, Student House Deposit and optional items)

With Room and Board in Student Houses,	
21 meals per week	$1,064.50
15 meals per week	1,053.00
Without Room and Board	544.00

Tuition fees for those carrying less than the normal number of units

Over 32 units	Full tuition
32 to 25 units	$125 per term
24 to 10 units	$5 per unit per term
Minimum tuition charge, per term	$50

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

EMERGENCY HOSPITALIZATION FEE

The emergency hospitalization fee, payable by each student at the beginning of each year, provides a certain amount of hospitalization and medical and surgical care in accordance with regulations prescribed by the Board of Trustees and administered by the Institute Physician and the Faculty Committee on Student Health (see page 68).

ASSOCIATED STUDENT BODY FEE

The Associated Student Body fee of $14.45 is payable by all undergraduate students. Of this fee, $5.50 is used for the support of athletics, $3.00 is a subscription to the BIG T, and the remainder is budgeted by the Board of Directors of the Associated Student Body for other student activities. The subscription to the CALIFORNIA TECH, 55 cents a year, is collected from every undergraduate.

[5]Optional.

GENERAL DEPOSIT

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

STUDENT HOUSES

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

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

SPECIAL FEES

Students in the jet-propulsion option of Aeronautical Engineering pay $100 an academic year, and students in Meteorology pay $150 an academic year in addition to the regular $500 tuition fee.

SCHOLARSHIPS, PRIZES, AND STUDENT AID

FRESHMAN PRIZE SCHOLARSHIPS

A number of freshman scholarships covering full tuition or half tuition are awarded each year to members of the incoming freshman class. The recipients of these scholarships are selected by the Freshman Admissions and Registration Committee from the candidates who have stood sufficiently high on the entrance examinations and have otherwise satisfied the entrance requirements of the Institute.

The scholarships are awarded on the basis of all the information available in regard to the applicants—the results of their examinations, their high school records and recommendations, the statements submitted as to their student activities and outside interests, and the result of personal interviews where these are possible. Financial need is taken into consideration. Applications for scholarships should be made on a form which may be obtained by writing to the Registrar or calling at the office.*

Honor Standing: The Freshman Admissions and Registration Committee awards *Honor Standing* each year to those freshman applicants who stand in the top ten percent on the entrance examinations, except that those who have had previous college work or have previously tried the examinations may, at the discretion of the Committee, be passed over in granting this award. (See page 89 for Honor Standing for Upperclassmen.)

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. If there are no such candidates, the Institute may award the scholarships elsewhere.

SOPHOMORE AND JUNIOR PRIZE SCHOLARSHIPS

The Institute has established a number of scholarships known as the Sophomore and Junior Prize Scholarships. These scholarships, which carry half tuition, are awarded at the end of each academic

*Those attending under Public Laws 346 or 16, who would have difficulty meeting expenses in spite of government allowances, may apply for grants in aid on the same form as that used for scholarship applications.

year to those students who, as the result of their work during the freshman and sophomore years, stand high in their respective classes. Financial need is taken into consideration, and application is made on a form obtainable in the Registrar's office.*

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

HARRIET HARVEY SCHOLARSHIP
WALTER HUMPHRY SCHOLARSHIP

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

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

DABNEY SCHOLARSHIP

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

ELIZABETH THOMPSON STONE SCHOLARSHIP

Miss Elizabeth Thompson Stone of Pasadena established, by her will, a scholarship known as the Elizabeth Thompson Stone Scholarship.

MERIDAN HUNT BENNETT SCHOLARSHIPS AND FELLOWSHIPS

Mrs. Russell M. Bennett of Minneapolis, in January, 1946, made a gift of approximately $50,000 to the Institute to constitute the Meridan Hunt Bennett Fund, as a memorial to her son, Meridan Hunt Bennett, a former student at the Institute. The income of this fund is to be used to maintain scholarships and fellowships which shall be awarded to undergraduate and graduate students of the Institute, the holders of such scholarships and fellowships to be known as Meridan Hunt Bennett Scholars, in the case of undergraduates, and Meridan Hunt Bennett Fellows, in the case of graduates.

*Those attending under Public Laws 346 or 16, who would have difficulty meeting expenses in spite of government allowances, may apply for grants in aid on the same form as that used for scholarship applications.

BRAYTON WILBUR-THOMAS G. FRANCK SCHOLARSHIP

Mr. Brayton Wilbur and Mr. Thomas G. Franck of Los Angeles, have established the Brayton Wilbur-Thomas G. Franck Scholarship Fund, the income to be used for a scholarship for a deserving student at the Institute.

BLUMENTHAL SCHOLARSHIP IN PHYSICS

Mr. and Mrs. H. A. Blumenthal of Los Angeles, have recently made provision for a scholarship in Physics in memory of their son, William David Blumenthal, a member of the class of 1942, who served as a member of the armed forces and lost his life in the European Theater of Operations. Preference in the awarding of this scholarship is to be given to a deserving applicant from the Los Angeles High School.

AMIE S. KENNEDY SCHOLARSHIP

Mrs. Amie S. Kennedy of Los Angeles, in December, 1945, made possible a scholarship for a worthy student, or for two or more students, as the Institute may determine.

LA VERNE NOYES SCHOLARSHIPS

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

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

Second, shall be descended by blood from some one who has served in the army or navy of the United States in said war, and who either is still in said service or whose said service in the army or navy was terminated by death or an honorable discharge.

The recipients are designated La Verne Noyes Scholars.

In addition to the foregoing named scholarships, there is a Scholarship Endowment Fund made up of gifts of various donors. The aggregate amount of capital funds held by the Institute for scholarship purposes is approximately $230,000.

LOAN FUNDS

The Institute has the following loan funds, from the income, and in certain cases the principal, of which it makes loans to students for the purpose of aiding them to pursue their education:

The Olive Cleveland Loan Fund—established by Miss Olive Cleveland.

The Howard R. Hughes Loan Fund—established by the gift of Mr. Howard R. Hughes.

The Raphael Herman Loan Fund—established by the gift of Mr. Raphael Herman.

The Noble Loan and Scholarship Fund—given by Mr. and Mrs. Arthur Noble of Pasadena.

The Thomas Jackson Memorial Loan Fund—established in 1932 by Mr. and Mrs. Willard C. Jackson in memory of their son Thomas Jackson, a member of the sophomore class of that year who died during the fall, at the beginning of a very promising career.

The Roy W. Gray Fund.

The James R. Page Loan Fund.

The David Joseph Macpherson Fund, given by Miss Margaret V. Macpherson in memory of her father, David J, Macpherson.

The John McMorris Loan Fund—established by the gift of an anonymous donor as a memorial to John McMorris.

The Scholarship and Loan Fund which has been constituted by gifts from a number of donors.

The Albert H. Stone Education Fund in Los Angeles has made available to the Institute from time to time funds for loans to students of the Institute.

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.

THE MARY A. EARL McKINNEY PRIZE

The Mary A. Earl McKinney prize, established in 1946, by Dr. Samuel P. McKinney of Los Angeles, a graduate of Civil Engineering of Rensselaer Polytechnic Institute, class of 1884, consists of the annual income from three thousand five hundred dollars.

It is awarded at Commencement in the form of a first and second prize, each consisting of a trophy and a sum of money, to the two students of the junior class, who show the greatest proficiency and improvement in English.

The department of English will announce each year the subject for an essay to be based on certain prescribed books. The three or four men presenting the best essays will engage in a discussion of the general subject, and the awards will be made by a panel of judges. The contest will be held in May.

STUDENT EMPLOYMENT

The Institute tries to help students to find suitable employment when they cannot continue their education without thus supplementing their incomes. The requirements of the courses at the Institute are so exacting, however, that under ordinary circumstances students who are entirely or largely self-supporting should not expect to complete a regular course satisfactorily in the usual time. It is highly inadvisable for freshman students to attempt to earn their expenses. Students wishing employment are advised to write, before coming to the Institute, to the Director of Placements.

PLACEMENT SERVICE

The Institute, in cooperation with the Alumni Association, maintains a Placement Office, under the direction of a member of the Faculty. With the services of a full-time secretary, this office assists graduates and undergraduates to find employment. Students, both graduate and undergraduate, wanting part-time employment during the school year or during vacations, should register at the Placement Office. Assistance will be given whenever possible in securing employment for summer vacations. Graduates who are unemployed or desire improvement in their positions should register at the Placement Office.

It should be understood that the Institute assumes no responsibility in obtaining employment for its graduates, although the Placement Office will make every effort to find employment for those who wish to make use of this service.

REGISTRATION REGULATIONS

Registration Dates		*Fees Payable*	*Instruction Begins*
Freshmen and Transfer Students	Oct. 4, 1946	Oct. 4, 1946	Oct. 8, 1946
Upperclassmen and Graduate Students	Oct. 7, 1946	Oct. 7, 1946	Oct. 8, 1946

For registration dates for 1947 see calendar on page 8.

Fees for Late Registration

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

Change of Registration

All changes in registration must be reported to the Registrar's Office by the student. A fee of one dollar is assessed for any registration change made after the first week of classes, unless such change is made at the suggestion of an officer of the Institute. Registration changes are governed by the last dates for adding or dropping courses as shown on the Institute calendar.

General Regulations

Every student is required to attend all classes and to satisfy the requirements in each of the courses in such ways as the instructor may determine.

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

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

SCHOLASTIC GRADING AND REQUIREMENTS

SCHOLASTIC GRADING

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

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

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

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

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

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

An incomplete or a condition in any term's work must be removed during the next term in residence by the date fixed for the removal of conditions and incompletes. Each student receiving such grades should consult with his instructor at the beginning of his next term in residence. Any condition or incomplete not so removed automatically becomes a failure unless otherwise recommended in writing to the Registrar by the instructor prior to the date for removal of conditions and incompletes.

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

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

SCHOLASTIC REQUIREMENTS

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

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

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

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

(a) If he fails during any one term to receive at least 54 credits.

(b) If he fails for the school year to receive a total of at least 270 credits.

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

*The units used at the California Institute may be reduced to semester hours by multiplying the Institute units by the fraction 2/9. Thus a twelve unit course taken throughout the three terms of an academic year would total thirty-six Institute units or eight semester hours. If the course were taken for only one term, it would be the equivalent of 2.6 semester hours.

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

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

Departmental regulations. Any student whose grade-point average (credits divided by units) is less than 1.9 in the subjects listed under his division* may, at the discretion of his department, be refused permission to continue the work of that option.‡ Thus, a student finishing his junior year in electrical engineering, whose grade-point average in the freshman, sophomore, and junior courses in his *division* (including physics, mathematics, and electrical engineering) was less than 1.9, could be refused permission by the electrical engineering department to continue with *senior* courses in the electrical engineering option. Such disbarment, however, does not prevent the student from continuing in some other option provided permission is obtained, or from repeating courses to raise his average in his original option.

Freedom from scholastic restrictions. After a student has completed at least three full terms of residence at the Institute and has been registered for his junior year, he shall no longer be subject to the scholastic regulation requiring that he make at least 270 credits* during the school year, except that a student who is *reinstated* to enter the junior or senior year is subject to this requirement during his junior or senior year.

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

Graduation requirement. To qualify for graduation a student must complete the prescribed work in some one option of the course

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

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

in engineering or of the course in science with a grade point average of 1.9.

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

Honor standing. (See page 80 for *Honor Standing* for entering freshmen.) At the close of each academic year the Committee on Honor Students awards *Honor Standing* to approximately fifteen students in each of the three classes remaining in residence. These awards are based primarily on the scholastic records of the students. Any holder of such an award who in any subsequent terms fails to maintain a scholastic standard set by the Committee loses his honor standing for the remainder of the academic year.

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

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

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

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

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

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

CANDIDACY FOR THE BACHELOR'S DEGREE

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

STUDY AND RESEARCH AT THE CALIFORNIA INSTITUTE

THE SCIENCES

ASTROPHYSICS

The General Education Board provided in 1928 for the construction by the Institute of an Astrophysical Observatory, now well under way, equipped with a 200-inch reflecting telescope and many auxiliary instruments. A prime purpose of the gift is to secure for the new Observatory the advantage, in its design, construction, and operation, of the combined knowledge and experience of the investigators in the research laboratories of the Institute and in the neighboring Mount Wilson Observatory of the Carnegie Institution of Washington. This new project thus continues and extends in a more formal way the cooperation which has been in progress between the California Institute and the Mount Wilson Observatory for several years, especially in the study of the astronomical, physical, and chemical aspects of the constitution of matter.

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

The new observatory will consist of two main features. One of these is the 200-inch telescope, with its building, dome, and auxiliary equipment, now being erected on Palomar Mountain in San Diego Country. The other will be an Astrophysical Laboratory located on the Institute campus, which will serve as the headquarters in Pasadena of the observatory staff and of the Graduate School of Astrophysics. Its equipment will include instruments and apparatus for the measurement of photographs, the reduction and discussion of observations, and for such astrophysical investigations as can be made there to the best advantage. Its instruments for the interpretation of astrophysical phenomena will be designed to supplement those of the laboratories of the Institute and the Pasadena laboratory of the Mount

Wilson Observatory. Well-equipped shops for the development of new instruments have been erected on the campus, and the Astrophysical Laboratory has been completed, though some of its chief instruments are still in process of construction.

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

An Observatory Council, comprising four members of the Executive Council of the Institute, and also including Dr. Walter S. Adams, has been placed by the trustees in full charge of the design, construction, and operation of the Astrophysical Observatory and Laboratory. With the approval of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed by the Observatory Council as its Executive Officer, in direct charge of design and construction. The organization of the Observatory Council and the personnel of its advisory committees are shown on page 53 of this Catalogue.

Any great increase in the size of telescopes requires a long study of the most promising methods of making large paraboloidal mirrors. After much experimental work, a new form of Pyrex glass was chosen as the best available material and a 120-inch disc was received in 1934. The 200-inch disc was received in 1936 and is now in process of being shaped up in the optical shop.

The extensive investigation of primary and auxiliary instruments, which forms such a vital part of the general scheme, has also made marked progress, through the active cooperation of many leading men of science and engineers. Microphotometers, radiometers, photoelectric cells and other instruments of various types have been carefully studied and tested in difficult research problems. The Research Laboratory of the Eastman Kodak Company has generously agreed to deal with many of the special photographic problems. The short focus spectrograph objective devised by Rayton has greatly increased the range of the 100-inch telescope and has made possible the recent researches of Hubble and Humason on the expanding universe. A new objective of still shorter focal length has been completed by Beck

after the design of the British Scientific Research Association, and successfully tested on Mount Wilson. A very advantageous method of coating telescope mirrors with aluminum instead of silver has been applied by Dr. John Strong to several large mirrors, including the 36-inch Crossley reflector on Mount Hamilton and the 60-inch and 100-inch reflectors on Mount Wilson.

It is expected that, after the Astrophysical Laboratory on the campus has been completely equipped, the Institute will offer to competent students the opportunity of pursuing advanced courses of study and research in astrophysics, leading to the degrees of Master of Science and Doctor of Philosophy. The opportunity already exists for some supervised research with the 18-inch and 8-inch Schmidt telescopes on Palomar Mountain. Undergraduate students who desire to prepare themselves for such graduate work should take the physics option of the course in science.

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

BIOLOGICAL SCIENCES

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

Adjacent to the campus there is a laboratory for plant physiology, with several greenhouses. Two of them are air-conditioned, allowing for exact control of temperature and humidity and partial control of light. They offer a unique opportunity for the study of plants under different synthetic climatic conditions and also enable complete reproducibility of experimental results.

At Arcadia, about five miles from the Institute, there is a ten-acre farm, with greenhouse and laboratory, for work in plant genetics. At Corona del Mar there is a marine laboratory. The building contains four large rooms and several smaller ones which give ample opportunity for research work in experimental biology in general. The proximity of the marine station to Pasadena (about 50 miles) makes it possible to supply the biological laboratories with living materials for research and teaching. The fauna at Corona del Mar and at Laguna Beach, which is near-by, are exceptionally rich and varied, and are easily accessible.

INSTRUCTION AND RESEARCH

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

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

CHEMISTRY AND CHEMICAL ENGINEERING

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

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

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

The undergraduate instruction is so arranged that in the last two years of the undergraduate course in science there are offered to students an option in chemistry and an option in applied chemistry. These options, especially when followed by the fifth-year courses in these subjects, prepare students for positions as teachers and investi-

gators in colleges and universities, as research men in the government service and in industrial laboratories and as chemists in charge of the operation and control of manufacturing processes, and, in the case of the fifth- and sixth-year chemical engineering, for positions involving the management and development of chemical industries on the chemical engineering side. For students who desire to enter the field of chemical research, for which there are now professional opportunities on both the scientific and applied sides, opportunities for more specialized study and research leading to the degree of Doctor of Philosophy are provided at the Institute in the fields of inorganic, analytical, physical, and organic chemistry, and chemical engineering.

First-year chemistry, which is taken by all freshman students of the Institute, puts special emphasis on the fundamental principles of chemistry. For two terms this subject centers around the chemistry of acids, bases, salts, metals, and non-metals. The third term is devoted to elementary qualitative analysis, accompanied by special lectures in various fields of chemistry given by staff members of the division. Provision is made for the execution in the laboratory of interesting and fruitful experiments closely coordinated with the lectures and classroom discussions.

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

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

The supervision of the research work of graduate students is distributed among the members of the staff of the Division of Chemistry and Chemical Engineering. Some of the many fields in which researches are being actively prosecuted are listed on page 186.

The fifth-year course in chemical engineering leads to the degree of Master of Science in Chemical Engineering. The fifth-year course contains an intensive problem study of chemical engineering, a laboratory course in the fundamentals of engineering measurement, a course in business economics, and elective studies in science and engineering. Upon completion of the fifth-year course the student becomes eligible to be considered for sixth-year work leading to the degree of Chemical Engineer. Approximately one-half of the work of the sixth year is devoted to research either in chemical engineering or in applied chemistry, the other half being occupied with graduate course work arranged with the approval of the Division of Chemistry and Chemical Engineering.

Chemical engineering may be offered as a major subject for the degree of Doctor of Philosophy, it may also be presented as a minor subject in connection with the doctorate in chemistry or in mechanical engineering. The lines of research being pursued in chemical engineering include engineering thermodynamics, phase equilibrium of hydrocarbons at elevated pressures, thermal transfer, fluid flow, and combustion.

GEOLOGICAL SCIENCES

The Division is housed in the Charles Arms Laboratory and in the Seeley W. Mudd Laboratory, designed especially for instruction and research in the geological sciences. Office space for graduate students is provided in these buildings.

Exceptional opportunities for research in the geological sciences exist at the Institute. An almost unrivaled variety of rock types, geologic structures, and physiographic forms occurs within convenient reach of Pasadena. The relatively mild climate permits field studies throughout practically the entire year, and consequently field training is an unusually important part of the department program. The scant vegetation of much of southeastern California permits study of rock types and delineation of structure to a degree not often available to the geologist.

Stratigraphic and faunal studies may be pursued in the Cenozoic and Mesozoic sedimentary rocks of the Southern Coast Range, 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 await critical investigation and frequently involve an interpretation of folding and faulting on a large scale. The many productive oil

fields in southern California afford opportunity to students interested in petroleum geology. Many of the actively worked metallic and nonmetallic deposits of California and Arizona are within reach of week-end field parties. The world famous mineral localities of Crestmore and Pala are within a few hours' driving time from the Institute. Suites of ores, minerals and rocks from these localities are available for study in the Institute's collections, in addition to suites from many other parts of the world.

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

A very wide range of graduate courses is offered in both theoretical geophysics and in geophysics as applied to prospecting for oil and other mineral substances. The geophysical staff comprises four members, devoting themselves to different phases of the subject. Instruction is given in seismic, gravity, electrical, magnetic and other methods of prospecting. The design and construction of geophysical instruments in the shop of the seismological laboratory receive attention.

The Seismological Laboratory of the California Institute is located about three miles west of the campus on a granite ridge affording firm bed-rock 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 seven 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.

MATHEMATICS

Study and research in pure mathematics leading to the degree of Doctor of Philosophy were initiated by the Institute in 1926-1927. Candidates for the degree are expected to acquire a reasonable familiarity with some of the major applications of mathematics to the physical sciences. The attention of those intending to take advanced

courses in mathematics is particularly directed to the foreign language requirements for mathematical work beyond the bachelor's degree.

METEOROLOGY

With the conclusion of the semester ending in June, 1946, meteorology is again offered only in the Graduate School. Prerequisites for admission to meteorology will be a Bachelor's degree in Science or Engineering, or the equivalent, with credit in mathematics through differential and integral calculus and differential equations. A minimum of two years of college physics is required and a course in thermodynamics is desirable. In general, it is felt that an undergraduate major in mechanical engineering or in physics with a minor in mathematics constitute the best preparation for graduate study in meteorology.

The fifth year curriculum in meteorology is designed to give the student a well rounded training in basic meteorology and to qualify him for a position of assistant forecaster in an airline or for a junior meteorologist rating in the U. S. Weather Bureau. Students satisfactorily completing the fifth year curriculum will be granted the degree of Master of Science in Meteorology. Although fifth year students assist on research projects, no thesis is required for the Master's degree.

Students who have completed the fifth year curriculum at the Institute, or who have obtained essentially the same preparation elsewhere, may apply for admission to the sixth year course leading to the professional degree of Meteorologist. Whereas, the fifth year curriculum is devoted to basic meteorology and short term forecasting, the course plan of the second graduate year provides training in the technique of preparing extended forecasts. Sixth year students are required to devote considerable time to original research in the second and third terms. An acceptable thesis is one of the sixth year requirements for the professional degree.

Qualified students will be accepted for further advanced study leading to the degree of Doctor of Philosophy.

Facilities of the Meteorology Department include a weather station, complete with instruments used in the making of routine observations, both surface and upper air. Fifth year students operate this weather station, as well as a forecasting office, in which Civil Aeronautics Administration teletype facilities permit the preparation of practice forecasts from current data.

PHYSICS

UNDERGRADUATE WORK

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

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

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

GRADUATE WORK

Graduate students should complete as soon as possible the courses required for admission to candidacy for the doctor's degree. (See page 120.) These provide an unusually thorough grounding in the fundamentals of physics, and the student learns to use these principles in the solution of problems of all kinds. In general, also, graduate students should begin research during their first year and continue it through their whole graduate period.

The Norman Bridge Laboratory of Physics is equipped to carry on research in all the principal fields of physics. It provides 65 rooms for research in addition to class and lecture rooms, the physics library, offices, laboratories for advanced and undergraduate instruction, shops, switchboard, apparatus, storage-battery, and machinery rooms. Equipment for making liquid air, hydrogen, and helium has been installed, and liquid air and liquid hydrogen are available in sufficient quantities for low temperature researches. Special facilities for research in the field of radiation are provided in the W. K. Kellogg Laboratory of Radiation and the High-Potential Research Laboratory with their million-volt transformers and high potential x-ray equipment. In both laboratories important work in nuclear physics and various phases of high-voltage x-rays is being carried on.

The student either may select his own problem in consultation with the department or may work into some one of the research projects already under way. The average yearly output of the laboratory for many years has been from fifty to sixty major papers.

There is a general seminar or research conference each week which is regularly attended by all research workers and all graduate students. In addition, there is a weekly theoretical seminar conducted for the benefit of those interested primarily in mathematical physics and several seminars on special fields of work such as x-radiation, nuclear physics, metals, physics of solids, and ultra-short electromagnetic waves.

For graduates in physics the main outlets are positions in colleges and universities, in the research laboratories of the government, and in the increasing number of industrial research laboratories of the country. There is at present a continuing demand for physicists in the National Defense activities of the government, and many graduates are engaged in such work.

ENGINEERING

UNDERGRADUATE WORK

"The four-year Undergraduate Course in Engineering," as prescribed in the Educational Policies of the Institute, "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." The Course is designed to provide a thorough basis for general engineering practice, for advanced study and research, or for industrial and administrative work.

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

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

GRADUATE STUDY AND RESEARCH IN ENGINEERING

Graduate study and research opportunities in Engineering are available in the fields of aeronautical, civil, mechanical, electrical, and chemical engineering, with courses quite definitely outlined, leading to the degree of Master of Science. These courses normally require one year of work following the Bachelor's degree and are designed to prepare the engineer for professional work of more specialized and advanced nature. A sixth year leads to the professional

degree of Aeronautical Engineer, Chemical Engineer, Civil Engineer, Electrical Engineer, or Mechanical Engineer. A two-year graduate program is offered in Industrial Design, leading to the professional degree of Industrial Designer. In addition, advanced work is offered in Aeronautics, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Chemical Engineering leading to the degree of Doctor of Philosophy. In all phases of the graduate program students are encouraged to include in their courses of study a considerable amount of work outside of their specialized fields, particularly in mathematics and physics.

AERONAUTICS

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

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

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

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

3. 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 largest item of equipment available for experimental research is a wind tunnel of the Göttingen closed circuit type with a working section 10 feet in diameter. Provision is made for using the working section either as an open or closed type. A 750 horsepower, direct-current motor drives a 15-foot propeller, and a wind velocity of considerably more than 200 miles per hour has been produced. A complete set of aerodynamical balances permits the rapid testing of complete airplane models as well as the undertaking of all types of scientific investigations in the wind tunnel. A fluid mechanics laboratory contains several smaller wind tunnels and a considerable amount of auxiliary apparatus especially suitable for the study of the basic problems connected with turbulent flows. A large structures laboratory has been equipped with specially designed testing machines for researches dealing chiefly with the problems connected with the modern use of stressed skin or monocoque structures. A completely equipped photoelasticity laboratory is being used for researches on the distribution of stresses in various complicated types of structure. Shop facilities also are available to students engaged in research problems.

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

As in the older 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 work leading to such graduate study and research. This affords a broad and thorough preparation in the basic science and engineering upon which aeronautics rests.

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

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

CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

(See pp. 94 to 96)

CIVIL ENGINEERING

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

ELECTRICAL ENGINEERING

The Electrical Engineering Department offers instruction leading to the degrees of Bachelor of Science, Master of Science, Electrical Engineer, and Doctor of Philosophy.

The field of electrical engineering affords opportunity for many choices of life work relating to design, research, production, operation and management. Some of these require only the preparation provided in the four-year undergraduate courses, whereas adequate preparation for the more technical work incident to an electrical engineering career requires the completion of the five-year course leading to the degree of Master of Science.

The instruction pattern for electrical engineering is therefore designed on a five-year basis, the fifth year courses being open to qualified students who have completed the four year electrical engineering option for the Bachelor of Science degree from the Institute, or have had substantially the same preparation in other colleges.

Other fields of endeavor call for a knowledge of mathematics, physics, and electrical engineering in excess of that obtainable in the five year curricula. To meet this need the Institute has provided courses of graduate study and research in electrical engineering leading to the degrees of Electrical Engineer and Doctor of Philosophy. These courses provide for advanced work in the application of mathematical analysis and physical laws to mechanical and electrical problems and may be taken by a limited number of exceptional students who have completed the five year electrical engineering

course at the Institute, or by students from other colleges who have substantially the same preparation.

Students desiring to become research men, college teachers, or professional experts in the highly mathematical and scientific phases of electrical engineering may continue their work for the degree of Doctor of Philosophy. Students desiring graduate course preparation for work relating to the application, development and manufacture of electrical equipment may continue their work for the degree of Electrical Engineer.

The distinctive features of undergraduate work and graduate work in electrical engineering at the California Institute of Technology are the creative atmosphere in which the student finds himself and the large amount of physics and mathematics courses included in the engineering curricula. The graduate work in electrical engineering greatly strengthens the undergraduate courses by bringing students who feel the fourth and fifth year courses best adapted to their needs in close touch with research men and problems.

Of the several electrical engineering laboratories at the California Institute, the High-Potential Research Laboratory is the most outstanding. This building and the million-volt transformer were provided by the Southern California Edison Company, Ltd. The million-volt transformer, which was designed by Professor R. W. Sorensen has a normal rating of 1,000 kilovolt amperes but is capable of supplying several times the rated load at the above potential, with one end of the winding grounded. A 2,000,000 volt surge generator supplemented by cathode-ray oscillographs and other apparatus used in the study of electric surges (artificial lightning) and its effect upon electrical apparatus provides ample facility for the study of high voltage transients. This laboratory is used both for the pursuit of special scientific problems connected with the structure of matter and the nature of radiation, and for the conduct of the pressing engineering problems having to do with the improvement in the art of transmission at high potentials. It also provides opportunities for instruction in this field, such as are not at present easily obtainable elsewhere by students of science and engineering.

Equipment and laboratories for research work in electronics, radio, and microwaves are available. Research projects now in progress or planned for the immediate future include basic studies of wave guide phenomena, propagation of microwaves through the various meteorological conditions encountered in Southern California, studies of the behavior of electric and electronic equipment at very high altitudes. Facilities for research in dynamo-electric machinery and in servo mechanisms are also available.

HYDRAULICS

Due to the recent establishment of research laboratories at the Institute covering several of the broader fields of hydraulic engineering, the opportunities for advanced study and research in such fields are exceptionally good. Researches are now being carried on or are just being completed in these laboratories in cooperation with the Metropolitan Water District of Southern California, the Bureau of Reclamation of the United States Department of the Interior, the Los Angeles County Flood Control District, and the Soil Conservation Service of the United States Department of Agriculture.

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

HYDRAULIC MACHINERY RESEARCH LABORATORY. The hydraulic machinery laboratory offers unique opportunities for research on centrifugal pumps and hydraulic turbines and for various other investigations in hydrodynamics. Instrumental equipment designed by the Institute staff provides means for measuring pressures, rates of flow, torques, and speeds with a precision of approximately 0.1 per cent. Included in this is a system of speed regulation for the dynamometer which insures constant speed independent of the load in steps of ½ revolution per minute from 500 r.p.m. to 5,500 r.p.m.

SOIL CONSERVATION LABORATORY. The Soil Conservation Laboratory is a cooperative undertaking with the Soil Conservation Service of the United States Department of Agriculture. Its objective is the study of the mechanism of the entrainment, transportation, and deposition of solid materials by flowing streams. This equipment includes: (a) a transportation flume designed to study primarily the

flow of a fluid carrying a suspended load. It is of the closed circuit type and circulates both the water and the solids in suspension. It is about 70 feet long and has an adjustable gradient. (b) A circulating type of flume for the study of rate of reduction of bed load. (c) A glass-walled flume for special studies. (d) For studies of field problems an outdoor model basin has been erected with provision for either clear or silt-laden flow.

MECHANICAL ENGINEERING

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

Research opportunities as well as course work are available in the several fields as outlined. Among the laboratories in which research facilities are particularly complete are a well equipped Metallography Laboratory including spectrographic equipment, an engines laboratory with facilities for investigation of various problems of the internal combustion engine, the Dynamics Testing Laboratory with facilities for study of the properties of materials under rapid loading.

Also under development are facilities for investigations in applied mechanics, including particularly vibration problems, transient phenomena in mechanical systems, and problems involved in measurements in dynamic systems. Work on certain phases of gas turbine research has also been initiated, and facilities for an experimental study of such problems, and for the development of suitable instrumentation in this field, are being planned.

Excellent opportunities are available for advanced work in machine design, especially in the field of hydraulic machinery. Work in the general fields of experimental stress analysis and mechanical properties of materials can also be undertaken.

Due to the close cooperation maintained between the Mechanical Engineering Department and other departments interested in related subjects, many additional opportunities for research are available to properly qualified mechanical engineering students.

Close connections are maintained between the Mechanical Engineering staff and industrial concerns in this area, and with various governmental research agencies, so that new problems, facilities, and research opportunities are continually becoming available.

INDUSTRIAL DESIGN

THE INDUSTRIAL DESIGN SECTION was introduced at the California Institute of Technology in 1941 to fill a need for specialized training in product design (as adapted to machine- and mass-production) on the basis of sound technological knowledge. This training combines the study of function and appearance of products with that of current engineering practice, utilizing the possibilities of such new, as well as existing, materials and manufacturing methods as best contribute to the solution of present problems, taking into particular consideration post war conditions and developments.

The program includes:

1. Training of technological and aesthetic abilities in class and shop instruction in a two year course leading to a professional degree.
2. Lectures by experts, and discussions on problems related to the course of study.
3. Visits to studios of designers, and to manufacturing plants.
4. Research development in close collaboration with industry.

To be admitted to graduate standing, 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 comparable courses offered by the Institute. He must, moreover, have attained such a scholastic record and, if from another institution, must present such recommendations as to indicate that he is fitted to pursue with success advanced study and research.

Upon successful completion of the two-year graduate course, students are awarded the professional degree of Industrial Designer.

THE HUMANITIES

One of the distinctive features of the California Institute is its emphasis upon the humanistic side of the curriculum. The faculty is in thorough sympathy with this aim and has given full support to it. Every student is required to take, in each of his four undergraduate years, one or more courses of a humanistic character. These courses in the Division of the Humanities include the subjects English and foreign literatures, European and American history, philosophy and social ethics, economics (including industrial relations) and government. All of them are so planned and articulated that the student obtains a solid grounding, and not merely the

superficial acquaintance which is too often the outcome of a free elective system. The standards of intellectual performance in these studies are maintained on the same plane as in the professional subjects.

One of the largest and most attractive buildings on the Institute campus is devoted to the work in literature, languages, philosophy, economics, history and government. This Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. It contains lecture rooms, a room for the exhibition of pictures, and other works of art, a library-reading room, a large seminar room, conference room, and offices, together with a commodious lounge which opens upon a walled garden of olive trees. In connection with the acceptance of this gift, a special endowment fund of $400,000 was raised for the support of instruction in the humanistic fields, this amount being subscribed by several friends of the Institute. In 1937 an additional endowment of $750,000 was received for the same purpose from the late Edward S. Harkness.

The Industrial Relations Section, which was established in 1939, has been supported by special contributions from a substantial number of individuals, companies and labor unions. The Section operates under the general direction of the Committee on the Industrial Relations Section, Professor William B. Munro, Chairman, appointed by the Board of Trustees.

The program of the Industrial Relations Section is four-fold: (1) it provides instruction in industrial relations for seniors and graduate students; (2) it holds periodic conferences and meetings with industrial executives and labor union officials for the discussion of current labor problems; (3) it conducts surveys and research studies on problems of industrial relations; and (4) it maintains a comprehensive reference library on this subject in its quarters in Culbertson Hall on the campus.

In addition to the regular staff of the Institute, scholars from other institutions give instruction or lectures in the Division of the Humanities. It is anticipated that with the opportunities for research in literature, history and economics, 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 the following degrees: Master of Science after a minimum of one year of graduate work; the professional degrees of Aeronautical Engineer, Chemical Engineer, Civil Engineer, Electrical Engineer, Geological Engineer, Geophysical Engineer, Industrial Designer, Mechanical Engineer, and Meteorologist, after a minimum of two years of graduate work; and the degree of Doctor of Philosophy.

2. To be admitted to graduate standing an applicant must in general have received a bachelor's degree representing the completion of an undergraduate course in science or engineering substantially equivalent to one of those courses offered by the Institute. He must, moreover, have attained such a scholastic record and, if from another institution, must present such recommendations as to indicate that he is fitted to pursue with distinction advanced study and research.

3. Application for admission to graduate standing should be made to the Dean of the Graduate School, on a form obtained from his office. If the applicant's preliminary training has not been substantially that given by the four-year undergraduate courses at the Institute, he may be admitted subject to satisfactory completion of such undergraduate subjects as may be assigned. Admission to graduate standing will be granted *only to a limited number of students of superior ability*, and application should be made as early as possible. Admission sometimes may have to be refused solely on the basis of limited facilities in the department concerned. Students applying for assistantships or fellowships need not make separate application for admission to graduate standing. See pages 129, 130.

4. Admission to graduate standing does not of itself admit to candidacy for a degree. Application for admission to candidacy for the degree desired must be made as provided in the regulations governing work for the degree.

5. Foreign students who are admitted to the Graduate School may be required to confine their work during their first term of

residence to undergraduate courses when this is necessary in order to familiarize the student with vernacular English and American teaching methods.

II. GRADUATE RESIDENCE

One term of residence shall consist of one term's work of not less than 45 units of advanced work in which a passing grade is recorded. If less than 45 units are successfully carried, the residence will be regarded as shortened in the same ratio; but the completion of a larger number of units in any one term will not be regarded as increasing the residence.

III. TUITION FEES

The tuition charge for all students registering for graduate work is $500 per academic year, (see page 79 for special fees in Jet Propulsion and meteorology) payable in three installments at the beginning of each term. Graduate students who cannot devote full time to their studies are allowed to register only under special circumstances. Students desiring permission to register for less than 33 units should petition therefor on a blank obtained from the Registrar. If such reduced registration is permitted, the tuition is at the rate of $125 a term for 32 to 25 units, and at the rate of $5 a unit for less than 25 units, with a minimum of $50 a term. If the courses registered for do not correspond to the full educational facilities made available to the student, additional tuition will be charged.

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

There is a fee of $4 per academic year to assist in defraying expenses for emergency hospitalization*. Each graduate student is required to make a general deposit of $25 to cover any loss of or damage to Institute property used in connection with his work in regular courses of study. Upon completion of his graduate work, or upon withdrawal from the Institute, any remaining balance of the deposit will be refunded.

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

*See page 68.

In regard to *fellowships and assistantships*, see pages 129 and 130 of this catalogue. In addition, to students with high scholastic attainments there may be awarded *graduate scholarships* covering one-half or the whole of the tuition fee. For such students *loans* also may be arranged, for which application should be made to the Student-Aid Committee.

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

I. GENERAL REQUIREMENTS

To receive the degree of Master of Science the student must complete in a satisfactory way the work indicated in the schedule of fifth-year courses (see pages 154 to 168) as well as in the schedule of the four-year course in science or in engineering, except that, in the case of students transferring from other institutions, equivalents will be accepted in subjects in which the student shows by examination or otherwise that he is proficient, and except in so far as substitutions may be approved by special vote of the Committee in charge.

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

All programs of study, and applications for admission to candidacy for the degree of Master of Science shall be in charge of the Committee on Courses in Science (in case the advanced work is to be in biology, chemistry, chemical engineering, geology, geophysics, mathematics, meteorology, paleontology, or physics), or of the Committee on Courses in Engineering (in case the work is to be in civil, mechanical or electrical engineering, or aeronautics); and recommendations to the Faculty for the award of the degree shall be made by the appropriate 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 these degrees may

be obtained from the Registrar, and must be submitted not later than the sixth week of the academic 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 85 of the catalogue apply also to students working toward the master's degree.

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 on registration.

4. Students registering for more than 50 units but less than 63 units in any term must have the approval of their department. Registration for more than 62 units must in addition have the approval of the Registration Committee.

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

III. SCHOLASTIC REQUIREMENTS

1. A minimum of 140 units of graduate residence at this Institute is required for the Master's degree. All or any part of this residence may be acquired prior to the completion of the work for the Bachelor's degree provided a total of fifteen terms of acceptable college work is completed. Courses used to fulfill requirements for the Bachelor's degree may not be counted as graduate residence.

2. Scholastic requirements for undergraduate students (see page 85) also apply to students working toward the master's degree.

3. Candidates for the degree of Master of Science who have completed the senior year at the Institute are subject to the same regulations as are juniors and seniors, as listed on page 87.

4. Candidates for the degree of Master of Science who have completed their undergraduate work at other institutions are subject to the same scholastic regulations applying to new transfer students as listed on page 75.

IV. THESIS

In the case of a required thesis two final copies must be filed with the Division concerned ten days before the degree is to be conferred. In the Division of the Geological Sciences and in the Department of Mathematics, a complete first draft of a thesis presented in partial fulfilment of the requirements for the degree of Master of Science must be submitted to the supervising instructor not later than six weeks before the date on which the degree is to be conferred.

C. REGULATIONS CONCERNING WORK FOR THE PROFESSIONAL DEGREE

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

2. *Residence.* At least six terms of graduate residence subsequent to a baccalaureate degree equivalent to that given by the California Institute are required for a professional degree. Of these, at least the last three terms must be at the California Institute. It must be understood that these are minimum requirements, and students must often count on spending a somewhat longer time in graduate work.

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

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

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

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

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

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

5. *Examination.* At the option of the department representing the field in which the degree is desired a final examination may be required. This examination would be conducted by a board to be appointed by the candidate's supervising committee.

Before submitting his thesis, the candidate must obtain written approval of it by the chairman of the division and the members of his supervising committee, on a form obtained from the office of the Dean of the Graduate School.

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

I. GENERAL REGULATIONS

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

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

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

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

With the approval of the Committee on Graduate Study, students are admitted to graduate standing by the department in which they choose their major work toward the doctor's degree. In some cases, applicants for the doctor's degree may be required to register for the master's degree first. The master's degree, however, is not a general prerequisite for the doctor's degree. Students who have received the master's degree and wish to pursue further studies leading towards the doctor's degree must file a new application for admission to graduate standing to work towards that degree.

III. REGISTRATION

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

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

4. The number of units allowed for a course of study or for research is so chosen that one unit corresponds roughly to one hour a week of work throughout the term, for a student of superior ability.

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

6. Graduate students studying for the doctor's degree who are devoting their whole time to their studies will be allowed to register for not more than 60 units in any one term. Students on part time teaching appointments will not be allowed to register for so many units. Teaching Fellows and Assistants will be allowed to register for not more than 45 units.

IV. GRADES IN GRADUATE COURSES

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

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

3. The following system of grades is used to indicate class standing in graduate courses: "A" excellent, "B" good, "C" satisfactory, "D" poor, "E" conditioned, "F" failed. In addition to these grades, which are to be interpreted as having the same significance as for undergraduate courses, the grade "P," which denotes passed, may be used at the discretion of the instructor, in the case of seminar, research, or other work which does not lend itself to more specific grading.

V. GENERAL REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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

The choice and scope of the minor subject must be approved by the departments in charge both of the major and of minor subjects, and must involve not less than 45 units of advanced study in each minor subject. Such advanced study must consist of subjects which are listed as graduate subjects.

2. *Residence:* At least three academic 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. However, no student will be allowed to continue work toward the doctor's degree for more than five years of graduate residence, except by special action of the Committee on Graduate Study.

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

summer research but not for course work, will not be required to pay tuition therefor.

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

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

3. *Admission to Candidacy:* Any student admitted to work for the doctor's degree who has been in residence one term* or more, who has satisfied the several departments concerned by written or oral examination or otherwise that he has a comprehensive grasp of his major and minor subjects as well as of subjects fundamental to them, who has satisfied the department of modern languages that he can read scientific German and French with reasonable facility, who has shown ability in carrying on research and whose research subject has been approved by the Chairman of the Division concerned, and whose program of study has been approved by both his major and minor departments may, on recommendation of the Chairman of the Division in which he is working, be admitted by the Committee on Graduate Study to candidacy for the degree of Doctor of Philosophy. Members of the permanent Institute staff of rank higher than that of Assistant Professor are not admitted to candidacy for a higher degree. For special departmental regulations concerning admission to candidacy, see Section VI.

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

4. *Examinations:* (a) The French and German examinations,

*One year's residence required prior to application for admission to candidacy in the Division of the Geological Sciences. See Section VI D.

prerequisite to admission to candidacy for the degree of Doctor of Philosophy, will be given at three times in the year, these times to be announced by the Registrar's Office. Candidates may in place of the above take the advanced undergraduate examinations offered at the end of each term. Students who have credit for courses in languages taken at the Institute and who have a grade above average may be exempted from further requirements after consultation with the language department.

Graduate students are permitted to audit all courses in the department of languages. In general, however, it is desirable for students without previous study in French and German to take these subjects in class for at least the first semester rather than to depend upon studying them by themselves. Students are advised to take examinations as long as possible before they expect to file application for candidacy, so that, if their preparation is inadequate, they may enroll in one of the language courses.

(b) Final examinations in their major and minor subjects are required of all candidates for the doctor's degree. These examinations, subject to the approval of the Committee on Graduate Study, may be taken at such time after admission to candidacy as the candidate is prepared, except that they must take place at least two weeks before the degree is to be conferred. The examinations may be written or oral, or both, and may be divided into parts or given all at one time at the discretion of the departments concerned. The student must petition for these examinations on a form obtained from the Dean of the Graduate School. For special departmental regulations concerning candidacy and final examinations, see Section VI.

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

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

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

of Philosophy, California Institute of Technology, Pasadena, California, Date *(year only)*.

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

6. *Grades on Degree*: The doctor's degree is awarded with the designations "*summa cum laude*," "*magna cum laude*," "*cum laude*," or without designation, in the Division of Physics, Mathematics, and Electrical Engineering, and in the Division of Civil and Mechanical Engineering and Aeronautics. It is awarded without designation in the Divisions of Biology, Chemistry and Chemical Engineering, and the Geological Sciences.

VI. SPECIAL REQUIREMENTS FOR THE DOCTOR'S DEGREE

In agreement with the general requirements for the doctor's degree adopted by the Committee on Graduate Study, as set forth in Section V (page 117), the various divisions and departments of the Institute have adopted the following supplementary regulations.

A. DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

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

Ph 101 abc	Electricity and Magnetism
Ph 103 abc	Analytical Mechanics
Ph 105	Optics
Ph 107	Spectroscopy
Ph 109 abc	Atomic and Nuclear Physics

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

Ma 101 abc	Modern Algebra
Ma 114 abc	Mathematical Analysis
Ma 256 ab	Modern Differential Geometry
Ma 102 ab	Introduction to Higher Geometry

and one of the following subjects:

Ph 101 ab	Electricity and Magnetism
Ph 103 ab	Analytical Mechanics
Ph 105 together with Ph 107	Optics together with Spectroscopy

and one or more elective courses, preferably Quantum Mechanics.

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

Ph 101 abc	Electricity and Magnetism

and one of the following subjects:

Ph 103 abc	Analytical Mechanics
AM 1 abcd	Applied Mechanics

and one of the following subjects:

Ph 5 abc	Introduction to Mathematical Physics
AM 15 abc	Engineering Mathematics
Ma 8 and	Methods of Advanced Calculus
Ma 10	Differential Equations

and 50 units from the following:

EE 120 ab	Advanced Alternating Current Analysis and Machinery
EE 144	Transmission Lines
EE 152	Dielectrics
EE 156	Electric Communication
EE 160	Electric Transients
EE 190	Ultra High Frequency Techniques
EE 226 abc	Engineering Mathematical Physics

2. An applicant may also satisfy any of the course requirements described above by taking an examination in the subject with the instructor in charge. Every examination of this type will cover the *whole* of the course specified and the student will not be permitted to take it either in parts (e.g. term by term) or more than twice. These so-called candidacy examinations will be given early in the first term of each academic year and the student must apply for permission to take them before the end of the second week of the term. Such application must be in writing and, if approved, will be regarded as one of the two permitted trials, whether or not the student actually takes the examination. (Note: The above regulations are not to be interpreted as preventing the student, with the permission of the instructor in charge, from satisfying the candidacy requirements by taking the examinations in a course without actual class attendance.)

No course which has been taken more than twice will be counted towards the fulfilment of the above candidacy requirements, nor will the student be permitted a total of more than three trials at the removal of any part of the candidacy requirements. A trial consists in registration for the course and class attendance for a sufficient period to appear in the instructor's records regardless of subsequent withdrawal.

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

Students registered for the Ph.D. degree who fail to meet at least two-thirds of the candidacy requirements by the end of their first academic year of graduate study will not be allowed to register for further work without special permission from the department.

3. In general a student will find it necessary to continue his graduate study and research for two years after admission to candidacy, and the final doctoral examination will be based upon this work rather than upon the candidacy courses.

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

5. A candidate for the degree of Doctor of Philosophy with a major in mathematics* must deliver a typewritten or printed copy of his completed thesis, in final form, to the professor in charge on or before May 1 of the year in which the degree is to be conferred.

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

B. DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

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

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

In Chemical Engineering the corresponding requirements consist of the following:

a. Candidacy examination in physical chemistry,
b. Candidacy examination in inorganic chemistry,
c. Candidacy examination in chemical engineering unit operations.
d. Candidacy examination in engineering thermodynamics,
e. Written report on the progress of research.

The examinations are written, except for that in inorganic chemistry, which is usually oral, and that in engineering thermodynamics, which may be partly oral. They cover their respective subjects substantially to the extent that these are treated in the undergraduate chemistry and applied chemistry options and in the

*It is requested that he deposit in the Graduate School Office an additional copy of his thesis in final form, for transmission to the Library of the American Mathematical Society.

fifth-year chemical engineering course; the proficiency expected is not less than that acquired by the abler undergraduates. A detailed informational knowledge is not so much desired as an understanding of general principles and a power to apply these to concrete problems. These examinations are ordinarily given once a year.

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

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

The written report must be a satisfactory description of the applicant's research up to the date of his application. By this report and his laboratory work the applicant must have given evidence of his industry and ability in research, and of his power to present his results in clear, forceful language and with discrimination as to what is essential in scientific papers.

2. It is expected that the applicant shall have studied mathematics and physics substantially to the extent that these subjects are covered in the first two years of the Institute undergraduate courses. In cases where the applicant's training is less extensive than this, the Division of Chemistry and Chemical Engineering may prescribe additional work in these subjects prior to recommending him as a candidate.

3. The 45 units of study offered for satisfaction of a minor requirement are to consist in general of graduate courses other than research; however, the Division of Chemistry and Chemical Engineering may, by special action, permit up to 23 units to consist of appropriate research.

4. After admission to candidacy a student must in general pursue advanced study and research for not less than 4 terms before he will be recommended by the Division of Chemistry and Chemical Engineering for the final examination for the doctor's degree.

5. The candidate must submit to the Division of Chemistry and Chemical Engineering two copies of his thesis, in final form, at least two weeks before the date of his final examination. These copies are returned to the candidate after his examination.

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

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

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

C. DIVISION OF CIVIL AND MECHANICAL ENGINEERING, AND AERONAUTICS

1a. *Civil Engineering.* To be recommended for candidacy for the doctor's degree in civil engineering the applicant must pass with a grade of C or better, the subjects prescribed and elected for the fifth year, or equivalent substitution satisfactory to the department, and such other advanced subjects related to the contemplated direction of study as the department may require, and must pass special comprehensive oral or written examinations in the field covered by these subjects.

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

Ma 10	Differential Equations

and one of the following:

EE 226 abc	Engineering Mathematical Physics
Ma 8 abc	Advanced Calculus
AM 15 abc	Higher Mathematics for Engineers and Physicists

and any one of the following three groups:

ME 101 ab	Advanced Machine Design
ME 105	Mechanical Vibrations
ME 210 abc	Science of Metals
ME 211 abc	Metallography Laboratory
AE 270 a	*Elasticity Applied to Aeronautics*
ME 115 ab	Thermodynamics
Ph 211	Thermodynamics
Hy 101 ab	Advanced Fluid Mechanics
Hy 201	Hydraulic Machinery
AE 266a and 267	Theoretical Aerodynamics

and also special comprehensive oral or written examinations in the fields covered by the required subjects at the discretion of the instructor.

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

AE 257 abc or	Engineering Mathematical Principles
Ma 114 ab	Mathematical Analysis

and

AE 251 abc	Aerodynamics of the Airplane
AE 266 abc	Theoretical Aerodynamics

and one of the following subjects:

AE 252 abc	Airplane Design
Ph 103 abc	Analytical Mechanics
AE 270 abc	Elasticity Applied to Aeronautics

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

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

D. DIVISION OF THE GEOLOGICAL SCIENCES

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

2. A student must have a minimum of three terms' residence at the California Institute before applying for admission to candidacy.

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

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

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

6. The first draft of the complete doctoral thesis containing all pertinent data, maps, and illustrations must be submitted to the Division Secretary not later than February 1. A paper prepared for publication, embodying the results of the research in whole or in part, must be submitted to the Division Secretary not later than March 1. Two copies of the final, revised thesis must be filed with the Division Secretary by May 1 for subsequent circulation among members of the examining committee.

7. Special requirement in Field Geology for graduate students in the Division of the Geological Sciences.

If, in the judgment of the Division, additional technical training in geologic mapping is desirable, a graduate student may be required to take Ge 21 or Ge 121, and/or Ge 123.

Students with adequate technical background in geologic mapping may be required to gain familiarity with California geology by taking Ge 123, or an appropriate problem in areal geologic research.

METEOROLOGY

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

My 201 abc	Weather Forecasting, Practice
My 202 abc	Meteorology Laboratory
My 207 abc	Dynamical Meteorology
AE 266 ab	Theoretical Aerodynamics
Ph 211	Thermodynamics

and one of the following subjects:

Ma 114 ab	Introduction to Mathematical Analysis
Ph 92 abc	Introduction to Mathematical Physics

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

E. DIVISION OF BIOLOGY

1. *Admission.* To be admitted to graduate study in Biology:—a) The applicant should have a satisfactory undergraduate record. b) He should have shown (as judged by the confidential reports of his instructors) a genuine interest in Biology and promise of development into an independent investigator. c) He should have studied the subjects required of undergraduate students majoring in Biology at the California Institute of Technology (see curriculum for Biology Option), or their equivalent. Applicants otherwise acceptable may be admitted with deficiencies in some of these subjects, but will be expected to make up such deficiencies early in the course of their graduate study. Applicants wishing to specialize in fields bordering between Biology and Chemistry (or Physics) may be admitted on the basis of a curriculum equivalent to the Chemistry (or Physics) Option at the California Institute of Technology, in which case they are expected to prepare themselves in the fundamental fields of Biology early in their graduate course; otherwise they should make application for admission to graduate study in the Division of Chemistry (or Physics). The student must consult with his advisory committee at the start of his graduate work in order to determine which of the undergraduate courses he will be required to complete, as well as to obtain approval of his program of advanced study. d) The applicant must be acceptable to the staff member expected to be in charge of his major field of study. This decision will be based on the instructor's opinion that the ensuing relationship will be mutually advantageous to both student and instructor. e) Students may be admitted to Graduate Study (1) leading to the Degree of Doctor of Philosophy, (2) leading to the Degree of Master of Science, or (3) as Special Graduate Students not studying towards a degree. As a rule, only students studying for the Doctor's degree will be admitted in Biology. A course of study leading to the Master's degree is not considered sufficient preparation for the development of original investigators, and hence lies outside the scope of graduate instruction in Biology. In the immediate post-war years, students who have been out of school for a number of years may be admitted as Special Graduate Students until they and the Biology Staff have decided upon a change of status. Such a student, later registering for study towards a degree, receives full credit towards that degree for work done as a Special Student. Special Students must reapply for admission to graduate study at the beginning of each academic year. f) The fields in which a student may pursue major work leading towards the doctor's degree

in Biology consist at present of:—Animal Physiology, Biochemistry, Bio-organic Chemistry, Embryology, Genetics, Invertebrate Zoology and Plant Physiology. g) One or more minors may be selected from the above list with the addition of Immunology, or in other Divisions of the Institute. The choice of the minor(s) must be approved by the student's advisory committee. h) While the Division of Biology has "Departments" of specialization, the student selects one instructor under whose direction he carries on his major study, and not a Department. The choice of the staff member with whom the student works is entirely up to the student, except that the staff member is free to refuse to accept him as a student. During the course of graduate study, a student may change his major or minor fields. The initiative in such changes is left to the student himself, but he must secure the approval of his committee.

2. *Advisory Committees.* At the start of his graduate work each student will have an advisory committee consisting of the instructor who supervises his major work, and the members of the Biology Committee on Graduate Study (at present constituted by Drs. Sturtevant and S. Emerson).

3. *Admission to Candidacy.* To be recommended for admission to Candidacy to the Doctor's Degree by the Division of Biology, the student must satisfactorily pass the approriate Candidacy examinations and have a satisfactory report from the instructors in charge of the major and minor subjects. Recommendations are made by a vote of the Biology Staff in regular meeting. The Candidacy examinations consist of comprehensive written or oral examinations in four of the following fields including (a) or (b), or both, the selection of which must be approved by the advisory committee:— a) General Botany, b) General Zoology, c) Animal Physiology, d) Biochemistry, e) Bio-organic Chemistry, f) Embryology, g) Genetics, h) Immunology, i) Plant Physiology. Each examination will be three hours in length and will usually be given only once a year, usually in the fifth week of the fall term. The student should make application to take the examinations, in whole or in part, at least two weeks before the scheduled date. This application should be made to the Biology Committee on Graduate Study (Dr. S. Emerson, chairman). Those examinations that are in the student's major and minor fields must be passed with a grade of B or better. For the others a grade of C is accepted as passing. The factual information required is more than that required of undergraduate students selecting the Biology Option, but emphasis will be placed especially on the student's ability to make reasonable inferences and deductions from this information, and

to show how it relates to his subjects of specialization. In the field of his major, the student is expected to be informed on current developments and to know the pertinent current literature. The student may satisfy the examinations c to i that he selects by passing (with the grades specified above) final examinations in the respective graduate courses, namely:— for c) Bi 260; d) Bi 210; e) Bi 214; f) Bi 220; g) Bi 225; h) Bi 114 and Ch 258; i) Bi 240. In place of one or two of the above examinations, c to i, students may substitute one-fourth or one-half, respectively, of the candidacy examinations required in the Division of Chemistry, the Division of Physics, or the Division of Geology. A student majoring in another Division and taking a minor in Biology, must pass examinations a or b and that one of c to i that is in the field of his minor. A student who fails any one of these examinations twice will not be allowed to register in the subsequent academic year except with special permission of the Division of Biology. The student must present a written report of his research and an outline of his future plan of work which must be approved by those in charge of his major work before admission to candidacy.

4. *Final Examination and Thesis.* A final oral examination covering principally the work of the thesis will be held at least two weeks before the degree is to be conferred. Two copies of the candidate's thesis must be submitted at least two weeks before the date of the final examination. The Examining Committee will consist of the instructors in charge of the major and minor work and such other individuals as may be designated by the chairman of the division.

E. OPPORTUNITIES FOR GRADUATE AND SCIENTIFIC WORK AT THE INSTITUTE

I. FELLOWSHIPS, SCHOLARSHIPS, AND ASSISTANTSHIPS

The Institute offers in each of its divisions a number of fellowships, scholarships, and graduate assistantships. These usually carry, as stipends, tuition with or without an additional grant.

Opportunitie are provided for appointees to secure board in the Athenaeum (see pages 61 and 133) and lodging in the Athenaeum or the Dormitory. The purpose of this plan is to enable the Fellows, Scholars, and Assistants of the various divisions to live together under attractive and healthful conditions, and thus secure the great educational and social advantages that result from intimate contacts with one another, with members of the professional staff of the Institute, and with others using the Athenaeum.

Students from any university or college who have completed their undergraduate work satisfactorily (see page 110) are eligible to apply for graduate assistantships, scholarships, and fellowships. In the award of such appointments preferred consideration will be given to students who have been accepted as candidates for the degree of Doctor of Philosophy.

Teaching Fellows and Graduate Assistants devote during the school year not more than fifteen hours a week to teaching or laboratory assistance of a character that affords them useful experience. This time includes that required in preparation and in marking note-books and papers, as well as that spent in classroom and laboratory. Of the remaining time at least one-half must be devoted to research, unless otherwise arranged by the division or department concerned; and the obligation to prosecute the research earnestly is regarded as no less binding than that of showing proper interest in the teaching and in the advanced study, which is also pursued so far as time permits.

Forms for making application for fellowships, scholarships, or assistantships may be obtained on request from the Dean of the Graduate School. In using these forms it is not necessary to make separate application for admission to graduate standing. When possible, these applications should reach the Institute by February 15. Appointments to fellowships, scholarships, and assistantships are for one year only; and a new application must be filed each year by all who desire appointments for the following year, whether or not they are already holders of such appointments.

II. RESEARCH FELLOWSHIPS AND SCHOLARSHIPS

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

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

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

3. Drake Fellowships and Scholarships: The income from the Drake Fund, provided by the late Mr. and Mrs. Alexander M. Drake, is used to maintain fellowships and scholarships in such numbers

and amounts as the Board of Trustees determine. The recipients are designated as Drake Fellows and Drake Scholars.

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

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

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

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

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

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

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

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

11. Cole Scholarships: The income from the Cole Trust, established by the will of the late Mary V. Cole in memory of her husband, Francis J. Cole, is used to provide three scholarships annually, one in each of the following fields: electrical engineering, mechanical engineering, and physics. The recipients are designated as Cole Scholars.

Special Fellowship and Research Funds

A considerable group of governmental units, industrial organizations, and private individuals have contributed funds for the support of Fellows engaged in fundamental researches related to their interests and activities. These include Allied Chemical and Dye Corporation, American Cyanimid Company, American Petroleum Institute, American Philosophical Society, Bell Aircraft Company, Boeing Aircraft Company, California Dehydrators Association, Consolidated-Vultee Aircraft Corporation, Curtiss-Wright Corporation, Douglas Aircraft Company, Earhart Foundation, Electrical Development Company, John G. Ellis, Gladding McBean and Company, Hughes Aircraft Company, International Business Machine Corporation, Lockheed Aircraft Corporation, Los Angeles County seismological interests, Charles E. Merrill, National Advisory Committee on Aeronautics, North American Aviation, Inc., Office of Scientific Research and Development, Pineapple Producers Cooperative Association, Rare Metals Institute, Richfield Oil Company, Submarine Signal Company, Texaco Development Corporation, Times-Mirror Company, United States Army, United States Army Air Forces, United States Army Ordnance, United States Engineers, United States Navy, United States Rubber Company, United States Soil Conservation Service, United States Weather Bureau, War Production Board, and Western Growers Association.

The Rockefeller Foundation Fund for Research in Immunology: This fund is contributed by The Rockefeller Foundation for the support of researches in immunology which are being carried out in the Division of Chemistry and Chemical Engineering and in the Division of Biology.

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

III. INSTITUTE GUESTS

Members of the faculties of other educational institutions and Research Fellows already holding the doctor's degree, who desire to carry on special investigations, may be invited to make use of the facilities of the Institute. Arrangement should be made in advance with the chairman of the division of the Institute concerned. Such guests are requested to file a card in the Registrar's office at the beginning of their work, giving Institute and home address, degrees, nature of work planned, etc.

IV. GRADUATE LIFE

The Athenaeum (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.

DESCRIPTION OF THE UNDERGRADUATE AND FIFTH-YEAR COURSES

THE COURSE IN SCIENCE

The course in science prepares for those scientific and engineering professions in which an extensive training in the basic sciences and in research is of more importance than a knowledge of the principles and practice of engineering. Accordingly, the four-year course in science, while including the same historical, literary and economic subjects as the course in engineering, requires much more extended study of the three sciences of chemistry, physics, and mathematics. In its junior and senior years there are offered a series of options which, when supplemented by the corresponding fifth-year courses, afford definite preparation for various scientific professions, as outlined in the following statement.

The option in chemistry and the option in physics and the fifth-year courses in chemistry and physics prepare students, on the chemical and physical sides respectively, for research and teaching in universities, colleges, and high schools, and for research positions in governmental laboratories and especially in the research and development departments of the larger chemical, metallurgical, and electrical companies.

The option in applied chemistry and the fifth-year and sixth-year courses in chemical engineering differ from those in chemistry in that they include, in place of some of the science work, general subjects in mechanical and electrical engineering, and (in the fifth year) an extended treatment of chemical engineering itself. This course is designed to fit men for the installation, operation, and the research development of industrial chemical processes.

The geology, paleontology and geophysics options and the graduate courses in these fields prepare students for teaching and research positions in colleges and universities, for government posts in connection with geological and mining surveys, for places as investigators and field explorers of museums and, above all, for professional work as geologists, paleontologists and geophysicists in the petroleum or mining industries.

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

THE COURSE IN ENGINEERING

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

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

Laboratory facilities are available for experimental work in hydraulics, thermodynamics, metallography, materials of construction, soil mechanics, and electricity, including a high-voltage laboratory with a maximum rating of one million volts.

The fifth-year courses in civil, mechanical, and electrical engineering, and aeronautics consist mainly of the engineering subjects that are fundamental in these separate branches of engineering. Thus the civil engineering course deals largely with the analysis, design and construction of water systems, sanitation works and structures; the mechanical engineering course, with machine design, steam and gas engineering, and power-plant design and operation; the electrical engineering course with the generation, transmission and utilization of electric power and the communication of intelligence by electrical means; and the aeronautics course with the principles of aerodynamics, the design and construction of airplanes, their engines and instruments. Of all these courses, engineering research or design forms an important part.

SCHEDULES OF THE UNDERGRADUATE COURSES

The school year is divided into three terms. The number of units assigned in any term to any subject represents the number of hours spent in class, laboratory, and preparation. In the following schedules, figures in parenthesis denote hours in class (first figure), hours in laboratory (second figure), and hours of outside preparation (third figure).

Besides the subjects shown in the course schedules, students are required to take assembly and physical education* in each term of each of the four school years. Students who continue their undergraduate work beyond four years continue to take physical education throughout their undergraduate course. Freshmen attend six orientation assemblies in addition to the general assemblies.

KEY TO ABBREVIATIONS

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

*War veterans, and men whose twenty-fourth birthday has occurred by the opening of the term, may be excused from the required work by action of the Physical Education Committee.

FIRST YEAR, ALL OPTIONS

The subjects listed below are taken by all students during their first year. Differentiation into the various options begins in the second year.

		Units per Term 1st	2nd	3rd
Ma 1abc	Plane Analytic Geometry, Differential and some Principles of Integral Calculus (4-0-8)	12	12	12
Ph 1abc	Mechanics, Molecular Physics, Heat, Sound (3-3-6)	12	12	12
Ch 1abc	Inorganic Chemistry, Qualitative Analysis (3-6-3)	12	12	12
En 1abc	English Composition and Reading (3-0-3)	6	6	6
H 1abc	History of European Civilization (3-0-2)	5	5	5
D 1abc	Freehand and Engineering Drafting (0-3-0)	3	3	3
		50	50	50

BIOLOGY OPTION

(For First Year see above)

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

	SECOND YEAR*	Units per Term 1st	2nd	3rd
Ma 2abc	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)†	12	12	12
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
H 2abc	American History (2-0-4)	6	6	6
Ch 12ab	Analytical Chemistry (2-6-2)	10	10	...
Ge 1a	Physical Geology (4-3-2)	9	...	...
Bi 1	Elementary Biology (3-3-3)	...	9	...
Bi 2	Genetics (2-4-3)	...	...	9
Bi 17	Vertebrate Anatomy (2-4-4)	...	...	10
		49	49	49

*Students taking the Biology option are required to take Bi 4, Invertebrate Zoology, at the Marine Laboratory for four weeks starting one week after the end of their Sophomore year. This course is taken without payment of additional tuition, and living quarters are provided at the Laboratory.

†Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2 d), physics (Ph 2 d) are given at the end of the third term of the second year.

BIOLOGY OPTION

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7abc	Introduction to Literature (3-0-5)	8	8	8
L 32abc	Elementary German (4-0-6)	10	10	10
Ch 41abc	Organic Chemistry (3-0-5)	8	8	8
Ch 47	Organic Chemistry Laboratory (0-6-0)	—	—	6
	Schedule A (1946-47, and alternate years thereafter)			
Ch 21abc	Chemical Principles (4-0-6)	10	10	10
Bi 3	General Botany (3-8-2)	13	—	—
Bi 5ab	Plant Physiology (3-6-3; 2-4-2)	—	12	8
		49	48	50
	Schedule B (1947-48, and alternate years thereafter)			
Bi 12	Histology and Microscopic Technique (1-6-2)	9	—	—
Bi 13	Mammalian Anatomy (0-3-1)	4	—	—
Bi 14	Immunology (2-4-4)	—	—	10
Bi 16ab	Animal Physiology (3-3-4)	10	10	—
Bi 6	Embryology (2-6-4)	—	12	—
Bi 8	Advanced Genetics (2-3-3)	—	—	8
		49	48	50

FOURTH YEAR

	Humanities Electives (3-0-6)**	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
L 35a	Scientific German (4-0-6)	10	—	—
Bi 7ab	Biochemistry (2-4-4)	—	10	10
Ec 3ab	Current Economic Problems (3-0-3)	6	6	—
	Elective	—	—	9
	Schedule A (1946-47 and alternate years thereafter)	23	22	18
		50	49	48
	Schedule B (1947-48 and alternate years thereafter)	23	22	18
		50	49	48

**Fourth year Humanities Electives (the courses to be offered in any one term will be announced before the close of the previous term):

Pl 1	Philosophy
Pl 4	Ethics
Pl 5	Sociology
Pl 6	Psychology
En 8	Contemporary English and European Literature
En 9	American Literature
En 10	Modern Drama
En 11	Literature of the Bible
En 17	Technical Report Writing
L 40	German Literature
Ec 48	Introduction to Industrial Relations
H 4	The British Empire
H 7	Modern and Contemporary Germany
H 8	The History of Russia
H 12	The History of Europe since 1789
H 13	Military and Naval History
H 14	Anglo-American Relations since 1783
H 15	The World since 1914

CHEMISTRY OR APPLIED CHEMISTRY OPTIONS

(For First Year see page 138)

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

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2abc	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)*	12	12	12
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
Ch 12abc	Analytical Chemistry (2-6-2)	10	10	10
H 2abc	American History (2-0-4)	6	6	6
Ge 1a	Physical Geology (4-3-2)	9	—	—
Bi 1	Elementary Biology (3-3-3)	—	9	—
Bi 2	Genetics (2-4-3)	—	—	9
	or			
Ay 1	Introduction to Astronomy (3-1-5)	—	—	9
		49	49	49
	THIRD YEAR			
En 7abc	Introduction to Literature (3-0-5)	8	8	8
Ec 3ab	Current Economic Problems (3-0-3)	6	6	—
Ch 21abc	Chemical Principles (4-0-6)	10	10	10
Ch 41abc	Organic Chemistry (3-0-5)	8	8	8
Ch 46abc	Organic Chemistry Lab. (0-6-0; 1-9-0)	6	6	10
L 32abc	Elementary German (4-0-6)	10	10	10
		48	48	46

CHEMISTRY OPTION

	FOURTH YEAR	Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6)†	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
Ch 13ab	Inorganic Chemistry (2-0-4)	6	6	—
Ch 22	Thermodynamic Chemistry (2-0-4)	—	6	—
Ch 29	Colloid and Surface Chemistry (3-0-5)	—	—	8
Ch 16	Instrumental Analysis (0-6-2)	8	—	—
Ch 26ab	Physical Chemistry Laboratory (0-6-2)	—	8	8
L 35a	Scientific German (4-0-6)	10	—	—
	Elective Subjects‡	13	17	21
		48	48	48

*Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2d), physics (Ph 2d) are given at the end of the third term of the second year.

†For the list of Humanities electives, see footnote, page 139.

‡Professional elective subjects include the following: Chemical Research, Inorganic Chemistry Ch 13c, Nuclear Chemistry Ch 27ab, Nuclear Chemistry Laboratory Ch 28, Photochemistry Ch 30, Qualitative Organic Chemical Analysis Ch 48, Quantitative Organic Chemical Analysis Ch 49, Organic Preparation Ch 50, Introduction to Mathematical Physics Ph 5abc, Biochemistry Bi 7ab.

APPLIED CHEMISTRY OPTION

FOURTH YEAR

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6)*	9	9	9
H 5ab	Current History (1-0-1)	2	2	--
H 10	U. S. Constitution (1-0-1)	--	--	2
Ch 16	Instrumental Analysis (0-6-2)	8	--	--
Ch 26ab	Physical Chemistry Lab. (0-6-2; 0-3-1)	--	8	4
Ch 29	Colloid and Surface Chemistry (3-0-5)	--	--	8
Ch 61ab	Industrial Chemistry (4-0-8; 2-0-4)	12	6	--
Ch 63ab	Chemical Engineering Thermodynamics (2-0-4; 4-0-8)	--	6	12
AM 2abc	Applied Mechanics (3-0-5)	8	8	8
EE 1abc	Basic Electrical Engineering (2-0-4)	6	6	6
EE 2ab	Basic Electrical Engineering Laboratory (0-3-0)	3	3	--
		48	48	49

*For the list of Humanities electives, see footnote, page 139.

CIVIL ENGINEERING OPTION

(For First Year see page 138)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 88.

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2abc	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)†	12	12	12
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
H 2abc	American History (2-0-4)	6	6	6
CE 1	Surveying (2-4-3)	9 or	9	----
ME 3	Materials and Processes (3-3-3)	9 or	9	----
Ge 1a	Physical Geology (4-3-2)	9	----	----
AM 1a	Applied Mechanics (Statics) (3-3-6)	----	----	12
D 2	Descriptive Geometry (0-6-0)	----	6	----
ME 1ab	Empirical Design (0-3-0; 0-6-0)	----	3	6
		48	48	48
	THIRD YEAR			
En 7abc	Introduction to Literature (3-0-5)	8	8	8
AM 1bcd	Applied Mechanics (Dynamics, Strength of Materials) (3-3-6)	12	12	12
CE 2	Advanced Surveying (2-7-3)	12	----	----
EE 1abc	Basic Electrical Engineering (2-0-4)	6	6	6
EE 2ab	Basic Electrical Engineering Laboratory (0-3-0)	3	3	----
Ec 2	General Economics and Economic Problems (4-0-6)	----	10	----
Hy 2ab	Hydraulics (3-0-6)		9	9
CE 7	Curves and Earthwork (2-0-5)	7	----	----
Ge 110	Engineering Geology (2-2-5)	----	----	9
CE 14a	Engineering Conference (0-4-0)	----	----	4
		48	48	48

†Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2d), physics (Ph 2d) are given at the end of the third term of the second year.

CIVIL ENGINEERING OPTION

FOURTH YEAR

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6)*	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
Ec 18	*Industrial Organization (3-0-6)*	—	9	—
CE 4	Highway & Airport Engineering (2-4-4)	—	—	10
CE 6	Transportation Engineering (2-0-4)	6	—	—
CE 8	Route Surveying (0-7-0)	7	—	—
CE 10abc	Theory of Structures (3-3-6; 3-0-6)	12	12	9
CE 12	Reinforced Concrete (3-3-6)	—	—	12
AM 3	Testing Materials Laboratory (1-6-1)	—	8	—
Ec 25	Business Law (3-0-3)	—	—	6
Hy 11	Hydraulic Laboratory (0-6-0)	—	6	—
ME 20	Heat Engineering (2-3-4)	9	—	—
CE 14bc	Engineering Conference (1-0-2; 1-0-1)	3	2	—
		48	48	48

*For the list of Humanities electives, see page 139.

ELECTRICAL ENGINEERING OPTION

(For First Year see page 138)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 88.

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2abc	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)†	12	12	12
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
H 2abc	American History (2-0-4)	6	6	6
CE 1	Surveying (2-4-3)	9 or	9	—
ME 3	Materials and Processes (3-3-3)	9 or	9	—
Ge 1a	Physical Geology (4-3-2)	9	—	—
AM 1a	Applied Mechanics (Statics) (3-3-6)	—	—	12
D 2	Descriptive Geometry (0-6-0)	—	6	—
ME 1ab	Empirical Design (0-3-0; 0-6-0)	—	3	6
		48	48	48
	THIRD YEAR			
En 7abc	Introduction to Literature (3-0-5)	8	8	8
AM 1bcd	Applied Mechanics (Dynamics, Strength of Materials) (3-3-6)	12	12	12
EE 1abc	Basic Electrical Engineering (2-0-4)	6	6	6
EE 2abc	Basic Electrical Engineering Laboratory (0-3-0)	3	3	3
AM 15abc	Engineering Mathematics (3-0-6)‡	9	9	9
ME 15abc	Thermodynamics and Fluid Mechanics (3-3-5)	11	11	11
		49	49	49

†Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2d), and physics (Ph 2d) are given at the end of the third term of the second year.

‡Electrical and mechanical engineering students with scholastic records that warrant the excess load may take Ph 5abc, Introduction to Mathematical Physics (4-0-8) as an alternate for Engineering Mathematics.

FOURTH YEAR

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6)*	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
Ec 2	General Economics and Economic Problems (4-0-6)	10	—	—
Ec 18	Industrial Organization (3-0-6)	—	9	—
Ec 25	Business Law (3-0-3)	—	—	6
EE 6ab	Electrical Machinery (2-0-4; 3-0-6)	—	6	9
EE 7	Electrical Engineering Laboratory (0-6-1)	—	—	7
EE 12	Electric Circuits (4-0-8)	12	—	—
Ph 7abc	Electricity and Magnetism (2-0-4)†	6	6	6
Ph 9	Electrical Measurements (0-6-0)	—	6	—
EE 70ab	Engineering Conference (1-0-1)	2	2	—
AM 3	Materials Testing Laboratory (1-6-1)	8	—	—
EE 62ab	Electron Tubes (2-3-5)	—	10	10
		49	50	49

*For the list of *Humanities electives*, see page 139.

†Electrical engineering students who have completed Ph 5abc will, as an alternate for Ph 7abc, take the following:

Ph 8	Electricity and Magnetism (3-0-6)	9	—	—
EE 15ab	High Frequency Circuits (2-0-4; 0-3-3)	—	6	6
		52	50	49

GEOLOGICAL SCIENCES OPTION

(For First Year see page 138)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in freshman and sophomore physics and chemistry may, at the discretion of the Division of the Geological Sciences, be refused permission to register for the third-year course in the Geological Sciences Option. Students whose grade-point average is less than 1.9 in the required geology subjects of the third year will be admitted to the required geology subjects of the fourth year only with the special permission of the Division of the Geological Sciences.

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2ab	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)‡	12	12	----
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
Ch 11	Qualitative Chemical Analysis (2-6-2)	----	----	10
H 2abc	American History (2-0-4)	6	6	6
CE 1	Surveying (2-4-3)	9	----	----
Ge 1a	Physical Geology (4-3-2)	9	----	----
Bi 1	Elementary Biology (3-3-3)	----	9	----
Ge 3ab	Mineralogy (3-3-2; 3-6-1)	----	8	10
	Options A and B§			
Ge 1b	Paleontology (4-1-4)	----	----	9
		48	47	47
	Option C			
Ma 2c	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)	----	----	12
		48	47	50

‡Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2d), and physics (Ph 2d) are given at the end of the third term of the second year.

§Students taking Option B are required to take Invertebrate Zoology, Bi 4, at the Marine Laboratory for four weeks starting one week after the end of the third term of their sophomore year. This course is taken without payment of additional tuition, and living quarters are provided at the Laboratory.

All majors in the Division of the Geological Sciences may attend the Summer Field Camp, Ge 123, without registration for credit.

GEOLOGICAL SCIENCES OPTION

THIRD YEAR*

		Units per Term 1st	2nd	3rd
En 7abc	Introduction to Literature (3-0-5)	8	8	8
CE 3	Plane Table Surveying (1-6-1)	8	—	—
Ge 4ab	Petrology (2-3-1; 2-4-2)	6	8	—
Ge 1c	Historical Geology (4-2-6)	—	12	—
Ge 107	Stratigraphy (4-2-6)	—	—	12
Ge 21abc	Field Geology (1-8-1)	10	10	10
Ge 175	Introduction to Applied Geophysics (2-0-3)	5	—	—
Ge 176	Elementary Seismology (3-0-3)	—	—	6
Ge 102	Oral Presentation (1-0-0)	—	—	1
	Option A			
Ch 24ab	Physical Chemistry (4-0-6)	10	10	—
Ge 14	Geologic Illustration (0-5-0)	—	—	5
D 5	Descriptive Geometry (0-6-0)	—	—	6
		47	48	48
	Option B			
Ge 111ab	Invertebrate Paleontology (2-6-2)	10	10	—
Ge 14	Geologic Illustration (0-5-0)	—	—	5
D 5	Descriptive Geometry (0-6-0)	—	—	6
		47	48	48
	Option C			
EE 1abc	Basic Electrical Engineering (2-0-4)	6	6	6
EE 2abc	Basic Electrical Engineering Laboratory (0-3-0)	3	3	3
		46	47	46

*Spring Field Trip, Ge 122, required in third and fourth years. Summer Field Geology, Ge 123, 12 units, required after third and fourth years.

GEOLOGICAL SCIENCES OPTION

FOURTH YEAR*

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6)†	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
Ec 2	General Economics and Economic Problems (4-0-6)	—	—	10
Ge 109	Structural Geology (4-0-6)	10	—	—
	Option A			
Ge 126	Geomorphology (4-0-6)	10	—	—
Ge 128	Introduction to Economic Geology (4-0-3)	—	7	—‡
Ge 125	Geology of Western America (4-0-3)	—	—	7
	or			
L 32abc	Elementary German (4-0-6)	10	10	10
Ge 105	Optical Mineralogy (2-5-1)	8	—	—
Ge 106ab	Petrography (2-6-2)	—	10	10
Ge 111ab	Invertebrate Paleontology (2-6-2)	10	10	—
Ge 121ab	Field Geology (0-10-0)	—	10	10
		49	48	48
			or	or
			51	51
	Option B			
Bi 6	Embryology (2-6-4)	—	12	—
Bi 17	Vertebrate Anatomy (2-4-4)	—	—	10
Ge 115	Micropaleontology (1-3-4)	8	—	—
Ge 121ab	Field Geology (0-10-0)	10	10	—
Ge 112ab	Vertebrate Paleontology (2-6-2)	—	10	10
		49	50	48
			or	or
			53	51
	Option C			
Ph 6abc	Introduction to Mathematical Physics and Differential Equations (5-0-10)	15	15	15
L 32abc	Elementary German (4-0-6)	10	10	10
Ge 128	Introduction to Economic Geology (4-0-3)	—	7	—
Ge 165	Introduction to General Geophysics (2-0-4)	—	6	—
		46	49	46

*Spring Field Trip, Ge 122, required in third and fourth years. Summer Field Geology, Ge 123, 12 units, required after third and fourth years.

†For the list of Humanities electives, see footnote page 139.

‡This alternative also in Option B.

MATHEMATICS OPTION

(For First Year see page 138)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue with the work of that option. A fuller statement of this regulation will be found on page 88.

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2abc	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)*	12	12	12
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
H 2abc	American History (2-0-4)	6	6	6
Ge 1a	Physical Geology (4-3-2)	9	—	—
Bi 1	Elementary Biology (3-3-3)	—	9	—
Ay 1	Introduction to Astronomy (3-1-5)	—	—	9
Ma 3	Theory of Equations (4-0-6)	10	—	—
Ma 16	Matrices and Quadratic Forms (4-0-6)	—	—	10
	Schedule A (1946-47, and alternate years thereafter)			
Ma 10	Differential Equations (4-0-6)	—	10	—
	Schedule B (1947-48, and alternate years thereafter)			
Ma 4	Geometry, 4-0-6)	—	10	—
		49	49	49
	THIRD YEAR			
En 7abc	Introduction to Literature (3-0-5)	8	8	8
Ec 3ab	Current Economic Problems (3-0-3)	6	6	—
Ph 6abc	Introduction to Mathematical Physics and Differential Equations (5-0-10)	15	15	15
L 32abc	Elementary German (4-0-6)	10	10	10
Ma 8	Methods of Advanced Calculus (4-0-6)	10	—	—
Ma 57	Introduction to Analysis (5-0-10)	—	—	15
	Schedule A (1946-47, and alternate years thereafter)			
Ma 4	Geometry (4-0-6)	—	10	—
	Schedule B (1947-48, and alternate years thereafter)			
Ma 10	Differential Equations (4-0-6)	—	10	—
		49	49	48

*Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2d), and physics (Ph 2d) are given at the end of the third term of the second year.

MATHEMATICS OPTION

FOURTH YEAR

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6)†	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
L 35a	Scientific German (4-0-6)	10	—	—
L 1ab	Elementary French (4-0-6)	—	10	10
	Schedule A (1946-47, and alternate years thereafter)			
Ma 12	Elementary Statistics (3-0-6)	9	—	—
Ma 111	Elementary Theory of Tensors (3-0-6)	—	9	—
	Approved Mathematics Electives	18	18	27
	Schedule B (1947-48, and alternate years thereafter)			
Ph 113	Principles of Quantum Mechanics (3-0-6)	9	—	—
	Approved Mathematics Electives	18	27	27
		48	48	48

†For the list of Humanities electives, see footnote page 139.

MECHANICAL ENGINEERING OPTION

(For First Year see page 138)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 88.

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2abc	*Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus* (4-0-8)*	12	12	12
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
H 2abc	American History (2-0-4)	6	6	6
CE 1	Surveying (2-4-3)	9 or	9	—
Me 3	*Materials and Processes* (3-3-3)	9 or	9	—
Ge 1a	Physical Geology (4-3-2)	9	—	—
AM 1a	Applied Mechanics (Statics) (3-3-6)	—	—	12
D 2	Descriptive Geometry (0-6-0)	—	6	—
ME 1ab	Empirical Design (0-3-0; 0-6-0)	—	3	6
		48	48	48
	THIRD YEAR			
En 7abc	Introduction to Literature (3-0-5)	8	8	8
AM 1bcd	Applied Mechanics (Dynamics, Strength of Materials) (3-3-6)	12	12	12
EE 1abc	Basic Electrical Engineering (2-0-4)	6	6	6
EE 2abc	Basic Electrical Engineering Laboratory (0-3-0)	3	3	3
AM 15abc	Engineering Mathematics (3-0-6)†	9	9	9
ME 15abc	Thermodynamics and Fluid Mechanics (3-3-5)	11	11	11
		49	49	49
	FOURTH YEAR			
	Humanities Electives (3-0-6)‡	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
Ec 2	General Economics and Economic Problems (4-0-6)	10	—	—
Ec 18	Industrial Organization (3-0-6)	—	9	—
Ec 25	Business Law (3-0-3)	—	—	6
ME 5abc	*Machine Design* (2-3-4)	9	9	9
ME 10	Metallurgy (3-3-6)	—	—	12
AM 3	Testing Materials Laboratory (1-6-1)	—	8	—
ME 16ab	Thermodynamics (3-0-6; 2-0-4)	9	6	—
ME 25	Mechanical Laboratory (0-6-3)	—	—	9
Hy 1	*Hydraulics* (3-0-6)	9	—	—
Hy 11	Hydraulic Laboratory (0-6-0)	—	6	—
ME 50ab	Engineering Conference (1-0-1)	2	—	2
		50	49	49

*Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2d), and physics (Ph 2d) are given at the end of the third term of the second year.

†Electrical and mechanical engineering students with scholastic records that warrant the excess load may take Ph 5abc, Introduction to Mathematical Physics (4-0-8) as an alternate for Engineering Mathematics.

‡For the list of Humanities electives, see footnote, page 139.

PHYSICS OR APPLIED PHYSICS OPTION

(For First Year see page 138)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 88.

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2abc	Solid Analytic Geometry, Vector Analysis, Differential and Integral Calculus (4-0-8)*	12	12	12
Ph 2abc	Electricity, Light, Electron Physics (3-3-6)	12	12	12
H 2abc	American History (2-0-4)	6	6	6
Ge 1a	Physical Geology (4-3-2)	9	—	—
Bi 1	Elementary Biology (3-3-3)	—	9	—
Ay 1	Introduction to Astronomy (3-1-5)	—	—	9
Ma 3	Theory of Equations (4-0-6)	10	—	—
Ch 43	Organic Chemistry (2-6-2)	—	10	—
Ch 11	Qualitative Chemical Analysis (2-6-2)	—	—	10
		49	49	49
	THIRD YEAR			
En 7abc	Introduction to Literature (3-0-5)	8	8	8
Ch 21abc	Chemical Principles (4-0-6)	10	10	10
Ph 6abc	Introduction to Mathematical Physics and Differential Equations (5-0-10)	15	15	15
EE 1abc	Basic Electrical Engineering (2-0-4)	6	6	6
EE 2abc	Basic Electrical Engineering Laboratory (0-3-0)	3	3	3
Ec 3ab	Current Economic Problems (3-0-3)	6	6	—
Ec 25	Business Law (3-0-3)	—	—	6
		48	48	48

PHYSICS OPTION

FOURTH YEAR

	Humanities Electives (3-0-6)†	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
L 32abc	Elementary German (4-0-6)‡	10	10	10
Ph 9	Electrical Measurements (0-6-0)	6	—	—
Ph 10	High Frequency Measurements (0-6-2)	—	8	—
Ph 101abc	Electricity and Magnetism (3-0-6; 4-0-8)	9	9	12
EE 12	Electric Circuits (4-0-8)	12	—	—
EE 62a	Electron Tubes (2-3-5)	—	10	—
Ma 57	Introduction to Analysis (5-0-10)‡	—	—	15
		48	48	48

*Comprehensive examinations covering the work of the first two years in English, history, mathematics (Ma 2d), and Physics (Ph 2d) are given at the end of the third term of the second year.

†For the list of Humanities electives, see footnote page 139.

‡Students who plan no Ph.D. work may substitute Ph 109abc Atomic and Nuclear Physics or Ph 103abc Analytical Mechanics for L 32abc; and EE 62b Electronics and EE 200 Electronics Research for Ma 57.

APPLIED PHYSICS OPTION

FOURTH YEAR

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6)†	9	9	9
H 5ab	Current History (1-0-1)	2	2	—
H 10	U. S. Constitution (1-0-1)	—	—	2
Ph 8	Electricity and Magnetism (3-0-6)	9	—	—
Ph 9	*Electrical Measurements (0-6-0)*	—	*6*	—
Ph 109abc	Atomic and Nuclear Physics (3-0-6)	9	9	9
AM 2abc	Applied Mechanics (3-0-5)	8	8	8
EE 12	Electric Circuits (4-0-8)	12	—	—
EE 15ab	High Frequency Circuits (2-0-4; 0-3-3)	—	6	6
EE 62ab	Electron Tubes (2-3-5)	—	10	10
EE 200	Advanced Work in Electrical Engineering (0-6-0)	—	—	6
		49	50	50

†*For the list of Humanities electives, see footnote page 139.*

SCHEDULES OF FIFTH- AND SIXTH-YEAR COURSES

AERONAUTICS

FIFTH YEAR

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

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6; 4-0-6)*	9 or 10	9 or 10	9 or 10
AE 251 abc	Aerodynamics (3-0-6)	9	9	9
AE 252 abc	Airplane Design (2-1-6)	9	9	9
AE 253 abc	Design of Aircraft Components (2-0-2)	4	4	4
AE 257 abc	Engineering Mathematical Principles (3-0-6)**	9	9	9
AE 258 abc	Introductory Mechanics and Thermodynamics of Fluids (3-0-6)	9	9	9
AE 290 abc	Seminar (1-0-0)	1	1	1
		50 or 51	50 or 51	50 or 51

*Graduate humanities electives to the extent of 9 or 10 units per term for a total of 27 or 30 units are required of all candidates for the Master's Degree in any option.

Humanities Electives: (The subjects to be offered in any one term will be announced before the close of the previous term.)

H 100	Seminar in International Problems
En 100	English Literature
Pl 100	Philosophy
Ec 100	Business Economics
Ec 110	Introduction to Industrial Relations

**AE 257 will be taken by all students who have previously had Advanced Calculus and Differential Equations. All students having only two years of mathematics preparation will take AM 15 in the 5th year, and those who continue with more advanced work must take AE 257 in the 6th year. This will delay the 6th year degree unless the research units are taken in the summer.

SIXTH YEAR

(Leading to the professional degree of Aeronautical Engineer)

		Units per Term 1st	2nd	3rd
AE 260 abc	Aeronautics Research	15	15	15
AE 266 abc	*Theoretical Aerodynamics (3-0-6)*	9	9	9
AE 270 abc	Elasticity Applied to Aeronautics (2-0-4)	6	6	6
AE 272 abc	Precision Measurements (1-0-2)	3	3	3
AE 290 abc	Aeronautics Seminar (1-0-0)	1	1	1
	Electives as below	16	16	16
		50	50	50
Structures Option				
AE 254 abc	Advanced Problems in Airplane Design (2-0-2)	4	4	4
AE 271 abc	Vibration and Flutter Problems (2-0-4)	6	6	6
AE 273 abc	Photoelasticity and Structural Testing Methods (2-0-4)	6	6	6
		16	16	16
Aerodynamics and Compressibility Option				
AE 261 abc	Hydrodynamics of Compressible Fluids (3-1-6)	10	10	10
AE 265 abc	Advanced Problems in Aerodynamics (2-0-4)	6	6	6
		16	16	16
*Jet Propulsion Option**				
	(Leading to the degree of Aeronautical Engineer—Jet Propulsion)			
AE 260 abc	Aeronautics Research	15	15	15
AE 265 abc	Advanced Problems in Aerodynamics (2-0-4)	6	6	6
AE 270 abc	Elasticity Applied to Aeronautics (2-0-4)	6	6	6
AE 280 abc	Materials and Chemistry Problems in Jet Propulsion (3-0-6)	9	9	9
AE 281 abc	Jet Propulsion Systems (3-0-6)	9	9	9
AE 282 abc	Jet Propulsion Laboratory (0-3-0)	3	3	3
AE 290 abc	Aeronautics Seminar (1-0-0)	1	1	1
		49	49	49

*Because of military demands, very few civilians can be admitted to the jet propulsion option for at least the next two years. See page 79 for extra fee.

BIOLOGY

As nearly all Biology majors are working for the Doctor's degree and following programs arranged by the student in consultation with members of the Division, no specific graduate curricula can be outlined. The Professional degree is not given in Biology.

CHEMISTRY

The needs of Chemistry majors vary so widely in the specialized fields of this subject that no specific graduate curricula can be outlined. Programs are selected from a comprehensive list of available subjects and are arranged by the student in consultation with members of the Division. Ordinarily about half of the student's time will be spent on research. The Humanities requirement for Master's candidates will be found on page 154. The Professional degree is not given in Chemistry.

CHEMICAL ENGINEERING

FIFTH YEAR

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

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6; 4-0-6)*	9 or 10	9 or 10	9 or 10
Ch 166 abc	Chemical Engineering (3-0-9)	12	12	12
Ch 167 abc	Chemical Engineering Laboratory (0-15-0)	15	15	15
	Electives—at least	14	14	14
		50 or 51	50 or 51	50 or 51

Elective subjects approved by a member of the Division to be chosen from advanced subjects in Chemistry, Chemical Engineering, Physics, Mathematics and Mechanical Engineering, or from the following subjects: Ma 10 Differential Equations, AM 15 Engineering Mathematics, ME 5 Machine Design, ME 10 Metallurgy.

SIXTH YEAR

(Leading to the professional degree of Chemical Engineer)

Programs are selected from a comprehensive list of available subjects and are arranged by the student in consultation with members of the Division. At least half of the student's time will be spent on research.

*For the list of Humanities Electives, see footnote, page 154.

CIVIL ENGINEERING

FIFTH YEAR

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

		Units per Term 1st	2nd	3rd
Ec 100 abc	Business Economics (4-0-6)	10	10	10
CE 120 a	Statically Indeterminate Structures (4-3-5)	12	—	—
CE 121 abc	Structural and Civil Engineering Design (0-12-0; 0-9-0)	12	9	9
CE 125	Irrigation and Water Supply (4-0-8)	—	—	12
CE 126	Masonry Structures (2-3-4)	—	9	—
CE 127	Sewerage and Sewage Treatment (2-3-4)	—	—	9
AM 15 abc	Engineering Mathematics (3-0-6)	9	9	9
AM 105 ab	Soil Mechanics (2-0-4; 1-3-2)	6	6	—
CE 130 abc	Engineering Seminar (1-0-1)	2	2	2
	Research or Thesis as arranged	—	5	—
		51	50	51

SUPPLEMENTARY SUBJECTS*

CE 120 bc	Statically Indeterminate Structures (2-0-4)	—	6	6
CE 122	*Earthquake Effects upon Structures*	—	—	—
CE 131	Sewage Treatment Plant Design	—	—	—
CE 132	Water Power Plant Design	—	—	—
CE 133	Water Treatment Plant Design	—	—	—
CE 134	Ground Water Investigations	—	—	—
CE 135	Geodesy and Precise Surveying	—	—	—
CE 136	Irrigation Investigations	—	—	—
CE 141	Structural Engineering Research	—	—	—
CE 142	Sanitation Research	—	—	—
CE 143	Highway Research	—	—	—
CE 144	Airport Design	—	—	—
CE 150	Foundations (2-3-4)	—	—	9
Ge 110	Engineering Geology (2-2-5)	—	—	9
AM 110 a	*Introduction to the Theory of Elasticity (2-0-4)*	6	—	—
AM 110 b	Theory of Plates and Shells (2-0-4)	—	6	—
AM 110 c	Mechanics of Materials (2-0-4)	—	—	6
AE 270 abc	Elasticity Applied to Aeronautics (2-0-4)	6	6	6
Hy 100	Hydraulics Problems	—	—	—
Hy 101 ab	Advanced Fluid Mechanics (2-0-4; 3-0-6)	—	6	9
My 105	Climatology (2-0-4)	—	—	6
My 201 abc	Weather Forecasting and Practice (3-0-6; 2-0-4)	9	9	6

SIXTH YEAR

(Leading to the professional degree of Civil Engineer)

Programs are arranged by the student in consultation with members of the Department.

*Where no hours are shown, units are to be arranged based upon work done.

ELECTRICAL ENGINEERING

FIFTH YEAR

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

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6; 4-0-6)*	9 or 10	9 or 10	9 or 10
EE 120 ab	Advanced Alternating Current Analysis and Machinery (4-0-8)	12	12	—
EE 121 abc	Alternating Current Laboratory (0-6-0)	6	6	6
EE 144	Transmission Lines (4-0-8)	—	—	12
		—	—	—
		27	27	27
		or	or	or
		28	28	28
	Electives	21	21	21

SIXTH YEAR

(Leading to the professional degree of Electrical Engineer)

Programs are selected from a comprehensive list of available subjects and are arranged by the student in consultation with members of the Division.

*For the list of Humanities Electives, see footnote, page 154.

GEOLOGICAL SCIENCES

FIFTH YEAR

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

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6; 4-0-6)*	9 or 10	9 or 10	9 or 10
Ge 100	Geology Club	1	1	1
Ge 102	Oral Presentation	1	1	1
Ge 295	Master's Thesis Research (units and subject by arrangement)			
	Elective units from groups A and B below to total	50 or 51	50 or 51	50 or 51

A. Geology and Paleontology

FIFTH AND SIXTH YEARS

(Leading to the degree of Geological Engineer)

		Units per Term 1st	2nd	3rd
Ge 105	Optical Mineralogy	8	—	—
Ge 106 ab	Petrography	—	10	10
Ge 107	Stratigraphy	—	—	12
Ge 109	Structural Geology	10	—	—
Ge 110	Engineering Geology	—	—	9
Ge 111 ab	Invertebrate Paleontology	10	10	—
Ge 112 ab	Vertebrate Paleontology	—	10	10
Ge 115	Micropaleontology	8	—	—
Ge 121 abc	Advanced Field Geology	10	10	10
Ge 122	Spring Field Trip	—	—	1
Ge 123	Summer Field Geology	—	—	12
Ge 125	Geology of Western America	—	—	7
Ge 126	Elementary Geomorphology	10	—	—
Ge 128	Introduction to Economic Geology	—	7	—
Ge 200	Mineragraphy	10	—	—
Ge 202	Metalliferous Deposits	—	10	—
Ge 209	Sedimentary Petrology	—	8**	—
Ge 210	Metamorphic Petrology	—	8†	—
Ge 211	Petrology (Seminar)	—	—	5
Ge 212	Non-metalliferous Deposits	—	—	10
Ge 213	Mineral Deposits (Seminar)	—	5*	—
Ge 214	Mineral Economics	—	5**	—
Ge 215	Mineralogy (Seminar)	5	—	—
Ge 220	History of the Geological Sciences (Summer reading)	—	—	5
Ge 226	Advanced Geomorphology	10**	—	—
Ge 227	Shoreline Geomorphology	10*	—	—
Ge 228	Geomorphology of Arid Regions	—	10**	—
Ge 229	Glacial Geomorphology	—	6*	—
Ge 230	Geomorphology (Seminar)	—	—	5
Ge 232	Petroleum Geology	10	—	—
Ge 233	Petroleum Geology Practices	—	10	—
Ge 235	Petroleum Geology (Seminar)	—	—	5
Ge 237	Tectonics	—	—	10

*For the list of Humanities Electives, see footnote, page 154.
†1946-1947
**1947-1948

		Units per Term 1st	2nd	3rd
Ge 238	Structural Geology (Seminar)	5	----	----
Ge 245 ab	Vertebrate Paleontology (Seminar)	----	5	5
Ge 248	Fossils of the California Tertiary	----	5	----
Ge 249	Stratigraphy of the Coast Ranges	----	----	5
Ge 250	Invertebrate Paleontology (Seminar)	5	----	----
Ge 297	Advanced Study (units and subject by arrangement)			
Ge 299	Research (units and subject by arrangement)			

B. GEOPHYSICS

FIFTH AND SIXTH YEARS

(Leading to the degree of Geophysical Engineer)

		Units per Term 1st	2nd	3rd
Ge 165	Introduction to General Geophysics	----	6	----
Ge 175	Introduction to Applied Geophysics	5	----	----
Ge 176	Elementary Seismology	----	----	6
Ge 178	Oceanography	----	3	----
Ge 261	Theoretical Seismology	6**	----	----
Ge 262	Interpretation of Seismograms of Teleseisms	----	4**	----
Ge 263	Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes	----	----	4**
Ge 267	Propagation of Sound Waves in the Atmosphere	3	----	----
Ge 273	Applied Geophysics I	5*	----	----
Ge 274 ab	Applied Geophysics II	5*	5*	----
Ge 275 ab	Applied Geophysics III	5**	5**	----
Ge 278	Interpretation of Field Seismograms	----	4*	----
Ge 279	Laboratory and Field Work in Electrical Methods of Prospecting	----	7*	----
Ge 280	Laboratory and Field Work in Gravitational and Magnetic Methods of Prospecting	----	7**	----
Ge 282 abc	Geophysics (Seminar)	1	1	1
Ge 297	Advanced Study (units and subject by arrangement)	----	----	----
Ge 299	Research (units and subject by arrangement)	----	----	----
My 275	Structure of the Atmosphere	----	----	3
CE 2	Advanced Surveying	12	----	----
CE 122	Analysis of Earthquake Effects upon Structures (units by arrangement)	----	----	----
EE 1 abc	Basic Electrical Engineering	6	6	6
EE 2 abc	Basic Electrical Engineering Laboratory	3	3	3
EE 156	Electrical Communication	6	----	----
EE 62	Vacuum Tubes	----	10	----
Ma 81 abc	Advanced Calculus	6	6	6
Ma 60	Mathematical Probability and Statistics	9	----	----
Ph 9 ab	Electrical Measurements	6	6	----
Ph 92 abc	Introduction to Mathematical Physics	10	10	10
Ph 101 abc	Electricity and Magnetism	9	9	9

*1946-1947
**1947-1948

INDUSTRIAL DESIGN

FIFTH YEAR

(The Master's degree is not given in the Industrial Design Option)

		Units per Term 1st	2nd	3rd
ID 101 abc	Industrial Design I (2-9-4)	15	15	15
ID 111 abc	Experimental Laboratory (0-8-0)	8	8	8
ID 121 abc	Design Techniques I (0-3-0)	3	3	3
ID 131	Design Trends (1-0-2)	3	—	—
ID 141 abc	Non-Metallic Materials (3-0-6)	9	9	9
ID 151	Cost Analysis (2-0-3)	—	—	5
ID 161	History of Art (1-0-2)	—	3	—
Ec 100 abc	Business Economics (4-0-6)	10	10	10
		48	48	50
	Elective for some students:			
ME 3	Materials and Processes (3-3-3)			

SIXTH YEAR

(Leading to the professional degree of Industrial Designer)

ID 201 abc	Industrial Design II (Thesis) (2-15-4)	21	21	24
ID 211 abc	Production Methods (1-6-1)	8	8	8
ID 221 abc	Design Techniques II (0-7-0; 0-4-0)	7	7	4
ID 231 abc	Technical Trends in Design (2-0-4)	6	6	6
ID 241 abc	Merchandising Analysis (2-3-4)	9	9	9
		51	51	51

MATHEMATICS

As nearly all Mathematics majors are working for the Doctor's degree and following programs arranged by the student in consultation with members of the Division, no specific graduate curricula can be outlined. The Professional degree is not given in Mathematics.

MECHANICAL ENGINEERING

FIFTH YEAR

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

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6; 4-0-6)*	9 or 10	9 or 10	9 or 10
ME 101 ab	Advanced Machine Design (2-6-2)	—	10	10
ME 105	Mechanical Vibrations (4-0-8)	12	—	—
ME 110	Physical Metallurgy (4-0-8)	12	—	—
ME 115 ab	Thermodynamics (3-0-6; 2-0-4)	—	9	6
ME 125 abc	Engineering Laboratory (2-6-4)	12	12	12
ME 150 abc	Mechanical Engineering Seminar (1-0-1)	2	2	2
Hy 101 ab	Advanced Fluid Mechanics (2-0-4; 3-0-6)	—	6	9
		47 or 48	48 or 49	48 or 49

Note: Students who have not had a course in Advanced Engineering Mathematics, Advanced Calculus, or the equivalent in their undergraduate work should substitute AM 15 abc for the equivalent amount of professional work. Engineering Laboratory is required of candidates for advanced degrees.

Note: All candidates for advanced degrees are required to take Engineering laboratory. Students who plan advanced study past the fifth year, and who have had AM 15 abc or an equivalent course in their undergraduate work may substitute one of the following courses for professional courses, subject to the approval of the Mechanical Engineering Department:

EE 226 abc Engineering Mathematical Physics
AE 257 abc Engineering Mathematical Principles

*For the list of Humanities Electives, see footnote, page 154.

MECHANICAL ENGINEERING

SIXTH AND SEVENTH YEARS

(The professional degree of Mechanical Engineer.
The degree of Doctor of Philosophy.)

A number of advanced courses in the fields related to mechanical engineering are offered by the Mechanical Engineering Department and by other departments of the Institute. The following list will suggest possible programs of study leading to advanced degrees in mechanical engineering. The special requirements for these advanced degrees will be found under the section "Information and Regulations for the Guidance of Graduate Students."

ME 200	Advanced Work in Mechanical Engineering
ME 206	Vibrations Laboratory
ME 210 abc	Science of Metals
ME 211 abc	Metallography Laboratory
ME 215	Internal Combustion Engines
ME 216 ab	Refrigeration and Air Conditioning
ME 217 ab	Steam and Gas Turbines
ME 218 ab	Aircraft Power Plants
ME 219	Experimental Background of Engine Research
ME 220	Lubrication
ME 300	Thesis
Hy 200	Advanced Work in Hydraulic Engineering
Hy 201 abc	Hydraulic Machinery
Hy 202 ab	Hydraulics of Free Surface Phenomena
Hy 203	Cavitation Phenomena
Hy 210 ab	Hydrodynamics of Sediment Transportation
Hy 300	Thesis
AE 261 abc	Hydrodynamics of Compressible Fluids
AE 266 abc	Theoretical Aerodynamics of Real and Perfect Fluids
AE 267 abc	Turbulence
AE 270 abc	Elasticity Applied to Aeronautics
Ch 63 ab	Chemical Engineering Thermodynamics
Ch 227 abc	The Structure of Crystals
Ch 228 abc	Crystal Structure Laboratory
Ch 229	Diffraction of Methods of Determining the Structure of Molecules
Ch 262 ab	Thermodynamics of Multi-Component Systems
Ph 211	Thermodynamics

METEOROLOGY**

FIFTH YEAR

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

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6; 4-0-6)*†	9 or 10	9 or 10	9 or 10
My 104	Structure of the Atmosphere (1-0-2)	—	—	3
My 105	Climatology (2-0-4)	—	—	6
My 201 abc	Weather Forecasting and Practice (3-0-6; 2-0-4)	9	9	6
My 202 abc	Meteorological Laboratory (0-15-0)	15	15	15
My 203 abc	Meteorological Instruments and Observations (1-3-0)†	4	4	4
My 206	Meteorological Geography (1-0-1)	2	—	—
My 207	Meteorological Thermodynamics and Kinematics (3-0-6)	—	9	—
Ma 8	Methods of Advanced Calculus (4-0-6)†	10	—	—
My 230 abc	Meteorological Seminar	1	1	1
My 240 ab	Meteorological Research	—	3	6
		50 or 51	50 or 51	50 or 51

SIXTH YEAR

(Leading to the professional degree of Meteorologist)

		Units per Term 1st	2nd	3rd
My 251 abc	Extended Forecasting, Theory and Practice (3-0-6; 2-0-4)	9	9	6
My 252 abc	Advanced Meteorology Laboratory (0-15-0)	15	15	15
My 255	Climatology (2-0-4)	6	—	—
My 257 abc	Dynamical Meteorology (2-0-4)	6	6	6
My 258	Meteorological Statistics (2-0-4)	—	6	—
Ge 267	Propagation of Sound Waves (1-0-2)	3	—	—
Ge 178	Oceanography (1-0-2)	—	3	—
Ma 12	Elementary Statistics (3-0-6)	9	—	—
My 230	Meteorology Seminar	1	1	1
My 240	Meteorology Research	1	10	13
	Electives	—	—	9
		50	50	50

*For the list of Humanities Electives, see footnote, page 154.

†Students who are to be candidates for the Professional Degree must elect Ph 92 (5-0-10) Introduction to Mathematical Physics in place of Ma 8 and Humanities, and My 213 abc (2-6-0), (0-1-0), (0-2-0) Meteorological Instruments and Observations in place of My 203 abc.

**For extra fee see page 79.

PHYSICS

FIFTH YEAR

(Leading to the degree of Master of Science in Physics.
The Professional degree is not given in Physics.)

		Units per Term 1st	2nd	3rd
	Humanities Electives (3-0-6; 4-0-6)*	9 or 10	9 or 10	9 or 10
Ph 103 abc	Analytical Mechanics (4-0-8)	12	12	12
Ph 105	Optics (4-0-8)	12	—	—
Ph 106	Optics Laboratory (0-6-0)	6	—	—
Ph 107	Spectroscopy (3-0-6)	—	9	—
Ph 108	Spectroscopy Laboratory (0-3-0)	—	3	—
Ph 109 abc	Atomic and Nuclear Physics (3-0-6)	9	9	9
Ph 142	Research	—	6	8
L 35 a	Scientific German (4-0-6)	—	—	10
		48 or 49	48 or 49	48 or 49

*For the list of Humanities Electives, see footnote, page 154.

SUBJECTS OF INSTRUCTION

AERONAUTICS

FIFTH YEAR AND ADVANCED SUBJECTS

AE 251 abc. **Aerodynamics of the Airplane.** 9 units (3-0-6); each term.
Prerequisites: AM 15 abc, Hydraulics.
Airfoil lift, drag and moment characteristics. Boundary layers. Effects of compressibility. Calculation of spanwise lift distribution on finite wings. Performance of complete airplane. Static stability. Dynamic stability. Maneuverability.
Texts: *Aerodynamics of the Airplane,* Millikan; *Technical Aerodynamics,* Wood; *Theory of Flight,* von Mises.
Instructors: Millikan, Corrsin.

AE 252 abc. **Airplane Design.** 9 units (2-1-6); each term.
Prerequisites: Applied Mechanics, Strength of Materials, and Machine Design.
The solution of problems connected with the structural design and analysis of airplane structural components. Special emphasis is placed on the problems dealing with monocoque construction. A modern airplane is considered and the key structural elements are designed and analysed.
Texts: *Airplane Structural Analysis and Design,* Sechler and Dunn; *Airplane Structures,* Niles and Newell.
Instructors: Sechler, Dunn.

AE 253 abc. **Design of Aircraft Components.** 4 units (2-0-2); each term.
A study of the non-structural components of airplanes including control and flap systems, landing gears, power plants, electrical, radio, and instrument installations, heating and ventilating problems, hydraulic systems and acoustics.
Instructor: Klein, assisted by engineers from aircraft companies.

AE 254 abc. **Advanced Problems in Airplane Design.**
Prerequisites: AE 252, AE 253.
The design of flying boats and seaplanes. A study of advanced design methods for airplane structural components.
Instructors: Klein, Sechler, Dunn.

AE 255. **Wind Tunnel Operation and Technique.** 6 units (0-3-3); one term.
A one-term course covering pressure and velocity measuring instruments, balances, model suspensions, wind tunnel calibrations and correction factors, data reduction and presentation, extrapolation of model results to full scale. Experiments on various aerodynamic phenomena are carried out by the students in a special wind tunnel constructed for instruction purposes.

AE 257 abc. **Engineering Mathematical Principles.** 9 units (3-0-6); each term.
Prerequisite: AM 15.
Ordinary differential equations, numerical methods of solution. Bessel functions. Lagrange equation in dynamics, oscillations of finite degrees of freedom. Oscillations of infinite degrees of freedom. Expansion in Orthogonal functions. Fourier series and Fourier integrals. Operational calculus and Laplace transform. Contour Integration. Characteristic value problem. Integral equations. Perturbation methods.
Text: *Mathematical Methods in Engineering,* Karman and Biot.
Instructors: Tsien, Charyk.

AE 258 abc. **Introductory Mechanics and Thermodynamics of Fluids.** 9 units (3-0-6); each term.

Dimensional analysis, thermodynamics, kinetic theory of gases, dynamical principles, circulation and vorticity, velocity potentials, stream functions, perfect fluid flows, one dimensional gas dynamics, viscosity, turbulence, Reynolds stresses, heat transfer, diffusion.

Reference texts: *Airfoil and Airscrew Theory*, Glanert; *Aerodynamic Theory*, Vol. I, Durand.

Instructor: Stewart.

AE 260 abc. **Research in Aeronautics.** Units to be arranged.

Theoretical and experimental investigations in the following fields: aerodynamics; fluid mechanics; compressibility; supersonics; structures, including photoelasticity; and flutter.

AE 261 abc. **Hydrodynamics of Compressible Fluids.** 10 units (3-1-6); each term.

Prerequisites: AE 251, AE 258.

One dimensional gasdynamics; subsonic and supersonic channel flow; normal and oblique shockwaves; condensation phenomena. Experimental methods employed in compressible fluid mechanics research using Schlieren, shadowgraph, interferometers, and other high speed instruments. Two- and three-dimensional vortices; Linearized theory of subsonic and supersonic flow fields; Hodograph methods. Boundary layer and interactive phenomena between boundary layers and shockwaves.

Text: *Introduction to the Aerodynamics of a Compressible Fluid*, Liepmann and Puckett.

Instructor: Liepmann.

AE 265 abc. **Advanced Problems in Aerodynamics.** 6 units (2-0-4); each term.

Prerequisites: AE 251, AE 257, AE 258.

Aerodynamics of propeller design. Flow in ducts and cooling problems. Aerodynamics of high speed flight including the effects of compressibility on stability and control.

Instructor: Bell.

AE 266 abc. **Theoretical Aerodynamics of Real and Perfect Fluids.** 9 units (3-0-6); each term.

Prerequisites: AE 251, AE 257, AE 258.

Hydrodynamics of perfect fluids, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, two-dimenisonal airfoil theory, three-dimensional wing theory, monoplanes, biplanes, interference, propellers, theory of airfoils in non-uniform motion, 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.

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

Instructors: Millikan, Stewart.

AE 267 abc. **Turbulence.** 3 units (1-0-2); each term.

Phenomenological theories of turbulence, conception of mixing length, similarity hypothesis, statistical theory of isotropic turbulence, laminar stability, experimental methods in turbulence research, hot-wire technique, etc.

Instructor: Liepmann.

AE 268. **Advanced Problems in Gas Dynamics.** 15 units (5-0-10); one term.

Prerequisites: AE 257, AE 258, AE 266.

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.

AE 269 abc. **Advanced Problems in Theoretical Aerodynamics.** 6 units (2-0-4); each term.

A seminar course in the applications of theoretical aerodynamics to aeronautical problems for students who have had AE 266 and AE 267.

Instructors: Karman, Millikan.

AE 270 abc. **Elasticity Applied to Aeronautics.** 6 units (2-0-4); each term.

Prerequisites: Applied Mechanics, AE 257.

Fundamental stress and strain relationships in elastic bodies. Theories of bending and torsion. Elastic stability problems including those of thin plates and shells.

Texts: *Elasticity in Engineering*, Sechler; *Theory of Elasticity, Elastic Stability*, and *Plates and Shells*, by Timoshenko.

Instructor: Sechler.

AE 271 abc. **Vibrations and Flutter Problems.** 6 units (2-0-4); each term.

Prerequisites: Applied Mechanics, AE 257.

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

AE 272 abc. **Precision Measurements.** 3 units (1-0-2); each term.

Prerequisites: Applied Mechanics, Mechanisms.

A study of the fundamental principles involved in making precision measurements. Determination of limits of error. Primary and secondary references. Problems in the design of precision instrumentation.

AE 273 abc. **Photoelasticity and Structural Testing Methods.** 6 units (2-0-4); each term.

Prerequisites: AE 270. (May be taken simultaneously)

The basic principles of photoelasticity used as a method of stress distribution determination. Types of photoelastic procedure, the equipment involved, and the results obtained. Discussions of newer types of testing instruments and machines, their advantages and disadvantages. Demonstrations and laboratory problems as required.

AE 280 abc. **Material and Chemistry Problems in Jet Propulsion.** 9 units (3-0-6); each term.

Prerequisites: ME 3, ME 10.

Chemical properties of propellants and fuels. Chemical equilibrium, combustion temperature. Combustion as a chemical kinetic problem. High temperature materials.

Instructors: Stosick, Johnston, Duwez, Tsien.

AE 281 abc. **Jet Propulsion Systems.** 9 units (3-0-6); each term.

Prerequisites: AM 15.

Fundamentals of rockets, solid propellant rocket design, liquid propellant rocket design. Under water jet propulsion systems. Impulse duct engine. General combustion chamber design for thermal jets. Ramjet, turbojet, turbofan, turoprop. Design principles of centrifugal and axial compressors. Design principles of gas turbines.

Instructors: Malina, Summerfield, Seifert, Rannie, Dunn.

AE 282 abc. **Jet Propulsion Laboratory.** 3 units (0-3-0); each term.

Laboratory demonstrations of the operation of jet propulsion systems and the reduction and interpretation of observed data.

Instructor: Seifert.

AE 290 abc. **Aeronautical Seminar.** 1 unit (1-0-0); each term.

Study and critical discussion of current contributions to aerodynamic and aeronautical engineering.

APPLIED MECHANICS

UNDERGRADUATE SUBJECTS

AM 1 a. **Applied Mechanics—Statics.** 12 units (3-3-6); third term.
Prerequisites: Ma 1 abc, 2 ab, Ph 1 abc, 2 ab.
Principles of statics; composition and resolution of forces and force systems; equilibrium of force systems; applications of these principles to engineering problems involving theory of structures, machine design, hydrostatics, and strength of materials.

AM 1 bcd. **Applied Mechanics—Dynamics and Strength of Materials.** 12 units (3-3-6); first, second, third terms.
Prerequisites: AM 1 a.
Principles of dynamics; dynamics of a particle, including equations of motion, impulse and momentum, work and energy; dynamics of rigid bodies; applications to engineering problems involving dynamic characteristics of machine parts, mechanical and structural vibrations, impact, fluid dynamics, etc. Theory of elasticity applied to engineering problems involving tension and compression, bending of beams, torsion of shafts, buckling, etc.; determination of the stresses, strains, and deformations in typical structures; theory of statically indeterminate structures; properties of the materials of construction; determination of safe loads for engineering structures and machines.

AM 2 abc. **Applied Mechanics.** 8 units (3-0-5); first, second, third terms.
Prerequisites: Ma 1 abc, 2 ab; Ph 1 abc, 2 ab.
An abridgement of AM 1 abcd designed particularly to meet the needs of students of Applied Physics and Applied Chemistry.

AM 3. **Testing Materials Laboratory.** 8 units (1-6-1); first or second terms.
Prerequisite: AM 1 c.
Tests of the ordinary materials of construction in tension, compression, torsion, and flexure; determination of elastic limit; yield point; ultimate strength, and modulus of elasticity; experimental verification of formulas derived in the theory of strength of materials.
Instructors: Converse and Assistants.

AM 15 abc. **Engineering Mathematics.** 9 units (3-0-6); first, second, third terms.
Prerequisites: Ma 1 abc, Ma 2 abc.
A course in the advanced mathematical treatment of engineering and physics problems. About half of the time is spent on the mathematical techniques, the remainder being devoted to the solution of problems in dynamics, structures, the vibrations of particles, strings, and plates, the flow of heat, fluids, and electricity, and the transient response of various physical systems to the appropriate kind of impulse. The mathematical topics include the usual methods of solving standard ordinary and partial differential equations, including the use of infinite series, elliptic integrals, Fourier series, Gamma and Bessel functions, vector analysis, functions of a complex variable, and the Laplace transform.

ADVANCED SUBJECTS

AM 105 a. **Soil Mechanics.** 6 units (1-3-2); first term.
Prerequisites: AM 1 abcd.
A study of the physical characteristics of soil, including origin, methods of classification and identification; elasticity, plasticity, the effects of soil moisture on physical properties, permeability, seepage, capillary action, and the effects of frost.
Texts: *Soil Mechanics*, Krynine; *Procedures for Soil Testing*, A.S.T.M.
Instructor: Converse.

AM 105 b. **Soil Mechanics.** 6 units (1-3-2); second term.
Prerequisites: AM 105 a.

A study of the mechanics of soil masses subjected to loads, including the distribution of stress within the soil mass, active and passive pressures on retaining walls, bearing capacity and settlement of footings, piles, stability of slopes, earth dams, highways and airport runways.

Texts: *Soil Mechanics*, Krynine; *Procedures for Soil Testing*, A.S.T.M.
Instructor: Converse.

AM 110 a. **Introduction to the Theory of Elasticity.** 6 units (2-0-4); first term.
Prerequisites: AM 1 abc.

Fundamental concepts of elasticity theory. Equations of stress equilibrium and strain compatibility. Solution of two-dimensional problems. Photo-elastic method of stress measurements. Analysis of stress and strain in three dimensions. Solution of torsion problems. Wave propagation in elastic solids.
Instructor: Housner.

AM 110 b. **Theory of Plates and Shells.** 6 units (2-0-4); second term.
Prerequisites: AM 1 abc.

Simplifiications introduced in elasticity theory. Laterally loaded plates with various boundary conditions. Elastic stability of plates. Membrane theory of shells. General theory of shells.
Instructor: Housner.

AM 110 c. **Mechanics of Materials.** 6 units (2-0-4); third term.
Prerequisites: AM 1 abc.

Experimental methods of stress determination. Theories of failures of stressed materials. Non-linear stress-strain relations. Plastic deformations.
Instructor: Housner.

BIOLOGY

UNDERGRADUATE SUBJECTS

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

Bi 2. **Genetics.** 9 units (2-4-3); third term.
Prerequisite: Bi 1.
An introductory subject presenting the fundamentals of genetics in connection with some general biological problems, such as variation and evolution.
Instructor: Sturtevant.

Bi 3. **General Botany.** 13 units (3-8-2); first term.
Prerequisite: Bi 1.
A general survey of the morphology and life histories of plants.
Instructors: Went, S. Emerson.

Bi 4. **Invertebrate Zoology.** 10 units (2-6-2).
Prerequisite: Bi 1.
A survey of the main groups of invertebrates.
(Students taking the Biology option are required to take this course at the Marine Laboratory for four weeks starting one week after the end of their sophomore year. This course is taken without payment of additional tuition, and living quarters are provided at the Laboratory.)
Instructor: MacGinitie.

Bi 5 ab. **Plant Physiology.** 12 units (3-6-3); second term; 8 units (2-4-2) third term.
Prerequisite: Bi 3.
A general study of water relations, growth and the chemical processes taking place in the living plant.
Instructors: Went, S. Emerson.

Bi 6. **Embryology.** 12 units (2-6-4); second term.
Prerequiiste: Bi 17.
A subject in descriptive and experimental embryology, covering both vertebrates and invertebrates.
Instructor: Tyler.

Bi 7 ab. **Biochemistry.** 10 units (2-4-4); second, third terms.
Prerequisites: Bi 16 a, Ch 41.
A lecture course on the chemical constitution of living matter; and the chemical changes in animal physiology, with laboratory work illustrating principles and methods in current use.
Instructors: Borsook and Huffman.

Bi 8. **Advanced Genetics.** 8 units (2-3-3); third term.
Prerequisite: Bi 2.
A course dealing more especially with biochemical genetics.
Instructor: Beadle.

Bi 12. **Histology and Microscopic Technique.** 9 units (1-6-2); first term.
Prerequisite: Bi 17.
A subject in technique and in the microscopic structure of animals.
Instructor: Tyler.

Bi 13. **Mammalian Anatomy.** 4 units (0-3-1); first term.
Prerequisite: Bi 17.
The dissection of a mammal.
Instructor: van Harreveld.

Bi 14. **Immunology.** 10 units (2-4-4); third term.
Prerequisites: Bi 2, Bi 6, Bi 16, Ch 41 ab.
A course on the principles and methods of immunology and their application to various biological problems. Some previous knowledge of organic chemistry, biochemistry, embryology and genetics is desirable.
Instructor: S. Emerson.

Bi 16 ab. **Animal Physiology.** 10 units (3-3-4); first, second terms.
Prerequisites: Bi 12, Bi 13, Ch 41 to be taken simultaneously or previously.
A survey of comparative and mammalian physiology.
Instructors: Wiersma and van Harreveld.

Bi 17. **Vertebrate Anatomy.** 10 units (2-4-4); third term.
Prerequisite: Bi 1.
This subject deals with the comparative anatomy of the vertebrates.
Instructor: MacGinitie.

Bi 18. **Review.** 3 units (1-0-2). No graduate credit.
A short review course of general botany and plant physiology required of graduate students who want to take a minor in plant physiology, but have had no previous courses in botany.
Instructor: Went.

ADVANCED SUBJECTS

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

Bi 102 abc. **Biological Assays.** 6 units (0-6-0); first, second, third terms.
A course, with lectures and laboratory practice, on certain biological tests for physiologically active substances.
Instructors: Went, Haagen-Smit, Bonner.

Bi 106. **Embryology.** 12 units (2-6-4); second term.
Prerequisite: Bi 17.
A subject in descriptive and experimental embryology, covering both vertebrates and invertebrates.
Instructor: Tyler.

Bi 107 ab. **Biochemistry.** 10 units (2-4-4); second, third terms.
Prerequisites: Bi 16 a, Ch 41.
A lecture course on the chemical constitution of living matter; and the chemical changes in animal physiology, with laboratory work illustrating principles and methods in current use.
Instructors: Borsook and Huffman.

Bi 112. **Histology and Microscopic Technique.** 9 units (1-6-2); first term.
Prerequisite: Bi 17.
A subject in technique and in the microscopic structure of animals.
Instructor: Tyler.

Bi 113. **Mammalian Anatomy.** 4 units (0-3-1); first term.
Prerequisite: Bi 17.
The dissection of a mammal.
Instructor: van Harreveld.

Bi 114. **Immunology.** 10 units (2-4-4); third term.
Prerequisites: Bi 2, Bi 6, Bi 16, Ch 41 ab.
A course on the principles and methods of immunology and their application to various biological problems. Some previous knowledge of organic chemistry, biochemistry, embryology and genetics is desirable.
Instructor: S. Emerson.

Bi 116 ab. **Animal Physiology.** 10 units (3-3-4); first, second terms.
Prerequisites: Bi 12, Bi 13, Ch 41 to be taken simultaneously or previously.
A survey of comparative and mammalian physiology.
Instructors: Wiersma and van Harreveld.

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

Bi 201. **Biology Seminar.** 1 unit.
Meets weekly for reports on current literature of general biological interest.
In charge: The staff.

Bi 202. **Biochemistry Seminar.** 1 unit.
A seminar throughout the academic year on special selected topics and on recent advances.
In charge: Borsook.

Bi 204. **Genetics Seminar.** 1 unit.
Reports and discussion on special topics.
In charge: Anderson.

Bi 205. **Experimental Embryology Seminar.** 1 unit.
Reports on special topics in the field; meets twice monthly.
In charge: Tyler.

Bi 206. **Immunology Seminar.** 1 unit.
Reports and discussion.
In charge: Tyler.

Bi 210 ab. **Advanced Biochemistry.** 12 units.
Lectures and laboratory studies of biological oxidations, fermentations, preparation of enzymes and study of their action, chemistry and physiology of vitamins. To be given once every three years.
Instructors: Borsook, Huffman.

Bi 211. **Applications of Thermo-chemistry to Biological Problems.**
To be given if enough students apply for it.
Instructor: Huffman.

Bi 214 abc. **Chemistry of Bio-Organic Substances.** 6 units (2-0-4); three terms.
Prerequisite: Ch 41 ab.
A series of lectures on selected topics of organic chemistry which have special interest from a biological viewpoint. The lectures will be accompanied by laboratory exercises and demonstrations dealing with the chemical and physiological behavior of naturally occurring substances.
Instructor: Haagen-Smit.

Bi 217. **Quantitative Organic Microanalysis.** Units based on work done (0-20-0); second term.
Laboratory practice in the methods of quantitative organic microanalysis required for structure determinations of organic compounds. Students must obtain permission from the instructor before registering for this subject as the enrollment is necessarily limited.
Instructor: Haagen-Smit.

Bi 220 abc. **Experimental Embryology.** 6 units (2-0-4); three terms.
Lectures and discussion of the problems of embryonic development, including such topics as growth of the ovary, breeding habits of animals, fertilization, cleavage, organ formation, metamorphosis, regeneration, tissue culture, embryonic metabolism, etc.
The subject may be taken for two consecutive years since the subject matter will de duplicated only in alternate years.
Instructor: Tyler.

Bi 221. **Experimental Embryology Laboratory.** Units to be decided by student and instructor: given any term.

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

Instructor: Tyler.

Bi 225 abc. **Graduate Genetics.** 6 units (2-0-4); three terms.

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

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

Bi 240 abc. **Plant Physiology.** 6 units (2-0-4); three terms.

Reading and discussion of the main problems of plant physiology.

Instructors: Went, Bonner.

Bi 241 abc. **Plant Chemistry.** 6 units (0-3-3); three terms.

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

Instructor: Bonner.

Bi 260 abc. **Advanced Physiology.** Units to be arranged; three terms.

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

Instructors: Wiersma, van Harreveld.

Bi 280-287. **Biological Research.**

Students may register for research in the following fields, the number of units to be determined by consultation with those in charge:

Animal physiology (280), biochemistry (281), bio-organic chemistry (282), embryology (283), genetics (284), immunology (285), marine zoology (286), plant physiology (287).

CHEMISTRY AND CHEMICAL ENGINEERING

UNDERGRADUATE SUBJECTS

Ch 1 abc. **Inorganic Chemistry, Qualitative Analysis.** 12 units (3-6-3); first, second, third terms.

Lectures, recitations, and laboratory exercises dealing with the general principles of Chemistry. The first and second terms are devoted to the preparation and properties of substances and to the fundamental laws and theories of chemistry. The subject matter for the third term is qualitative analysis of the common metals.

Instructors: Pauling, Swingle and Teaching Fellows.

Ch 11. **Qualitative Chemical Analysis.** 10 units (2-6-2); third term.

Prerequisite: Ch 1 c.

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

Text: *Chemical Analysis*, Swift.

Instructor: Swift.

Ch 12 ab. **Analytical Chemistry.** 10 units (2-6-2); first, second terms.

Prerequisite: Ch 1 c.

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

Text: *Chemical Analysis*, Swift.

Instructor: Swift.

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

Prerequisite: Ch 12 b.

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

Instructor: Swift.

Ch 13 abc. **Inorganic Chemistry.** 6 units (2-0-4); first, second, third terms.

Prerequisites: Ch 12 b, 21 ab.

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

Instructor: Yost.

Ch 16. **Instrumental Analysis.** 8 units (0-6-2); first term.

Prerequisite: Ch 12 c.

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

Instructors: Badger and Teaching Fellows.

Ch 21 abc. **Chemical Principles.** 10 units (4-0-6); first, second, third terms.

Prerequisites: Ch 12 ab or Ch 11; Ph 2 abc; Ma 2 abc.

Conferences and recitations dealing with the general principles of chemistry from an exact, quantitative standpoint, and including studies on the pressure-volume relations of gases; on thermodynamics, 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 electro-chemistry. A large number of problems are assigned to be solved by the student.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Bates.

Ch 22. **Thermodynamic Chemistry.** *6 units (2-0-4); second term.*

Prerequisite: Ch 21 abc.

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

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Bates.

Ch 24 ab. **Physical Chemistry.** 10 units (4-0-6); first, second terms.

Prerequisites: Ch 12 ab; Ma 2 ab; Ph 2 abcd.

A discussion of selected topics in physical chemistry, adapted to the needs of Science Course students in the Geology Option.

Text: *Physical Chemistry for Colleges,* Millard.

Instructor: Corey.

Ch 26 ab. **Physical Chemistry Laboratory.** 8 units (0-6-2); second term; and 8 units (0-6-2) or 4 units (0-3-1); third term.

Prerequisites: Ch 12 ab, Ch 21 a.

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

Instructor: Badger.

Ch 27 ab. **Nuclear Chemistry.** 5 units (2-0-3).

Prerequisite: Ch 21 abc.

Lectures on: The properties of nuclei, natural and artificial radioactivity, rates of radioactive transformations, fluctuation phenomena, radiations and their absorption by matter, instruments and techniques of measurement in nuclear chemistry, nuclear reactions, the production of radioactive isotopes, isolation and identification of radioactive isotopes, applications of radioactive and stable isotopes to the study of chemical reactions, the physical and chemical properties of various radioactive substances.

Instructors: Dodson and Yost.

Ch 28. **Nuclear Chemistry Laboratory.** 8 units (0-6-2).

Prerequisite: Ch 27 a.

A laboratory course dealing with the handling of radioactive substances, radiation measurements, the determination of decay rates, chemical studies of radioactive elements, the use of radioactive elements as tracers.

Instructors: Dodson and Teaching Fellows.

Ch 29. **Colloid and Surface Chemistry.** *8 units (3-0-5); third term.*

Prerequisite: Ch 21 abc.

Classroom exercises with outside reading and problems, devoted to the properties of surfaces and interfaces, and to the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired.

Text: *Colloid Chemistry,* Weiser.

Instructor: Badger.

Ch 30. **Photochemistry.** 6 units (2-0-4).

Lectures and discussions on photochemical processes, especially in their relation 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: Wulf.

Ch 41 abc. **Organic Chemistry.** 8 units (3-0-5); first, second, third terms.
Prerequisite: Ch 12 c.

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

Text: *Organic Chemistry*, Lucas.

Instructor: Lucas.

Ch 43. **Organic Chemistry.** 10 units (2-6-2); second term.
Prerequisite: Ch 1 abc.
Lectures and recitations, accompanied by laboratory exercises, dealing with the synthesis and the physical and chemical properties of the more important compounds of carbon.
Text: *Organic Chemistry*, Lucas.

Instructor: Niemann.

Ch 46 abc. **Organic Chemistry Laboratory.** 6 units (0-6-0) first, second terms; 10 units (1-9-0) third term.
Prerequisite: Ch 12.
Laboratory exercises to accompany Ch 41 ab. The preparation and purification of carbon compounds and the study of their characteritsic properties. Qualified students may pursue research work.

Text: *Mimeographed Notes*, Lucas and Pressman.

Instructors: Lucas and Teaching Fellows.

Ch 47. **Organic Chemistry Laboratory.** 6 units (0-6-0); third term.
Prerequisite: Ch 12.
Similar to 46. Selected experiments for students of biology.

Instructors: Lucas and Teaching Fellows.

Ch 48. **Qualitative Organic Chemical Analysis.** 12 units (2-9-1); first term.
Prerequisites: Ch 41 abc, Ch 46 abc.
A laboratory study of the class reactions of carbon compounds, and practice in the methods of identifying unknown substances.

Instructor: Lucas.

Ch 49. **Quantitative Organic Chemical Analysis.** 10 units (1-9-0); second term.
Prerequisite: Ch 48.
Practical studies in the quantitative analysis of organic compounds, including the semi-micro estimation of carbon, hydrogen, nitrogen, halogens, sulfur, and methoxyl.

Instructor: Niemann.

Ch 50. **Organic Preparations.** Units to be arranged; any term.
Prerequisites: Ch 41 abc, Ch 46 abc.
Laboratory practice in the synthesis of typical organic compounds.

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

Ch 61 ab. **Industrial Chemistry.** 12 units (4-0-8) first term; 6 units (2-0-4) second term.

Prerequisite: Ch 21 a.

A study of the most 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: *Chemical Process Industries*, Shreve.

Instructor: Lacey.

Ch 63 ab. **Chemical Engineering Thermodynamics.** 6 units (2-0-4) second term; 12 units (4-0-8) third term.

Prerequisite: Ch 21 a.

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

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

Instructor: Lacey.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ch 113 ab. **Inorganic Chemistry.** 4 units; first and second terms.

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

Instructor: Yost.

Ch 122 ab. **Thermodynamic Chemistry.** 6 units (2-0-4); first term; 9 units (3-0-6) second term.

This subject is open to students who have had a course in physical chemistry. During the first term the elements of thermodynamics are reviewed. The second term is the same as Ch 22.

Text: *Chemical Principles*, Noyes and Sherrill.

Instructor: Bates.

Ch 129. **Colloid and Surface Chemistry.** 8 units (3-0-5); third term.

This course is the same as Ch 29.

Instructor: Badger.

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

This course is the same as Ch 48.

Instructor: Niemann.

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

This course is the same as Ch 49.

Instructor: Niemann.

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

This course is the same as Ch 50.

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

Ch 166 abc. **Chemical Engineering.** 12 units (3-0-9); first, second, third terms.

Prerequisites: Ch 61, Ch 63 ab.

Problems and discussions designed to bring the student in touch with the problems involved in carrying out chemical reactions efficiently on a commercial scale.

The unit operations of chemical industry (such as materials transfer, heat transfer, mixing, filtration, distillation) are studied both as to principle and practice.

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

Instructor: Lacey.

Ch 167 abc. **Chemical Engineering Laboratory.** 15 units (0-15-0); first, second, third terms.

Prerequisites: Ch 21, Ch 61, Ch 63.

A course of laboratory work to give training in the methods and technique fundamental to engineering measurements and to research encountered by the chemical engineer.

Instructors: Sage, Hough.

Ch 180-186. **Chemical Research.**

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

Ch 221 abc. **The Nature of the Chemical Bond** (Seminar). 6 units; first, second, third terms.

This subject comprises the detailed non-mathematical discussion of the electronic structure of molecules and its correlation with the chemical and physical properties of substances.

This seminar will be held every third year.

Text: *The Nature of the Chemical Bond*, Pauling.

In charge: Pauling.

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

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

This seminar will be held every third year.

In charge: Yost, Badger.

Ch 223 ab. **Kinetics of Homogeneous and Heterogeneous Reactions** (Seminar). 6 units; first and second terms.

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

This seminar will be held every third year.

In charge: Badger.

Ch 224 abcd. **Statistical Mechanics** (Seminar). 6 units; four terms.

A discussion of statistical mechanics and its applications to physics and chemistry. The topics treated will include a sufficient exposition of classical and quantum theory mechanics to serve as a foundation for statistical mechanics and the relations between statistical mechanics and thermodynamics.

Text: *Principles of Statistical Mechanics*, Tolman.

In charge: Tolman.

Ch 226 abc. **Introduction to Quantum Mechanics, with Chemical Applications.** 9 units; first, second, third terms.

A review of Lagrangian and Hamiltonian mechanics and of the old quantum theory is first given, followed by the discussion of the development and significance of the new quantum mechanics and the thorough treatment of the Schrödinger wave equations, including its solution for many simple systems such as the rotator, the harmonic oscillator, the hydrogen atom, etc. During the second and third terms various approximate methods of solution (perturbation theory, the variation method,

etc.) are discussed and applied in the consideration of the resonance phenomenon, the structure of many-electron atoms and of simple molecules, the nature of the covalent chemical bond, the structure of aromatic molecules, and other recent chemical applications.

This subject will be presented every third year.

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

Instructor: Pauling.

Ch 227 abc. **The Structure of Crystals.** 9 units; first, second, third terms.

The following topics are discussed:

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

This subject will be presented every third year.

Instructors: Sturdivant, Pauling.

Ch 228 abc. **Crystal Structure Laboratory.** Units determined by the instructor; any term.

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

Instructor: Sturdivant.

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

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

Instructors: Sturdivant, Schomaker.

Ch 230. **Photochemistry.** 6 units; third term.

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

Instructor: Wulf.

Ch 232. **Radioactivity and Isotopes.** 6 units; third term.

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

Instructors: Yost, Dodson.

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

The theory of the structure of the spectra of both the diatomic and the simpler polyatomic molecules is presented, and the transition rules and their relation to the symmetry elements of molecules are discussed. Emphasis is laid on the methods

of interpreting and analyzing molecular spectra, and it is shown how from an analysis one obtains information regarding the structure and other properties of a molecule of interest to the chemist. Problems are given in the interpretation of actual data.

Instructor: Badger.

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

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

Instructor: Haagen-Smit.

Ch 244 ab. **The Reactions of Organic Compounds.** 6 units; first and second terms.

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

This subject will be presented every third year.

Instructor: Niemann.

Ch 245 ab. **The Synthesis of Organic Compounds.** 6 units; first and second terms.

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

This subject will be presented every third year.

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

Ch 246 ab. **Theoretical Organic Chemistry.** 6 units; first and second terms.

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

This subject will be presented every third year.

Instructor: Lucas.

Ch 250 abc. **Current Problems of Biochemistry.** 3 units; first, second, third terms.

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

Instructor: Zechmeister.

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

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

Instructor: Zechmeister.

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

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

This subject will be presented every third year.

Instructor: Niemann.

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

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

Instructor: Niemann.

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

Lectures on the properties of proteins and related substances.
Instructor: Niemann.

Ch 255 abc. **Chemistry of Bio-Organic Substances.** 8 units; three terms.

A series of lectures on selected topics of organic chemistry which have special interest from a biological view-point. The lectures will be accompanied by laboratory exercises and demonstrations dealing with the chemical and physiological behavior of naturally occurring substances. For undergraduates, prerequisite: Ch 41 abc; Ch 46 ab.

Instructor: Haagen-Smit.

Ch 256. **Chemistry of Bio-Organic Substances.**

Advanced work with opportunity for research is offered to properly qualified graduate students.

Instructor: Haagen-Smit.

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

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

This subject will be presented every third year.

Instructor: Buchman.

Ch 258. **Immunochemistry.** 6 units (2-0-4).

After a discussion of the techniques of immunology, a detailed presentation is given of the properties of antisera, serological reactions, hypersensitivity, and immunity and resistance to disease.

Text: *Fundamentals of Immunology*, Boyd.

Instructor: Campbell.

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

Prerequisite: Ch 21.

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

Instructor: Sage.

Ch 261. **Phase Equilibria in Applied Chemistry.** 6 units (2-0-4); first term.

Prerequisites: Ch 21, Ch 61.

Problems and discussions relating to industrial applications involving heterogeneous equilibria, primarily in solid-liquid systems.

Instructor: Lacey.

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

Prerequisites: Ch 260 and Ch 63 or ME 16.

A presentation of the background necessary for a working knowledge of the thermodynamics of multi-component systems from the engineering view-point. The work includes numerous problems relating to the application of these principles to industrial practice.

Instructor: Sage.

Ch 280-286. **Chemical Research.**

Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical and inorganic chemistry (280), physical chemistry (282), organic chemistry (284), immunochemistry (285), and applied chemistry and chemical engineering (286).

The main lines of research now in progress are:

The free-energies, equilibria, and electrode-potentials of reactions.
Low temperature calorimetry; the determination of thermodynamic properties of substances from structural data.
The study of crystal structure and molecular structure by diffraction of X-rays and electrons.
The application of quantum mechanics to chemical problems.
Band spectra and Raman spectra in their chemical relations.
The infra-red spectroscopic study of the hydrogen bond.
The magnetic properties and structure of hemoglobin and related substances.
The magnetic properties of absorbed gases.
The diamagnetic anisotropy of crystals.
The crystal structure of amino acids, peptides, and proteins.
The kinetics of chemical reactions including photochemical reactions.
The chemistry of carotenoids and other plant pigments.
The use of chromatographic methods of analysis and separation of stereoisomers; especially the study of the nature of carotenoid isomers.
The Walden inversion.
Isomerism, hydration, and complex formation of unsaturated compounds.
The synthesis and study of vitamin B_1 analogs.
The viscosity of gases and liquids at high pressures.
The influence of turbulence upon heat transfer in fluids.
Phase and thermodynamic behavior of hydrocarbons.
The flow of fluids through porous media.
The synthesis of hydrocarbons containing three- and four-membered rings.
The structure of the naphthenic acids.
Studies on the constitution of the phosphatides and the cerebrosides.
The synthesis of fluorine analogs of thyroxine and a study of their role in animal metabolism.
Studies on the mechanism of the in-vivo oxidation of glycosides.
The study of plant hormones and related substances of physiological importance.
The chemistry of protozoa.
Chemical genetics.
Immunochemistry; the structure of antigens and antibodies.

Ch 290-296. **Chemical Research Conferences.**
Each 1 unit; given both semesters.

Ch 290. **General Research Conference in Chemistry.**

Ch 291. **Crystal and Molecular Structure.**

Ch 294. **Organic Chemistry.**

Ch 296. **Applied Chemistry.**

These conferences consist of reports on the investigations in progress in the laboratory and on other researches which have appeared recently in the literature. They are participated in by all men engaged in related lines of research in the laboratory, and are conducted by the chemistry professors connected with the respective branches.

CIVIL ENGINEERING

UNDERGRADUATE SUBJECTS

CE 1. **Surveying.** 9 units (2-4-3); first or second terms.

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

Text: *Elementary Plane Surveying,* Davis.

Instructor: Michael.

CE 2. **Advanced Surveying.** 12 units (2-7-3); 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.

Instructor: Michael.

CE 3. **Plane Table Surveying.** 8 units (1-6-1); first term.

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

Text: *Elementary Plane Surveying,* Davis.

Instructor: Michael.

CE 4. **Highways and Airports.** 10 units (2-4-4); third term.

A comparison of various types of highway construction; the design, construction and maintenance of roads and pavements. An introduction to airport design.

Instructor: Michael.

CE 6. **Transportation Engineering.** 6 units (2-0-4); first term.

Prerequisites: CE 1, 2.

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

Text: *Elements of Railroad Engineering,* Raymond.

Instructor: Thomas.

CE 7. **Curves and Earthwork.** 7 units (2-0-5); first term.

Prerequisite: CE 1.

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

Text: *Railway Curves and Earthwork,* Allen.

Instructor: Michael.

CE 8. **Route Surveying.** 7 units (0-7-0); first term.

Prerequisite: CE 7.

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

Text: *Railway Curves and Earthwork,* Allen.

Instructor: Michael.

CE 10 abc. **Theory of Structures.** 12 units (3-3-6) first, second terms; 9 units (3-0-6) third term.

Prerequisite: AM 1 c.

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

Texts: *Structural Theory,* Southerland and Bowman; *Structural Design in Steel,* Shedd.

Instructor: Martel.

CE 12. **Reinforced Concrete.** 12 units (3-3-6); third term.

Prerequisites: AM 1 c, CE 10 a.

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

Text: *Reinforced Concrete,* Caughey.

Instructor: Martel.

CE 14 abc. **Engineering Conferences.** 4 units (0-4-0) third term junior year; 3 units (1-0-2) first term senior year; 2 units (1-0-1) second term senior year.

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. In the third term junior year, students will visit and inspect engineering projects.

Instructors: Michael, Eagleson.

FIFTH-YEAR AND ADVANCED SUBJECTS

CE 120 a. **Statically Indeterminate Structures.** 12 units (4-3-5); first term.

Prerequisites: CE 10 abc, 12.

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

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

Instructor: Martel.

CE 120 bc. **Statically Indeterminate Structures.** Units to be based upon work done; any term.

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

Instructor: Martel.

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

Prerequisites: CE 10 abc, 12.

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

Instructor: Thomas.

CE 121 b. **Structural Design.** 9 units (0-9-0); one term.

Prerequisites: CE 10 abc, 12.

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

Instructors: Thomas, Martel.

CE 121 c. **Civil Engineering Design.** 9 units (0-9-0); one term.
Prerequisite: CE 125.
Special problems including preliminary investigations of irrigation or water power projects; study of stream flow data, the effect of reservoir storage upon distributed flow, determination of size and type of economic development.
Instructor: Thomas.

CE 122. **Earthquake Effects upon Structures.** Units to be based upon work done; any term.
A comparison of analytical study and experimental effects of vibrations on simple structures with the effects of earthquakes upon buildings.
Instructor: Martel.

CE 125. **Irrigation and Water Supply.** 12 units (4-0-8); third term.
Prerequisite: Hy 1.
A study of modern practice of the collection, storage, purification and distribution of water for municipal, domestic and irrigation uses; design, construction and operation of systems; consideration of the conditions adapted to irrigation developments, dams, reservoirs, canals; laws pertaining to irrigation; the economic aspects of projects.
Text: *Water Supply and Utilization*, Baker and Conkling.
Instructor: Thomas.

CE 126. **Masonry Structures.** 9 units (2-3-4); second term.
Prerequisite: CE 12.
Theory of design and methods of construction of masonry structures; foundations, dams, retaining walls, and arches.
Text: *Design of Masonry Structures*, Williams.
Instructor: Martel.

CE 127. **Sewerage and Sewage Treatment.** 9 units (2-3-4); second or third terms.
Prerequisite: Hy 1.
A study of systems for the collection and treatment of sewage, the design of sewers and storm drains; characteristics of various treatment processes; factors affecting treatment plant design; inspection of local plants.
Text: *Sewerage and Sewage Disposal*, Metcalf and Eddy.
Instructor: Banta.

CE 130 abc. **Engineering Seminar.** 2 units (1-0-1); first, second, third terms.
Conferences participated in by faculty and graduate students of the Civil Engineering department. The discussions cover current developments and advancements within the fields of civil engineering and related sciences, with special consideration given to the progress of research being conducted at the Institute.

CE 131. **Sewage Treatment Plant Design.** Units to be based upon work done; any term.
A design of treatment works for a selected community and site involving special conditions of location, volume, and requirements for disposal. Includes selection of type of treatment, arrangement of tanks and equipment, and general design of structures.
Instructor: Banta.

CE 132. **Water Power Plant Design.** Units to be based upon work done; any term.
A design of a power plant in conformity with the conditions of head, flow, and load fluctuations at a particular site. Includes selection of number and type of units, design of water passages and general structural features.
Instructor: Thomas.

CE 133. **Water Treatment Plant Design.** Units to be based upon work done; any term.

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

Instructor: Thomas.

CE 134. **Ground Water Investigations.** Units to be based upon work done; any term.

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

Instructor: Thomas.

CE 135. **Geodesy and Precise Surveying.** Units to be based upon work done; any term.

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

Instructor: Michael.

CE 136. **Irrigation Investigations.** Units to be arranged.

Prerequisite: CE 125.

Investigation of irrigation methods and practices and the presentation of reports.

Instructor: Thomas.

CE 141. **Structural Engineering Research.** Units to be based upon work done; any term.

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

Instructor: Martel.

CE 142. **Sanitation Research.** Units to be based upon work done; any term.

Exceptional opportunities for advanced study in the fields of water and sewage treatment are available at the numerous plants located in this locality.

Instructor: Banta.

CE 143. **Highway Research.** Units to be based upon work done; any term.

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

Instructor: Michael.

CE 144. **Airport Design.** Units to be based upon work done; any term.

Prerequisite: CE 4.

Preparation of a layout and design of an airport, including studies of a proposed site, surface and subsurface drainage; runway, and taxiway. Design of base courses and runways surfaces. Accessory structures and lighting.

Instructor: Michael.

CE 150. **Foundations.** 9 units (2-3-4); third term.

Prerequisite: AM 105 ab.

Types and methods of construction of foundations for buildings, bridges, and other major structures. Spread footings and foundation slabs, piles and pile driving equipment, open and pneumatic caissons, cofferdams, underpinning, methods of exploration.

Instructor: Converse.

ELECTRICAL ENGINEERING

UNDERGRADUATE SUBJECTS

EE 1 abc. **Basic Electrical Engineering.** 6 units (2-0-4); EE 1 a first term only, EE 1 bc second or third terms.

Prerequisites: Ma 2 abcd; Ph 2 abcd.

An introductory study of electric and magnetic fields and circuits, electromagnets, direct and alternating current machinery and electronic devices.

Instructors: Maxstadt, Pickering and Assistants.

EE 2 abc. **Basic Electrical Engineering Laboratory.** 3 units (0-3-0); first, second, third terms.

Prerequisites: Ma 2 abcd; Ph 2 abcd.

This course is the laboratory for the corresponding EE 1 course. Use of measuring instruments, operation of direct and alternating current machinery and determination of their characteristics and instrumentation of electronic circuits.

Text: *Laboratory Notes.*

Instructors: Maxstadt and Assistants.

EE 6 ab. **Electrical Machinery.** 6 units (2-0-4) second term; 9 units (3-0-6) third term.

Prerequisites: EE 1 abc; EE 2 abc.

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

Instructors: Maxstadt, Sorensen and Assistants.

EE 7. **Electrical Engineering Laboratory.** 7 units (0-6-1); third term.

Prerequisites: EE 1 abc; EE 2 abc; Ph 7 ab and enrollment in EE 6.

A continuation of EE 2 abc. Efficiency tests of alternating current machinery. Graphic analysis of alternator performance; operation of transformers, alternators and direct current machines in parallel; communication circuit testing; use of electronic devices; writing of engineering test reports.

Text: *Laboratory Notes.*

Instructors: Maxstadt and Assistants.

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

Prerequisites: EE 1 abc; EE 2 abc; EE 6 ab; EE 7.

A course of study relating to the calculation of voltage, current, and power in electrical power and electronic circuits, including an introductory study of filter circuits. In all of these studies free use is made of the symbolic or complex method of solving problems using Kirchoff's laws, Thevenin's theorem and other special methods of calculation.

Texts: *Alternating Current Circuits,* Kerchner and Corcoran; *Problems in Alternating Currents,* Lyon.

Instructors: Sorensen and Assistants.

EE 15 ab. **High Frequency Circuits.** 6 units (2-0-4) second term; (0-3-3) third term.

Prerequisites: Ph 7 a, Ph 8, EE 62 to be taken concurrently.

Maxwell's equations, electromagnetic fields, generation and propagation of microwaves. Laboratory experiments illustrating microwave phenomena.

Instructors: Mackeown and Pickering.

EE 62 ab. **Electron Tubes.** 10 units (2-3-5); second, third terms.

Prerequisites: EE 1 abc; EE 12.

Fundamental theory of electron tubes in radio, communication and control circuits.

Instructors: Mackeown and Pickering.

EE 65. **Electronics Laboratory.** *4 units (0-3-1); second, third terms.*
Prerequisites: EE 62, or to be taken concurrently.
Laboratory measurements at audio and radio frequencies using modern electronic devices.
Instructors: Pickering and Assistants.

EE 70 ab. **Engineering Conference.** 2 units (1-0-1); first, second terms.
Prerequisites: EE 2 ab; EE 3 ab.
Presentation and discussion of new developments in the industry. Review of current literature.
Instructors: Mackeown, Maxstadt, Pickering, Sorensen.

FIFTH-YEAR SUBJECTS

EE 120 a. **Advanced Alternating Current Analysis and Machinery.** 12 units (4-0-8); first term.
Prerequisites: EE 7 and preceding courses.
Advanced study of magnetic and electric circuits. Solution of problems involving the symbolic method and complex notation; symmetrical components; analysis of electromotive force and current, nonsinusoidal wave forms; analysis of oscillograms.
Texts: *Problems in Electrical Engineering*, Lyon; *Applications of the Method of Symmetrical Components*, Lyon.
Instructors: Sorensen, Begovich.

EE 120 b. **Advanced Alternating Current Analysis and Machinery.** 12 units (4-0-8); second term.
Prerequisites: EE 120 and preceding subjects.
An advanced study of the alternator, the induction motor and the stationary transformer, with particular emphasis on problems involving polyphase polarity, together with single and polyphase multiple circuit.
Texts: *Alternating Current Machinery*, Bryant and Johnson; *Problems in* Alternating Current Machinery, Lyon.
Instructors: Sorensen, Begovich.

EE 121 abc. **Alternating Current Laboratory.** 6 units (0-6-0); first, second, third terms.
Prerequisites: EE 7 and preceding courses.
Complete tests of the induction motor; the operation of transformers in parallel; study of polyphase connections; photometric measurements; use of the oscillograph; calibration of watt-hour meters and relays, high voltage tests of insulation. Special emphasis is placed on the report.
Text: *Advanced laboratory notes.*
Instructors: Maxstadt and Assistants.

EE 128. **Electric Traction.** 9 units (3-0-6); third term.
Prerequisites: EE 1 abc; EE 6 ab.
Modern electric and oil-electric railways, studies of the motive power, train requirements, frictional and other resistances, schedules, acceleration and braking; the portable power plant vs. substations and contact conductor. Safe speeds and riding qualities are studied.
Text: *Transit Engineering*, Tuthill.
Instructors: Lindvall, Maxstadt.

EE 130. **Electric Lighting and Power Distribution.** 6 units (2-0-4); third term.
Prerequisites: EE 1 abc; EE 6 ab.
Electric distribution and wiring; calculation of simple alternating current circuits; installation and operation costs and selling price of electric power.
Text: *Electrical Distribution Engineering*, Seelye.
Instructor: Maxstadt.

EE 144. **Transmission Lines.** 12 units (4-0-8); third term.
Prerequisites: EE 120 ab, and preceding subjects.
Line performance and protection; elementary transient phenomena; use of hyperbolic functions in line calculation; generalized system constants; the stability problem.
Instructor: Lindvall.

EE 148. **Specifications and Design of Electrical Machinery.** 6 units (3-0-3); first term.
Prerequisites: EE 7, and preceding subjects.
Preparation of specifications and design calculations for alternating and direct current machinery.
Text: *Electrical Machine Design,* Gray.
Instructor: Sorensen.

EE 152. **Dielectrics.** 6 units (2-0-4); third term.
Prerequisites: EE 120 ab, and preceding subjects.
A study of electric fields in insulations, particularly air, and the effects on sparking voltage of the sparking distance, atmospheric pressure and humidity; corona phenomena; high frequency voltages, characteristics of commercial insulations.
Text: *Theory of Dielectrics,* Schwaiger and Sorensen.
Instructor: Sorensen.

EE 156. **Electric Communication.** 6 units (2-0-4); first term.
Prerequisites: EE 12, EE 62 ab, EE 65 ab.
A study of modern means of communication with special emphasis on recent developments. Includes a study of four terminal networks and filter theory.
Instructor: Mackeown.

EE 157. **Communications Laboratory.** 6 units (0-3-3); first term.
Prerequisite: Must be taking or have taken EE 156.
Use of measuring instruments and circuits at audio frequencies. Includes four terminal networks, filters and transmission lines.
Instructors: Pickering and Assistants.

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

EE 163. **Radio.** 6 units (2-0-4); first term.
Prerequisite: EE 62.
Study of circuits used in radio transmitter and receivers. Includes frequency and phase modulation, transmission and propagation of radio waves.
Instructor: Mackeown.

EE 170. **Feed Back Amplifiers and Servo Machanism.** 9 units (3-0-6); third term.
Prerequisites: Ma 15 abc; EE 62 ab.
Theory and analysis of electrical, hydraulic and mechanical feed back and servo mechanism systems.
Instructors: Pickering, Mackeown.

EE 190. **Ultra High Frequency Techniques.** 15 units (5-0-10); second term.
Prerequisites: EE 62, EE 156, Ph 8.
Application of Maxwell's equations to equipment used at ultra high frequencies. Includes wave guides, cavity resonators, velocity modulated tubes, magnetrons, etc.
Instructor: Mackeown.

EE 191. **Ultra High Frequency Laboratory.** 9 units (0-6-3); second term.
Prerequisites: EE 190, or be enrolled for it.
Laboratory measurements and use of ultra high frequency equipment.
Instructors: Pickering and Assistants.

ADVANCE SUBJECTS

EE 200. **Advanced Work in Electrical Engineering.**
Special problems relating to electrical engineering will be arranged to meet the needs of students wishing to do advanced work in the field of electricity. The Institute is equipped to an unusual degree for the following lines of work: Theory of Electrical Machine Design, Electric Transients, and High Voltage Engineering Problems, under the direction of Professors R. W. Sorensen and F. C. Lindvall; Electrical Engineering Problems relating to electronic applications under the direction of Professors S. S. Mackeown and W. H. Pickering; Electrical Problems relating to the distribution and uses of electric power for lighting and industrial uses; Studies of Light Sources and Illumination under the direction of Professor F. W. Maxstadt.

EE 220. **Research Seminar in Electrical Engineering.** 2 units.
Meets once a week for discussion of work appearing in the literature and in industry. All advanced students in electrical engineering and members of the electrical engineering staff are expected to take part.
In charge: Sorensen, Mackeown, Lindvall, Pickering, Maxstadt.

EE 221. **Transmission Line Problems.** 15 units. By arrangement.
A study of transmission line transient problems, inductive interference, power limit analysis, etc.
Instructor: Sorensen.

EE 223 ab. **Electric Strength of Dielectrics.** 15 units; second and third terms.
A study of the effect of high potentials applied to dielectrics.
Text: *Theory of Dielectrics,* Schwaiger and Sorensen.
Instructor: Sorensen.

EE 224 abc. **Vacuum Tube and Radio Frequency Circuits.** Units to be based on work done; first, second, third terms.
A study of the literature on vacuum tubes and associated circuits. Experimental work with oscillators, transmitters, and receivers.
Instructor: Mackeown.

EE 225. **Principles of Electrical Design.** 15 units; first term.
A discussion and calculation course in the analysis of the principles and methods used in the design of electrical machinery.
Instructors: Sorensen, Maxstadt.

EE 226 abc. **Engineering Mathematical Physics.** 15 units (3-0-12); first, second, third terms.
Prerequisites: B.S. in Engineering; Differential Equations, Ma 10 or Ma 11.
This subject is designed to develop the correlation of mathematics and physics with problems in engineering design and application. The following subjects will be treated in detail: mechanical vibrations, oscillations in electro-mechanical systems, short circuit forces, power system transients, electric motors applied to variable or pulsating loads, heat transfer and transient heat flow. The principle of constant flux linkage in electrical transient analysis; solution of mechanical problems by electrical methods; application of Heaviside operational calculus to mechanical and thermal problems.
Instructor: Lindvall.

EE 227. **Operational Circuit Analysis.** 6 units (2-0-4); third term. Not given every year.

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

Instructor: Mackeown.

EE 228. **Conduction of Electricity in Gases.** Units to be arranged; first, second, third terms. Not given every year.

Selected topics in glow, arcs, and spark discharges.

Instructor: Mackeown.

EE 229. **Advanced Circuit Analysis.** Units to be arranged; three terms.

Development of circuit equations from Maxwell's equations; application of Maxwell's equations to circuits at high frequency; and other selected topics.

Instructors: Mackeown, Pickering.

EE 230 abc. **Microwave Electronics.** 6 units (2-0-4); three terms.

The behavior of vacuum tubes at ultra high frequencies, electron transit time effects, microwave oscillators.

Instructor: Pickering.

ENGINEERING DRAFTING

D 1a. **Freehand Drawing.** 3 units (0-3-0); first term.

The study of geometrical forms and their representation by means of freehand orthographic and perspective. Training in pencil rendering is given and the fundamental principles of perspective are illustrated by simple engineering studies and the use of machine parts. Emphasis is placed on careful observation and accurate drawing.

Instructors: Wilcox and Assistants.

D 1b. **Engineering Drafting.** 3 units (0-3-0); second term.

This course is designed to give the student a general knowledge of the most important types of engineering drawings. Instruction is given in the proper use of drafting equipment and in the fundamental principles of drafting and lettering. Elementary detail drawings are included.

Text: *Engineering Drawing,* sixth edition, French.

Instructors: Wilcox, Hummel.

D 1c. **Engineering Drafting.** 3 units (0-3-0); third term.

Prerequisite: D 1b.

A continuation of D 1b. Emphasis is placed on the elementary geometry of engineering drawing and visualization in three dimensions. Elementary principles of design are discussed and the accepted standards of machine drafting are applied in the making of simple working drawings.

Text: *Engineering Drawing,* sixth edition, French.

Instructors: Wilcox, Hummel.

D 2. **Descriptive Geometry.** 6 units (0-6-0); second term.

Prerequisites: D 1 abc.

The course is designed to supplement the study of shape description as given in D 1 abc, and to present a graphical means of solving the more difficult three-dimensional problems. Special emphasis is placed on the ability to visualize and analyze three-dimensional structures. Analytical solution of the simpler problems is discussed. The work includes problems covering the geometrical relationship of straight lines and planes, curved lines, single curved surfaces, double curved surfaces, warped surfaces, intersections, and developments. The course stresses the practical application of descriptive geometry in the various fields of engineering.

Text: *Geometry of Engineering Drawing,* Hood.

Instructors: Tyson, Wilcox, Hummel.

D 5. **Descriptive Geometry.** 6 units (0-6-0); third term.

Prerequisites: D 1 abc.

This course is planned primarily for geology students and is designed to cover the fundamentals of descriptive geometry as given in the first part of D 2. Emphasis is placed, throughout the course, on practical problems in mining and earth structures.

Text: *Geometry of Engineering Drawing,* Hood.

Instructors: Tyson, Welch.

D 7. **Advanced Engineering Drafting.** Maximum of 6 units. Elective; any term.

Prerequisites: D 1 abc; D 2; ME 1 ab.

The study and execution of layout drawings involving further applications of machine mechanisms.

Instructor: Tyson.

GEOLOGICAL SCIENCES

UNDERGRADUATE SUBJECTS

Ge 1 a. **Physical Geology.** 9 units (4-3-2); first term.
Prerequisites: Ch 1 ab; Ph 1 ab.
A consideration of the composition and structure of the Earth and the internal and external processes which modify the crust and the surface. Dynamical and structural geology. Lectures, recitations, laboratory and field trips.
Text: *Text-book of Geology,* Part I, Longwell, Knopf and Flint.
Instructors: Buwalda and Teaching Fellows.

Ge 1 b. **Elementary Paleontology.** 9 units (4-1-4); third term.
Prerequisite: Ge 1 a.
A discussion of the principles on which the history of life is based. Illustrations of evolution taken from certain groups of animals of which the fossil record is essentially complete. Occasional field trips.
Text: *Organic Evolution,* Lull.
Instructor: Stock.

Ge 1 c. **Historical Geology.** 12 units (4-2-6); second term.
Prerequisite: Ge 1 a.
A consideration of the geologic history of the Earth, as shown by the changing patterns of land and sea and by the succession of faunas and floras. Conferences, lectures, and occasional field trips.
Text: *Historical Geology,* R. C. Moore.
Instructor: Durham.

Ge 3 ab. **Mineralogy.** 8 units (3-3-2) second term; 10 units (3-6-1) third term.
Prerequisites: Ge 1 a, Ch 1 abc.
A study of the physical and chemical properties of minerals, of the associations and modes of occurrence; of their industrial applications; with training in their identification.
Text: *Manual of Mineralogy,* Dana, Hurlbut.
Instructors: Campbell, Jahns.

Ge 4 a. **Petrology.** 6 units (2-3-1); first term.
Prerequisites: Ge 1 a, Ge 3 a.
A study of the origin and occurrence, and training in the megascopic identification of the more important igneous rocks.
Text: *Principles of Petrology,* Tyrell.
Instructors: Campbell, Jahns.

Ge 4 b. **Petrology.** 8 units (2-4-2); second term.
Prerequisites: Ge 1 a, Ge 3 ab.
A study of the principal sedimentary and metamorphic rocks.
Text: *Principles of Petrology,* Tyrell.
Instructors: Campbell, Jahns.

Ge 14. **Geologic Illustration.** 5 units (0-5-0) third term.
Freehand sketching of landscape forms and visible geologic structures in the field developing both line and shading technique in representation. Also classroom exercises utilizing various mediums. Training in the drawing of block diagrams illustrating land forms and geologic structure sections in perspective. Problems in projection.
Text: *Block Diagrams,* Lobeck.
Instructor: Willoughby.

Ge 21 abc. **Introduction to Field Geology.** 10 units (1-8-1); first, second, third terms.

Prerequisites: Ge 1 ab, Ge 3 ab.

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

Text: *Field Geology,* Lahee.

Instructor: Jahns.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ge 102. **Oral Presentation.** 1 unit (1-0-0); third term.

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

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

Instructor: Jones.

Ge 105. **Optical Mineralogy.** 8 units (2-5-1); first term.

Prerequisite: Ge 3 ab.

The principles of optical crystallography; training in the use of the petrographic microscope in identification of crystalline materials.

Text: *Elements of Optical Mineralogy,* vol. I, Winchell.

Instructor: Jahns.

Ge 106 ab. **Petrography.** 10 units (2-6-2); second and third terms.

Prerequisites: Ge 105, Ch 24 ab.

A systematic study of rocks; identification of their constituents by means of the polarizing microscope; interpretation of textures; problems of genesis; qualitative and quantitative classifications.

Text: *Petrology for Students,* Harker.

Instructor: Campbell.

Ge 107. **Stratigraphy.** 12 units (4-2-6); third term.

General principles of stratigraphy. Correlation and description of sedimentary deposits. Type sections of the stratigraphic column. Stratigraphy of California.

Instructor: Durham.

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

Prerequisite: Ge 21 ab.

A consideration of the structural features of the Earth's crust; folds, faults, joints, foliation.

Text: *Structural Geology,* Billings.

Instructor: Buwalda.

Ge 110. **Engineering Geology.** 9 units (2-2-5); third term.

Prerequisite: Ge 1 a.

A discussion of those geological conditions that affect particular engineering operations, such as tunnelling, the building of dams, the retention of water in reservoirs, foundation excavation, harbor work, control of erosion and landslides, materials of construction, etc. Lectures and assigned reading.

The course is planned primarily for civil engineers.

Instructor: Buwalda.

Ge 111 ab. **Invertebrate Paleontology.** 10 units (2-6-2); first, second terms.

Prerequisites: Ge 1 ab.

Morphology and geologic history of the common groups of fossil invertebrates, with emphasis on progressive changes in structures and their significance in evolu-

tion and in adaptive modifications. Laboratory, conferences, lectures, and occasional field trips.

Texts: *Tertiary Faunas,* Davies; *Invertebrate Paleontology,* Twenhofel and Shrock.

Instructor: Durham.

Ge 112 ab. **Vertebrate Paleontology.** 10 units (2-6-2); second, third terms. Prerequisite: Ge 1 b.

Osteology, affinities, and history of the principal groups of fossil mammals and reptiles. History of vertebrate life with special reference to the region of western North America.

Instructor: Stock.

Ge 115. **Micropaleontology.** 8 units (1-3-4); first term.

Prerequisite: Ge 111 ab.

Introduction to the morphology and classification of the foraminifera. Their use in stratigraphic correlation with special reference to the Tertiary of California.

Texts: *The Foraminifera, their Classification and Economic Use,* Cushman; *A Manual of the Foraminifera,* Galloway.

Ge 121 ab. **Field Geology.** 10 units (0-10-0); first, second, third terms.

Prerequisites: Ge 3 ab, Ge 21 ab.

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

Instructor: Jahns.

Ge 122. **Spring Field Trip.** 1 unit (0-1-0); week between second and third terms.

Brief studies of various localities in the Southwest representative of important geologic provinces. Trips are conducted in successive years to Owens and Death Valleys where excellent Paleozoic sections are exposed, and Basin Range structure and morphology may be observed; to the Salton Basin and Lower California where the San Andreas fault and the Peninsular Range may be studied; to the San Joaquin Valley and the mountains to the west where important Tertiary formations are exposed and typical Coast Range structure may be seen; and to the Grand Canyon of the Colorado River where a fascinating record of Archean, Algonkian and Paleozoic geologic history may be investigated.

Required of junior, senior, and graduate students in the Division of Geological Sciences.

Instructors: Buwalda, Maxson.

Ge 123. **Summer Field Geology.** 12 units (0-12-0).

Prerequisites: Ge 3 ab, Ge 21 ab.

Intensive field mapping of a selected area from a centrally located field camp. Determination of the stratigraphy, fossil content, structure, and geologic history. The area chosen will probably lie in the California Coast Ranges in odd-numbered years and in the Great Basin in even-numbered years. As an occasional alternative an expedition will be conducted to localities important in California geology. The interpretations of classical localities afforded in the literature will be studied in the field. The subject begins immediately after Commencement (about June 12th). Required at the end of both the Junior and Senior year for the bachelor's degree in the Geology course.

Ge 125. **Geology of Western America.** 7 units (4-0-3); third term.
Presents an organized concept of the geologic history of the Rocky Mountains, the Colorado Plateau, Basin and Range, and Coast Range Provinces. Lectures, mainly by staff members personally familiar with the regions discussed, and assigned reading.
Instructors: Buwalda, Campbell, Jahns, Maxson.

Ge 126. **Geomorphology.** 10 units (4-0-6); first term.
Prerequisites: Ge 109, 121 ab.
Nature of erosional processes in a humid climate and the topographic features developed. Sequence of land forms in the normal physiographic cycle. Brief discussion of the arid, shoreline, and glacial cycles.
Text: *Geomorphology,* Von Engeln.
Instructor: Maxson.

Ge 128. **Introduction to Economic Geology.** 7 units (4-0-3); second term.
A survey course of geology applied to petroleum, ground water, ore deposits, and engineering.
Instructors: Buwalda, Campbell, Jahns, Maxson.

Ge 165. **Introduction to General Geophysics.** 6 units (2-0-4); second term, 1947-48.
Prerequisites: Ma 2 ab, Ph 2 ab.
Structure of the Earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density.
Instructor: Gutenberg.

Ge 175. **Introduction to Applied Geophysics.** 6 units (3-0-3); first term.
A survey of pure and applied geophysics designed mainly for geological, engineering, and other students who do not expect to enroll in specialized subjects in this field.
Instructor: Potapenko.

Ge 176. **Elementary Seismology.** 6 units (3-0-3); third term.
A survey of the geology and physics of earthquakes.
Instructor: Richter.

Ge 178. **Oceonography.** 3 units (1-0-2); second term.
Prerequisites: Ma 2 abc, Ph 2 abc.
Physical properties of ocean water; temperature, salinity in the oceans; tides, waves; currents.
Instructor: Gutenberg.

GRADUATE SUBJECTS

Courses given in alternate years are so indicated. Courses in which the enrollment is less than five may, at the discretion of the instructor, not be offered.

Ge 200. **Mineragraphy.** 10 units (2-6-2); first term.
Prerequisite: Ge 3.
Methods of identification of opaque minerals in crushed samples and polished sections, together with applications to research and practical problems.
Texts: *Microscopic Determination of Ore Minerals,* M. N. Short; U.S.G.S. Bull., 914; *Mineral Deposits,* 4th edition, Lindgren.
Instructor: Jahns.

Ge 202. **Metalliferous Deposits.** 10 units (2-6-2); second term.
Prerequisites: Ge 106, Ge 200.
A study of metalliferous deposits with respect to geographic distribution, structure, alteration, and mode of formation. The laboratory work will consist of a study of ore suites and altered rocks in hand specimens, polished and thin sections.
Text: *Mineral Deposits,* 4th edition, Lindgren.

Ge 209. **Sedimentary Petrology.** 8 units, second term 1947-48.
Prerequisite: Ge 106.
Discussion, reports and conferences on sediments, particularly from the petrographic viewpoint. The work in the laboratory affords an introduction to the various quantitative methods for detailed analysis of sediments.
Text: *Sedimentary Petrography,* 3rd edition, Milner.
Instructor: Campbell.

Ge 210. **Metamorphic Petrology.** 8 units; second term 1946-47.
Prerequisite: Ge 106.
A study of metamorphic processes.
Text: *Metamorphism,* Harker.
Instructor: Campbell.

Ge 211. **Petrology** (Seminar). 5 units; third term.
Discussion of classic and current literature with consideration of recent advances in the field of petrology. Occasional conferences on research problems are included.
In charge: Campbell.

Ge 212. **Non-Metalliferous Deposits.** 10 units (2-6-2); third term.
Prerequisites: Ge 3, 106.
A study of the industrial minerals; their occurrence, exploitation, beneficiation. In the laboratory the petrographic microscope is applied not only to problems of identification and paragenesis of the ores, but also to problems involving processed and fabricated materials. Occasional field trips.
Text: *Industrial Minerals and Rocks,* Seeley W. Mudd Series (A.I.M.E.)
Instructor: Campbell.

Ge 213. **Mineral Deposits** (Seminar). 5 units; second term 1946-47.
Prerequisite: Ge 202.
Discussion of problems and current literature concerning ore deposits.

Ge 214. **Mineral Economics** (Seminar). 5 units; second term 1947-48.
Prerequisite: Ge 202.
Discussion and investigation of factors involved in ore estimation, economics of mining and evaluation of mineral deposits.

Ge 215. **Mineralogy** (Seminar). 5 units; first term.
Prerequisite: Ge 200.
Discussion of current literature and special problems related to mineralogy.
In charge: Jahns.

Ge 220. History of the Geological Sciences. 5 units, summer reading course.
Development of basic concepts and specialized fields by great geologists of the past. Intended to provide historical background and understanding of growth of the science.
Assigned reading during summer, examination second week of fall term.
Instructor: Maxson.

Ge 226. **Advanced Geomorphology.** 10 units (3-0-6); first term 1947-48.
Prerequisites: Ge 109, 121 ab, 126.
Consideration of mechanics of weathering and stream erosion. Detailed analysis of the sequence of land forms in the normal cycle of erosion in relation to varied types of geologic structure. Lectures, assigned reading. Field trips to San Gabriel Mountains and Coast Ranges.
References: Cotton, *Landscape.*
Davis, *Geographical Essays.*
Penck, *Die Morphologische Analyse.*
Instructor: Maxson.

Ge 227. **Shoreline Geomorphology.** 10 units (3-0-7); first term 1946-47.
Prerequisite: Ge 126.
Processes of marine erosion and the shoreline cycle.
Field trips along the coast of California.
Text: *Shore Processes and Shoreline Development,* Johnson.
Instructor: Maxson.

Ge 228. **Geomorphology of Arid Regions.** 10 units (3-0-7); second term 1947-48.
Prerequisite: Ge 126.
Processes of erosion in an arid climate. Land forms of arid regions and their modes of origin. The arid cycle of erosion in the Basin Range Province.
Lectures, assigned reading. Field trips to the Mojave Desert and Death Valley.
Reference: Cotton, *Climatic Accidents.*
Instructor: Maxson.

Ge 229. **Glacial Geomorphology.** 6 units (2-0-4); second term 1946-47.
Prerequisite: Ge 126.
Study of land forms produced by glaciation with especial attention to alpine glaciation.
Reference: Cotton, *Climatic Accidents.*
Instructor: Maxson.

Ge 230. **Geomorphology** (Seminar). 5 units; third term.
Discussion of research and current literature in geomorphology.
In charge: Maxson.

Ge 232. **Petroleum Geology.** 10 units (3-0-7); first term.
Prerequisites: Ge 109, 121 ab.
Theories of origin, principles of movement and accumulation of oil and gas; types of reservoir structures.
Instructor: Maxson.

Ge 233. **Petroleum Geology Practices.** 10 units (3-0-7); second term.
Prerequisites: Ge 109, 121 ab.
Studies of individual oil fields involving discussion of structural conditions, preliminary estimates of reservoir capacity, practical methods of surface and sub-surface mapping, and sub-surface correlation.
Instructor: Maxson.

Ge 235. **Petroleum Geology** (Seminar). 5 units; third term.
Problems of petroleum geology. Current literature and discussion of new discoveries.
In charge: Maxson.

Ge 237. **Tectonics.** 10 units (3-0-7); third term.
Prerequisites: Ge 109, or equivalent, and Ge 121 ab, or equivalent.
Advanced structural and tectonic geology. Structure of some of the great mountain ranges; theories of origin of mountains, mechanics of crustal deformation; isostasy; continental drift.
Instructor: Buwalda.

Ge 238. **Structural Geology** (Seminar). 5 units; first term.
Critical review of literature dealing with some part of the field of structural geology.
In charge: Buwalda.

PALEONTOLOGY

Ge 245 ab. **Vertebrate Paleontology** (Seminar). 5 units; second and third terms.
Discussion of progress and results of research in vertebrate paleontology.
Critical review of current literature.
In charge: Stock.

Ge 248. **Fossils of the California Tertiary.** 5 units; second term.
Study of some of the more important invertebrate fossils of the California Tertiary with especial emphasis on their use as horizon markers in field geology.
Instructor: Durham.

Ge 249. **Stratigraphy of the Coast Ranges** (Seminar). 5 units; third term.
Review, discussion and criticism of literature of the California Coast Ranges, with especial emphasis on correlation and fauna.
In charge: Durham.

Ge 250. **Invertebrate Paleontology** (Seminar). 5 units; first term.
Critical review of classic and current literature in invertebrate paleontology. Study of paleontologic principles and methods.
In charge: Durham.

GEOPHYSICS

Ge 261. **Theoretical Seismology.** 6 units (2-0-4); first term 1947-48.
Prerequisites: Ma 8, or Ma 10, or Ph 5 abc.
Studies and conferences on the principles of physical seismology.
Instructor: Gutenberg.

Ge 262. **Interpretation of Seismograms of Teleseisms.** 4 units (0-3-1); second term, 1947-48.
Prerequisite: Ge 261.
Instructor: Gutenberg.

Ge 263. **Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes.** 4 units (0-3-1); third term 1947-48.
Prerequisite: Ge 261.
Instructor: Richter.

Ge 267. **Propagation of Sound Waves in the Atmosphere.** 3 units (1-0-2); first term.
Prerequisites: Ma 8, or Ma 10, or Ph 5 abc.
Velocity of sound in air; effect of temperature and wind on paths and amplitudes of sound waves.
Instructor: Gutenberg.

Ge 273. **Applied Geophysics I.** 5 units (2-0-3); first term 1946-47.
Prerequisites: Ma 8, or Ma 10, or Ph 5 abc.
Methods of seismology applied to geological problems and prospecting.
Instructor: Gutenberg.

Ge 274 ab. **Applied Geophysics II.** 5 units (2-0-3); first, second terms 1946-47.
Prerequisites: Ma 8, Ma 10, or Ph 5 abc.
Theory of methods of electrical prospecting.
Instructor: Potapenko.

Ge 275 ab. **Applied Geophysics III.** 5 units (2-0-3); first, second terms 1947-48.
Prerequisites: Ma 8, or Ma 10, or Ph 5 abc.
Theory of gravitational and magnetic methods of prospecting.
Instructor: Potapenko.

Ge 278. **Interpretation of Field Seismograms.** 4 units (0-3-1); second term 1946-47.
Prerequisite: Ge 273.
Instructor: Gutenberg.

Ge 279. **Laboratory and Field Work in Electrical Methods of Prospecting.** 7 units (0-4-3); second term 1946-47.
Prerequisite: Ge 274.
Instructor: Potapenko.

Ge 280. **Laboratory and Field Work in Gravitational and Magnetic Methods of Prospecting.** 7 units (0-4-3); second term 1947-48.
Prerequisite: Ge 275.
Instructor: Potapenko.

Ge 282 abc. **Geophysics** (Seminar). 1 unit; first, second, third terms.
Prerequisite: At least two subjects in geophysics.
Discussion of papers in both general and applied geophysics.
In charge: Gutenberg, Buwalda, Potapenko.

Ge 299. **Research.**
Original investigation, designed to give training in methods of research, to serve as theses for higher degrees, and to yield contributions to scientific knowledge. These may be carried on in the following fields:

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

Special requirement in Field Geology for graduate students in the Division of the Geological Sciences.

If, in the judgment of the Division, additional technical training in geologic mapping is desirable, a graduate student may be required to take Ge 21 or Ge 121, and/or Ge 123.

Students with adequate technical background in geologic mapping may be required to gain familiarity with California geology by taking Ge 123, or an appropriate problem in areal geologic research.

SUBJECTS IN THE HUMANITIES

ECONOMICS

The subjects in this group have the twofold purpose of giving the student an insight into fundamental economic principles, and of acquainting him with some of the aspects of the practical operation of business enterprises. They furnish the important connecting link between the technical engineer and the man of affairs.

UNDERGRADUATE SUBJECTS

Ec 2. **General Economics and Economic Problems.** 10 units (4-0-6); one term.

The purpose of this subject is to describe in as great detail as possible the economic life of the community. It includes a study of production, distribution, and exchange of goods, the nature of money and credit, the development of economic institutions, and an analysis of a number of pressing economic problems.

Instructors: Laing, Untereiner.

Ec 3 ab. **Current Economic Problems.** 6 units (3-0-3); first, second terms.

A course in economic principles, approached through a study of current problems, national and international. An exploration of the causes and significance of inflation, unemployment, labor unrest, government controls, international trade and finance, and other headline topics. No textbook. Class discussions are based on news items, assigned readings, and special reports.

Instructor: Untereiner.

Ec 18. **Industrial Organization.** 9 units (3-0-6); second term.

After outlining the historical background of industry with the economic changes involved, this subject surveys the major problems facing management, especially in factory operations. The principal topics included are organization, plant layout, costs and budgets, methods, time and motion study, production control, labor relations, and wage scales.

Instructor: Untereiner.

Ec 25. **Business Law.** 6 units (3-0-3); third term.

The principles of law as applied to business affairs; a study of the law governing contracts, negotiable instruments, agency, partnership, corporations, and employer's liability. Studies will be made of engineering specifications.

Instructor: Archibald B. Young.

Ec 48. **Introduction to Industrial Relations.*** 9 units (3-0-6).

An examination of the causes of, and the proposed remedies for, some of the labor problems present in our modern industrial economy: unemployment, industrial accidents, illness, old age, wages, hours of work, and industrial disputes. In appraising solutions to these problems, consideration is given to (a) the history and functions of organized labor, (b) the efforts of employers to solve labor problems, especially through some of the techniques of personnel administration, and (c) the role of government in regulating labor conditions.

Instructor: Veysey.

*The fourth year Humanities electives to be offered in any given term will be scheduled before the close of the preceding term.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ec 100 abc. **Business Economics.** 10 units (4-0-6); first, second, third terms. Open to graduate students.

This course endeavors to bridge the gap between engineering and business, especially industry. It is intended for two groups of technically trained students: 1) those who wish, sooner or later, to take advantage of opportunities in industry beyond their strict technical fields, and 2) those who will be engaged in teaching and in scientific research, but who wish to get an understanding of industry in both its technical and philosophical aspects. The broad assumptions in the course are that technical training is an excellent approach to positions of general responsibility in business and industry, and that technically trained men going into industry can make significant contributions to the improved functioning of the economy.

The principal divisions of the subject matter of the course are: 1) business organization, 2) industrial promotion and finance, 3) factory management, 4) industrial sales, and 5) business economic topics, especially the business cycle. This treatment provides a description of the industrial economy about us and of the latest management techniques. The points of most frequent difficulty are given special study. The case method of instruction is used extensively in the course.

Instructor: Gilbert.

Ec 110. **Industrial Relations.** 10 units.

Not open to students who have taken Ec 48, Introduction to Industrial Relations. An introductory course dealing with the basic problems of employer-employee relationships and covering the internal organization of an enterprise, the organization and functions of unions, and the techniques of personnel administration with emphasis on the problem of setting wage rates. Two book reports are required.

Instructors: Gray, Arthur H. Young.

ENGLISH

English composition is prescribed for all students in the freshman year, and an introduction to 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 writing and speaking. The instruction in literature is intended to provide an appreciative acquaintance with some of the chief works of major authors, past and present, 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.

A comprehensive examination in English and history is required of all students at the end of the sophomore year. This examination is not confined to particular courses, but covers the general attainments of the students in their humanistic work throughout the first two years.

UNDERGRADUATE SUBJECTS

En 1 abc. **English: Reading, Writing, and Speaking.** 6 units (3-0-3); first, second, third terms.

A thorough review of the principles of composition; constant practice in writing and speaking; and an introduction to studious reading of essays, biographies, short stories, novels and plays.

Instructors: Bode, Davenport, Eagleson, Eaton, Huse, Jones, Judy, MacMinn, Sheridan, Stanton.

En 7 abc. **Introduction to Literature.** 8 units (3-0-5); first, second, third terms.

Prerequisite: En 1 abc.

This course is designed to give the student a discriminating acquaintance with a selected group of principal literary works. The reading for the first term is concentrated on Shakespeare; for the second and third terms, on representative British and American authors.

Instructors: Eagleson, Eaton, Huse, Jones, Judy, MacMinn, Stanton.

En 8. **Contemporary English and European Literature.*** 9 units (3-0-6).

Senior elective. Prerequisite: En 7.

A survey of English and Continental literature from the last quarter of the nineteenth century to the present.

Instructors: Eagleson, Judy.

En 9. **American Literature.*** 9 units (3-0-6).

Senior elective. Prerequisite: En 7.

A study of major literary figures in the United States from Whitman and Mark Twain to those of the present. The larger part of the course is concerned with contemporary writers. An emphasis is placed on national characteristics and trends as reflected in novel and short story, biography, poetry, and drama.

Instructor: MacMinn.

En 10. **Modern Drama.*** 9 units (3-0-6).

Senior elective. Prerequisite: En 7.

A study of leading European, British, and American dramatists from Ibsen to writers of the present. Special attention is given to dramatic technique, and to the

*The fourth year Humanities electives to be offered in any given term will be scheduled before the close of the preceding term.

plays both as types and as critical comments upon life in the late nineteenth and twentieth centuries.

Instructors: Huse, Stanton.

En 11. **Literature of the Bible.*** 9 units (3-0-6).

Senior elective. Prerequisite: En 7.

A study of the Old and New Testaments, and the Apocrypha, exclusively from the point of view of literary interest. The history of the English Bible is reviewed, and attention is brought to new translations. Opportunity is offered for reading modern fiction, poetry, and drama dealing with Biblical subjects.

Instructor: MacMinn.

En 12 abc. **Debating.** 4 units (2-0-2).

Elective, with the approval of the Registration Committee.

A study of the principles of argumentation; systematic practice in debating; preparation for intercollegiate debates.

Instructor: Untereiner.

En 13. **Reading in English and History.** Units to be determined for the individual by the department.

Elective, with the approval of the Registration Committee, in any term.

Collateral reading in literature and related subjects, done in connection with regular courses in English or history, or independently of any course, but under the direction of members of the department.

En 14. **Special Composition.** 2 units (1-0-1).

This subject may be prescribed for any student whose work in composition, general or technical, is unsatisfactory.

En 15 abc. **Journalism.** 3 units (1-0-2); first, second, third terms.

Elective, with the approval of the Registration Committee.

A study of the elementary principles of newspaper writing and editing, with special attention to student publications at the Institute.

Instructor: MacMinn.

En 16. **Spelling.** No credit.

This subject may be prescribed for any student whose spelling is unsatisfactory.

En 17. **Technical Report Writing.*** 9 units (3-0-6).

Senior elective. Prerequisite: En 7.

Practice in writing reports and articles in engineering, science, or business administration. The course includes some study of current technical and scientific periodicals. The major project is the preparation of a full-length report.

Instructors: MacMinn, Stanton.

FIFTH-YEAR AND ADVANCED SUBJECTS

En 100 abc. **Seminar in Literature.** 9 units (3-0-6).

A study of some selected group of writers chosen to illustrate modern trends in literary and social history.

Instructors: Wright and others.

*The fourth year Humanities electives to be offered in any given term will be scheduled before the close of the preceding term.

HISTORY AND GOVERNMENT

All students are required to pass a comprehensive examination in English and History at the end of the sophomore year. This examination does not cover specific courses, but the general attainments of the students in their systematic work throughout the first two years.

UNDERGRADUATE SUBJECTS

H 1 abc. **History of European Civilization.** 5 units (3-0-2); first, second, third terms.

Lectures and discussions of the civilization of Greece and Rome, of the institutions of the Middle Ages, of the foundations and development of the modern Eurpean state system, and of the commanding problems of our own day.

Instructor: Craig.

H 2 abc. **American History.** 6 units (2-0-4); first, second, third terms.

Lectures and discussions on the History of the United States since colonial times, with special attention to constitutional development and the changing aspects of the country's foreign relations.

Instructors: Schutz, Sterling.

H 4. **The British Empire.*** 9 units (3-0-6).

A study of the development of Britain's Empire since the Napoleonic era.

Attention will be paid to such topics as: The breakdown of the old imperial policy as effected by the American Revolution, the industrial revolution, and the liberal-humanitarian movement of the 19th century; the establishment of new imperial interests in China, Southeast Asia, the Southwest Pacific, and Africa; imperial competition with France, Germany, Russia and the United States; the internal development of colonies and dominions and the emergence of the British Commonwealth of Nations; the problem of Home Rule for India.

Instructor: Sterling.

H 5 ab. **Current History.** 2 units (1-0-1); first, second terms.

This subject is given collaterally with senior humanities electives, and is articulated with a selected weekly journal of general information and opinion. Its purpose is to direct attention to outstanding problems in current national and international affairs.

Instructor: Sterling.

H 7. **Modern and Contemporary Germany.*** 9 units (3-0-6).

A study of what is sometimes called "The German Problem." A brief review of modern German history to the accession of Frederick II (The Great) to the throne of Prussia in 1740 will be followed by a more intensive treatment of German history in the subsequent period. Attention directed to: the rise and growth of Prussia; the political unification of Germany; the expansion of German influence in Europe, the Near East, and overseas; German economic development; domestic problems such as church and state, the state and education, representative and responsible government, state socialism and labor unions; the first world war and its aftermath; the National Socialist Revolution; and the second world war; problems of peace-making.

Instructor: Sterling.

H 8. **The History of Russia.*** 9 units (3-0-6).

An account and discussion of the rise of Russia as a national state; of Russian national expansion in Eurasia and of Russia's long struggle to secure warm water outlets for her land empire. Special emphasis will be placed on a study of Russian

*The fourth year Humanities electives to be offered in any given term will be scheduled before the close of the preceding term.

economic development, particularly as regards the "land problem," and on the growth of the revolutionary movement of the 19th and 20th centuries.
Instructor: Sterling.

H 10. **The Constitution of the United States.** 2 units (1-0-1); third term.
A study of the principles and provisions of the national constitution in the light of present-day interpretation by the courts. Required of all seniors.
Instructor: Munro.

H 12. **The History of Europe since 1789.*** 9 units (3-0-6).
This course, beginning with the French Revolution, will attempt to trace the development and spread of popular nationalism and political democracy throughout the countries of Europe, showing how these were affected by increasing industrialization and competiton for overseas markets and materials. The course will pay particular attention to the origins of the First World War, to the revolutionary movements growing out of that war, and to the circumstances which led to World War II.
Insructor: Sterling.

H 13. **Military and Naval History.*** 9 units (3-0-6).
This course will seek to analyze the basis of national power, not only of the United States in its position of unprecedented strength and responsibility, but also of the other great powers of history. Emphasis will be placed on the military and naval aspects of this power, and on the period since the Industrial Revolution.
Instructors: Craig, Sterling.

H 14. **Anglo-American Relations Since 1783.*** 9 units (3-0-6).
This course is intended to make an all-round survey of the varied ties between England and the United States. Much cultural, economic, literary, and social history will be included, in addition to the more conventional diplomatic and political history.
Instructor: Davies.

H 15. **The World Since 1914.*** 9 units (3-0-6).
This course is intended to provide a solid survey of recent international relations. Its purpose will be to study: the machinery by which nations conduct their foreign affairs; national foreign policies; war and its origins; the rise of new political philosophies; industrial development and ramifications; population trends; the problem of empire and dependent peoples; international law and organization. Special effort will be made to relate United States policy to this complex of problems.
Instructor: Sterling.

FIFTH-YEAR AND ADVANCED SUBJECTS

H 100 abc. **Seminar in History and Government.** 9 units (3-0-6).
A study of recent developments in national and international history.
Instructors: Davies, Sterling, and others.

*The fourth year Humanities electives to be offered in any given term will be scheduled before the close of the preceding term.

LANGUAGES

The subjects in modern languages are arranged primarily to meet the needs of science students who find it necessary to read books, treatises, and articles in French and German. In the study of these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English.

L 1 ab. **Elementary French.** 10 units (4-0-6); second, third terms.

A subject in grammar, pronunciation, and reading that will provide the student with a vocabulary and with a knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency in this subject. Students who have had French in the secondary school should not register for these subjects without consulting the Professor of Languages.

Selected readings.

Instructor: Bowerman.

L 32 abc. **Elementary German.** 10 units (4-0-6); first, second, third terms.

This subject is presented in the same manner as the Elementary French. Students who have had German in the secondary school or junior college should not register for these subjects without consulting the Professor of Languages.

Instructor: Bowerman.

L 35 a. **Scientific German.** 10 units (4-0-6); first term.

Prerequisite: L 32 abc, or one year of college German.

This is a continuation of L 32 abc, with special emphasis on the reading of scientific literature.

Instructor: Bowerman.

L 39 abc. **Reading in French 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 or German, done under direction of the department.

L 40. **German Literature.*** 9 units (3-0-6); third term.

Prerequisites: L 32 abc, L 35 a.

The reading of selected German classics, poetry and drama, accompanied by lectures on the development of German literature. Elective and offered only to students whose work in the prerequisites has been above average. Selected readings from Schiller and other classical authors.

Instructor: Bowerman.

*The fourth year Humanities electives to be offered in any given term will be scheduled before the close of the preceding term.

PHILOSOPHY, PSYCHOLOGY, AND SOCIOLOGY

UNDERGRADUATE SUBJECTS

Pl 1. **Introduction to Philosophy.*** 9 units (3-0-6).
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.

Pl 4. **Ethics.*** 9 units (3-0-6).
The fundamental ethical concepts and theories that have emerged in the process of human thought. The major social problems of modern life.

Pl 5. **Sociology.*** 9 units (3-0-6).
The genesis and evolution of human society. The influence of economic, religious and social forces. The nature of social control and the analysis of mores, morals and legal codes. The development of social institutions and the nature of change in these institutions.
The class is conducted as a discussion group.
Instructor: Laing.

Pl 6. **General Psychology.*** 9 units (3-0-6).
A study of modern psychological theory and practice. Among topics considered are: the nature and measurement of intelligence; human and animal learning; feeling, emotion, attitude; nervous structures and functions; sense organs and functions; imagination, dreams; memory and forgetting; current psychological doctrines, etc.
Instructor: Brighouse.

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl 100 abc. **Seminar in Philosophy.** 9 units (3-0-6).
A study of some aspects of philosophical, ethical or social development.
Not given 1946-47.

*The fourth year Humanities electives to be offered in any given term will be scheduled before the close of the preceding term.

HYDRAULICS

UNDERGRADUATE SUBJECTS

Hy 1. **Hydraulics.** 9 units (3-0-6); first term.

Prerequisites: AM 1 abcd, or concurrent registration.

A general survey of the kinematics and dynamics of fluid motion. General equations of motion, applications to laminar flow, turbulence and the boundary layer, flow in pipes and channels, flow around immersed bodies, turbulence and heat transfer, sediment transportation, cavitation, wave motion.

Hy 2 ab. **Hydraulics.** 9 units (3-0-6); second and third terms. (For Civil Engineers)

Prerequisite: AM 1 ab.

Kinematics and dynamics of fluid motion with particular emphasis on the properties of water. Hydrostatics, flow of water in pipes, nozzles, channels; hydraulic turbines; centrifugal pumps and other hydraulic equipment.

Hy 11. **Hydraulic Laboratory.** 6 units (0-6-0); second term.

Prerequisite: AM 1 abcd.

Experiments on the characteristics of fluid flow and tests of hydraulic machines.

ADVANCED SUBJECTS

Hy 100. **Hydraulics Problems.** Units to be based upon work done, any term. Special problems or courses may be arranged to meet individual needs.

Hy 101 a. **Advanced Fluid Mechanics.** 6 units (2-0-4); second term.

Prerequisites: Hy lab. or Hy 2 ab and Hy 11.

Dimensional analysis; hydraulic similitude, theory and use of hydraulic models; elementary principles of flow; principles of energy, continuity and momentum; theory and use of the flow net; development of generalized equations of flow; circulation and vorticity; velocity and force potentials; stream function; conformal transformation; cavitation; equations of viscous motion; laminar flow; lubrication; percolation.

Instructor: Wagner.

Hy 101 b. **Advanced Fluid Mechanics.** 9 units (3-0-6); third term.

Prerequisite: Hy 101 a.

Fluid turbulence; boundary layer; separation; resistance of immersed bodies; flow in closed conduits; resistance and roughness; flow in open channels; hydraulic jump; sub- and super-critical flow phenomena; weirs and spillways; erosion; transportation of sediment; wave phenomena; and miscellaneous topics.

Instructor: Wagner.

Hy 200. **Advanced Work in Hydraulic Engineering.** Units to be based upon work done; any term.

Special problems in hydraulics will be arranged to meet the needs of students wishing to do advanced work in this field.

Hy 201 abc. **Hydraulic Machinery.** 6 units (2-0-4); first, second, third terms.

A study of such rotating machinery as turbines, pumps, and blowers, and their design to meet specific operating conditions.

Hy 202 ab. **Hydraulics of Free Surface Phenomena.** 6 units (2-0-4).

A study of the hydrodynamics of a fluid having a free surface with special reference to gravity wave phenomena. Fields studied will include low and high velocity in open channels and wave phenomena in enclosed bodies of fluid.

Hy 203. **Cavitation Phenomena.** 6 units (2-0-4).

Study of the experimental and analytical aspects of cavitation and allied phenomena. Problems will be considered from the field of hydraulic machinery and also for bodies moving in a stationary fluid.

Hy 210 ab. **Hydrodynamics of Sediment Transportation.** 6 units (2-0-4).

A study of the mechanics of the entrainment, transportation, and deposition of solid particles by flowing fluids. This will include problems of water and wind erosion, and density currents.

Hy 300. **Thesis.**

INDUSTRIAL DESIGN

FIFTH-YEAR SUBJECTS

ID 101 abc. **Industrial Design I.** 15 units (2-9-4); first, second, third terms.

Basic elements in industrial design. Analysis of interdependence of function, construction, or manufacturing process, material and appearance. Abstract and practical form problems. Selected problems in product design.

Instructors: Welch, Greene.

ID 111 abc. **Experimental Laboratory.** 8 units (0-8-0); first, second, third terms.

Training in carrying design concepts from the drawing through a working model. Instruction in shop procedures as applied in industry to production in metallic and non-metallic materials.

Instructor: Morant.

ID 121 abc. **Design Techniques I.** 3 units (0-3-0); first, second, third terms.

Instruction in the methods of two and three dimensional presentations, including free-hand and mechanical drawing, lettering, perspective, color rendering, model construction, montages, and use of photography in presentation.

Instructors: Merendino, Welch.

ID 131. **Design Trends.** 3 units (1-0-2); first term.

The evolution of industrial design through the various phases of machine age styles.

Instructors: Greene, Welch.

ID 141 abc. **Non-Metallic Materials.** 9 units (3-0-6); first, second, third terms.

A study of plastics, fibres, and the developments of the chemical laboratory as related to modern manufacturing and design.

Instructor: Youtz.

ID 151. **Cost Analysis.** 5 units (2-0-3); third term.

Instruction in specialized accounting practice of value to the designer in controlling, analyzing, and estimating production costs and in cooperating with the needs of industry.

Instructor: Huston.

ID 161. **History of Art.** 3 units (1-0-2); second term.

A survey of the development of forms through the ages with the correlation of aesthetic expression and theory with the cycles of political, social, and economic change.

Instructors: Visiting Lecturers and Members of the Faculty.

ADVANCED STUDIES

ID 201 abc. **Industrial Design II** (Thesis). 21 units (2-15-4); first, second terms; 24 units, third term.

Selected advanced problems in industrial design and a major problem selected individually by the student, giving an opportunity and the encouragement for the exercise of personal initiative in the solution. This class is conducted as a seminar. The third term is devoted largely to thesis work.

Instructors: Visiting Lecturers and Members of the Faculty.

ID 211 abc. **Production Methods.** 8 units (1-6-1); first, second, third terms.
Tool engineering, tool planning, and tool design. Industrial practices and research.
Instructor: Morant.

ID 221 abc. **Design Techniques II.** 7 units (0-7-0) first, second terms; 4 units (0-4-0) third term.
Production illustration, breakdown-diagrams, and advanced training in presentation through color rendering.
Instructors: Merendino, Greene, Welch.

ID 231 abc. **Technical Trends in Design.** 6 units (2-0-4); first, second, third terms.
Analysis of industrial design problems as they appear from the standpoint of technological development and current manufacturing trends. Review of patent and trademark regulations as affecting the work of the professional designer.
Instructor: Youtz.

ID 241 abc. **Merchandising Analysis.** 9 units (2-3-4); first, second, third terms.
A study of the broader implications of the work of the designer in controlling and analyzing public demand and needs as related to manufacturing, marketing, and pricing problems.
Instructor: Youtz.

Supplementary lectures by visiting designers and engineers, and seminars are offered as occasion permits. (See page 109).

MATHEMATICS

UNDERGRADUATE SUBJECTS

Note: Students intending to take the Mathematics Option must indicate their choice at the beginning of their sophomore year.

Ma 1 abc. **Freshman Mathematics.** 12 units (4-0-8); first, second, third terms.

Prerequisites: High school algebra and trigonometry.

An introduction to differential and integral calculus and the fundamentals of plane analytic geometry.

Text: *Analytic Geometry and Calculus,* Phillips.

Ma 2 abc. **Sophomore Mathematics.** 12 units (4-0-8); first, second, third terms.

A continuation of the freshman calculus, through partial differentiation, multiple integration and the use of series. The course includes as well topics in solid analytic geometry and vector analysis.

Texts: *Calculus* and *Analytic Geometry,* Middlemiss; *Analytic Geometry and Calculus,* Phillips.

Ma 3. **Theory of Equations.** 10 units (4-0-6); first term.

Includes topics in algebra of interest to mathematicians, physicists and applied mathematicians. Topics treated: numerical solution of equations, the fundamental algebraic operations, properties of number fields and polynomials, linear equations and determinants with application to vector spaces, symmetric functions.

Text: *Introduction to Theory of Equations,* Weiner.

Instructor: Wear.

Ma 4. **Geometry.** 10 units (4-0-6); second term.

A treatment of the classical metric, affine, and projective geometries of two and three dimensions.

Text: *Higher Geometry,* Graustein.

Instructor: Wear.

Ma 8. **Methods of Advanced Calculus.** 10 units (4-0-6); first term.

Prerequisites: Ma 1, 2.

This course will deepen and extend the students' knowledge of the techniques and methods of the calculus. The topics treated will include: elementary functions of a complex variable, line integrals, gamma functions, elliptic functions and calculus of variations.

Text: *Methods of Advanced Calculus,* Franklin.

Ma 10. **Differential Equations.** 10 units (4-0-6); second term.

Prerequisites: Ma 1, 2.

This course will stress the rigorous development of the subject rather than formal methods of solution. Topics treated will include the general existence theorems, systems of differential equations, solutions of equations by means of operators, series, and iteration methods, treatment of non-linear differential equations and perturbation methods.

Text: *Differential Equations,* Agnew.

Instructors: Goldsworthy, Ward.

Ma 12. **Elementary Statistics.** 9 units (3-0-6); first term.

Prerequisites: Ma 1, 2.

This course is intended for anyone interested in the applications of statistics to science and engineering, and is a prerequisite to all other courses in statistics. The topics treated will include the preparation and systematization of experimental

data, the fundamental statistical concepts; population, sample, mean and dispersion, curve fitting and least squares, significance tests and problems of statistical estimation.

Text: Selected references.

Instructor: Dilworth.

Ma 16. **Matrices and Quadratic Forms.** 10 units (4-0-6); third term.

This course is intended for mathematicians and those physicists and engineers who must use the methods and techniques of modern linear algebra. It will cover the more frequently used parts of matrix algebra, linear transformations, quadratic forms and linear spaces.

Instructors: Bell, Ward.

Ma 57. **Introduction to Analysis.** 15 units (5-0-10); third term.

Prerequisites: Ma 1, 2; and either Ma 8 or Ph 15.

This course will give a rigorous treatment of the fundamentals of classical real variable theory. Among the topics treated will be: the real number system, the concept of a function, continuity, differentiability, Riemann integrability, double limits and uniform convergence, infinite series and integrals, orthogonal functions, general properties of functions defined by definite integrals, the classical conditions for Fourier series expansions. This course or its equivalent is a prerequisite to graduate courses in analysis.

Ma 60. **Mathematical Probability and Statistics.** 9 units (3-0-6).

Prerequisites: Ma 12.

This course will give the mathematical development underlying modern statistical methods. Topics treated will include: characteristic functions, properties of the binomial, Poisson and normal distributions, the fundamental sampling statistics and their distributions, stochastic convergence and the central limit theorem.

Instructor: Dilworth.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ma 81 abc. **Advanced Calculus.** 6 units; three terms.

Prerequisites: Ma 1, 2.

This subject is the same as Ma 8, but with reduced credit for graduate students. Graduate students in mathematics receive no credit for taking this subject.

Ma 101 abc. **Modern Algebra.** 9 units; three terms.

Prerequisites: Ma 8, reading knowledge of German.

Abstract algebra as developed since about 1910.

Instructors: Bell, Dilworth.

Ma 102 abc. **Introduction to Higher Geometry.** 12 units; three terms.

Prerequisites: Ma 1 ab, 2 abd, 4 ab.

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

Instructor: Wear.

Ma 106 abc. **Introduction to Theory of Functions of Real Variables.** 9 units; three terms. Required for graduation (B.S.) in mathematics.

Prerequisite: Ma 8 ab.

Postulational treatment of real number system, descriptive properties of point sets, continuous and discontinuous functions, derivatives and differentials. Riemann integration, functions of several real variables, implicit functions. Modern integration theory. Topological spaces, metric spaces and normed spaces with special emphasis on function spaces, Hilbert spaces and Banach spaces. Existence theorems for differential equations. Theory of functionals and functional transformations.

Polynomials and power series in normed linear spaces. Differentials in normed linear spaces. Integral equations and other functional equations.
Instructor: Michal.

Ma 111 ab. **Elementary Theory of Tensors.** 9 units; two terms.
Prerequisites: Ma 8, 10.
Fundamental properties of tensors, differential forms, covariant differentiation, geodesic coordinates, Riemannian differential geometries. Applications to dynamics, fluid mechanics, elasticity theory and other physical and engineering subjects.
Instructor: Michal.

Ma 113 abc. **Geometry.** 12 units; three terms.
Prerequisite: Ma 2 abd.
Algebraic geometry; projective geometry; differential geometry; tensor analysis and its applications to numerous geometrical problems; non-Euclidean geometry; Riemannian differential geometry; geometry of dynamics; hyperspace; elementary group theory and its geometrical applications.
Texts: *Applications of the Absolute Differential Calculus,* McConnell; *Riemannian Geometry,* Eisenhart; collateral reading.
Instructor: Michal.

Ma 114 abc. **Mathematical Analysis.** 12 units; three terms.
Prerequisites: Ma 8, 10.
Theory of convergence, integration and residues, expansions of functions in infinite series, asymptotic and divergent series. Fourier series. Differential equations and function theory, integral equations, the gamma function and the zeta function, the hyper-geometric function and related functions of mathematical physics, elliptic functions, ellipsoidal harmonics.
This course will be offered every alternate year.
Text: *Functions of a Complex Variable,* Copson.
Instructors: Bohnenblust, Ward.

Ma 119 abc. **Introduction to Theory of Numbers.** 9 units; three terms.
Prerequisites: Ma 1 abc, 2 abc.
The fundamental theorem of arithmetic, continued fractions, congruences, Bernouilli numbers, quadratic residues, quadratic forms and other topics in elementary number theory.
Instructor: Ward.

Ma 137 abc. **Real Variables.** 9 units; three terms.
Prerequisites: Ma 8 or its equivalent.
The real number system; the fundamental concepts of topology and point-set theory; types of abstract spaces and mappings of spaces, set functions, functionals and sequences, continuous and discontinuous functions, series and summability methods, measure of sets, Lebesgue and Stieltjes integration, differentiability, function spaces and Hilbert space, linear operators.
Instructors: Bohnenblust, Ward.

Ma 138 abc. **Applied Mathematics.** 12 units; three terms.
Prerequisites: Ma 8 or Ma 10.
Matrix calculus, tensor calculus and operational calculus—including Laplace transform theory and numerical methods. Most of the course will be devoted to applications of the subjects to vibrations, circuit theory, flutter theory in aeronautics, fluid mechanics, elasticity theory, classical dynamics of particles and rigid bodies, and to modern physics. A brief but adequate introduction to analytic functions of a complex variable and conformal mapping will be given. The applications will include airfoil theory and the more advanced portions of Laplace transform theory.
Instructor: Michal.

Ma 139 abc. **Topology and Modern Geometry.** 9 units; three terms.
Prerequisites: Ma 8 and Ma 10.
An introduction to topology, topological algebra and topological spaces. Applications to various mathematical domains, especially to the foundations of Euclidean and Non-Euclidean geometries, and to the foundations of differential geometry.
Instructor: Michal.

GRADUATE SUBJECTS

Note: For all subjects numbered above 200, a reading knowledge of French and German is required.

Ma 202 abc. **Modern Theory of Differential Equations.** 9 units; three terms.
Prerequisites: Ma 10, 114.
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 205 abc. **Theory of Functions.** 15 units; three terms.
Theory of convergence and infinite processes, properties of continuous and discontinuous functions, functions of limited variation, selected topics on analytic functions, point sets, measure of point sets, Stieltjes integrals, Lebesgue integrals, Fourier series and integrals, orthogonal functions, convergence in the mean, geometry of Hilbert Space. Function theory in abstract spaces.
Text: *The Theory of Functions*, Titchmarsh.
Instructor: Michal.

Ma 209 abc. **Functionals and Functional Equations.** 15 units; three terms.
Prerequisite: Graduate standing in Mathematics, including a course in Analysis.
Functional operations; permutable functions, functions of composition; integral equations, integro-differential equations; differentials of functions, functional equations with functional derivatives; infinite matrices; Stieltjes and Lebesgue integrals; abstract spaces; partial differential equations and their characteristics; calculus of variations. Applications to the sciences. Analytic functionals.
Instructor: Michal.

Ma 218 abc. **Advanced Mathematical Statistics.** 9 units; three terms.
Prerequisite: Ma 60.
Characteristic function methods, the moment problem, limit theorems of probability theory, selected topics in sampling theory.
Instructor: Dilworth.

Ma 251 a. **Seminar in Algebra and the Theory of Numbers.** 6 units; first term.
Prerequisite: Graduate standing.
Topics selected to suit the class.
In charge: Bell.

Ma 251 b. **Mathematical Logic.** 6 units; second term.
Instructor: Bell.

Ma 251 c. **Theory of Algebraic Numbers.** 6 units; third term.
Prerequisite: Graduate standing.
Instructor: Bell.

Ma 252 abc. **Seminar in Continuous Groups.** 9 units; three 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. Topological groups.
In charge: Michal.

Ma 253 abc. **Seminar in Foundations of Abstract Algebra.** 6 units; three terms.

Prerequisite: Graduate standing.

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

In charge: Ward.

Ma 254 abc. **Seminar in Modern Theories of Integration.** 6 units; three terms.

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

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

In charge: Michal.

Ma 255 abc. **Methods of Mathematical Physics.** 12 units; three terms.

Prerequisites: Ma 8, 10.

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

Instructor: Ward.

Ma 256 abc. **Modern Differential Geometry.** 9 units; three terms.

Prerequisite: Graduate standing.

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

Instructor: Michal.

Ma 257 abc. **Seminar in Abstract Spaces.** 6 units; three terms.

Prerequisite: Graduate standing.

Metric spaces, linear vector spaces; topological spaces; abstract polynomials; general function theories; analysis and geometry in abstract spaces; connections with abstract algebra and the theory of functionals; analysis of selected papers of Frechet, Riesz and Banach; contemporary researches; applications to mathematical problems in modern theoretical physics.

In charge: Michal.

Ma 260. **Reading.**

Occasionally advanced work is given by a reading course under the direction of an instructor. Hours and units by arrangement.

Ma 261. **Research.**

By arrangement with members of the staff, properly qualified graduate students are directed in research. Hours and units by arrangement.

Ma 270 abc. **Seminar in Applied Mathematics.** 6 units; three terms.

Prerequisite: Graduate standing.

Subjects selected according to the interest of the members of the seminar.

In charge: Michal.

Ma 271 abc. **Seminar in Mathematical Analysis.** 3 or 6 units; three terms.

A fortnightly seminar open to anyone who has taken or is taking a course in analysis or functional theory.

In charge: Michal.

MECHANICAL ENGINEERING

UNDERGRADUATE COURSES

ME 1 a. **Empirical Design.** 3 units (0-3-0); second term.
Prerequisites: D 1 abc.
This course is designed to supplement D 1 bc with the more advanced drafting and layout techniques, and to introduce elementary principles of design. Drafting room problems are formulated to incorporate these principles and to introduce the use of design reference material.
Instructors: Tyson, Welch.

ME 1 b. **Empirical Design.** 6 units (0-6-0); third term.
Prerequisites: D 1 abc, D 2, ME 1 a.
This course is a continuation of ME 1 a. Problems involving simple design features, the use of reference material and a consideration of materials, are stressed. Machine mechanisms including the transfer of velocities and accelerations through linkages by graphical methods, gearing applications, gear trains and cams are studied in relation to layout and machine design.
Instructors: Tyson and Assistants.

ME 3. **Materials and Processes.** 9 units (3-3-3); first or second term.
Prerequisites: Ph 1 abc, Ch 1 abc.
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 with their relative importance industrially and with the competition for survival which these materials and processes continually undergo.
Text: *Materials and Processes*, Clapp and Clark.
Instructor: Clark.

ME 5 abc. **Machine Design.** 9 units (2-3-4); first, second, third terms.
Prerequisites: ME 1, AM 1 abc.
Application of the mechanics of machinery and strength of materials, which are reviewed and extended, to practical design and construction. Fastenings: riveting, welding, screws, bolts and keys. Power transmission: shafting, sleeve and rolling bearings, belts, chains, gears, couplings, and clutches. Elements of power machinery: cylinders, cylinder heads, piping and valves, springs, crankshafts, flywheels, packing and seals. Variety in design is explained by pointing out the different requirements of every application.
Instructor: Hollander.

ME 10. **Metallurgy.** 12 units (3-3-6); third term.
Prerequisite: ME 3.
A study of the properties of ferrous and non-ferrous metals and alloys with respect to their application in engineering; the principles of heat treatment for a proper understanding by engineers for application in specification of alloys for design. The microstructures of ferrous and non-ferrous metals and alloys are studied in the laboratory.
Text: *Engineering Physical Metallurgy*, Heyer.
Instructor: Clark.

ME 15 abc. **Thermodynamics and Fluid Mechanics.** 11 units (3-3-5); first, second, third terms.
Prerequisites: Ma 2 abc, ME 1 ab.
A study of the first and second laws of thermodynamics and their application to flow and non-flow processes both with and without friction. Emphasis will be

placed on single component systems. Fluid motion treated from the point of view of thermodynamics and of mechanics for flow with and without friction. Steady flow versus non-steady flow. Introduction to the detailed mechanics of fluid motion and its relation to energy dissipation.

Application of the basic principles to the main types of fluid motions encountered in engineering problems and to the main classes of industrial heat engines, thermodynamic processes, and hydraulic machinery.

Laboratory demonstrations of thermodynamic and fluid mechanic principles. Tests of industrial heat engines and hydraulic machinery.

Instructor: Daugherty.

ME 16 ab. **Thermodynamics.** 9 units (3-0-6) first term; 6 units (2-0-4); second term.

Prerequisite: ME 15 abc.

Further discussion of engineering applications of thermodynamics, including more detailed analyses of the examples included in ME 15, and additional items such as the following: Combustion processes and flue gas analysis; heat transfer (correlate conduction and convection discussion with fluid mechanics discussion of turbulence); gas and vapor mixtures.

Instructor: Daugherty.

ME 20. **Heat Engineering.** 9 units (2-3-4); first term.

An abridgement of ME 15, 16, and 17 for students in civil engineering.

ME 25. **Mechanical Laboratory.** 9 units (0-6-3); third term.

Prerequisite: ME 15 abc.

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

Text: *Power Plant Testing*, Moyer.

ME 50 ab. **Engineering Conferences.** 2 units (1-0-1); first, third terms.

A course in public speaking for engineers, on engineering topics.

Instructor: Daugherty.

FIFTH-YEAR AND ADVANCED SUBJECTS

ME 101 ab. **Advanced Machine Design.** 10 units (2-6-2); second, third terms.

Prerequisites: ME 5 abc, ME 10.

The application of machine elements to specific problems of design by combining them to form a self-contained unit for a definite purpose. Attack of such a design problem by setting up the different requirements of the specified unit, and showing how they may vary, according to the number of such units to be made, the methods of manufacture, space, weight, and cost limitations, required life, wear, and duty. Selection of materials and of permissible stresses and strains for various conditions. Examination and justification of established constructions, with a consideration of possible improvements and of different methods of approach.

Examples in the design course are chosen to broaden the students' knowledge of sound practice, and to show that for a good solution of such design problems a fundamental knowledge of mechanics, thermodynamics, and hydraulics is essential as well as a knowledge of the strength and properties of materials and the methods of forming them by casting, forging, welding, machining, and other processes.

Instructor: Hollander.

ME 105. **Mechanical Vibrations.** 12 units (4-0-8); first term.

Prerequisites: AM 1 abcd, Ma 10 or AM 15 abc.

A study of the theory of vibrating systems, and the applications of such theory to problems of mechanical design. Subjects considered include theory of resonant systems; elimination of undesirable vibrations; vibration instrumentation; periodic disturbing forces, such as in engine vibration problems; critical speed phenomena;

transient excitations; self-excited vibrations and instability in mechanical systems; introduction to non-linear systems.
Instructor: Hudson.

ME 110. **Physical Metallurgy.** 12 units (4-0-8); first term.
Prerequisite: ME 10.
A study of phase equilibria, the fundamental structure of metals and alloys, the transformations in steel, hardenability of steel, the function of alloying elements in steel, grain size and grain growth, precipitation hardening, and powder metallurgy.
Text: References and lecture notes.
Instructor: Clark.

ME 115 ab. **Thermodynamics.** 9 units (3-0-6) second term; 6 units (2-0-4) third term.
Prerequisites: ME 15 abc, ME 16 ab.
Advanced work in engineering thermodynamics and application to practical engineering problems.
Instructor: Daugherty.

ME 125 abc. **Engineering Laboratory.** 12 units (2-6-4); first, second, third terms.
The techniques of making measurements encountered in engineering practice and research, with the use of special and standard measuring instruments, and the recognition of precision and accuracy of data secured. The planning of tests and research, and the analysis of data.
Instructors: ME Department Staff.

ME 150 abc. **Mechanical Engineering Seminar.** 2 units (1-0-1); first, second, third terms.
Attendance required of graduate students in mechanical engineering. Conference on research work and reviews of new developments in engineering.
Instructor: Daugherty.

ME 200. **Advanced Work in Mechanical 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 206. **Vibrations Laboratory.** 6 units (0-3-3).
Prerequisites: One of the following courses; ME 105, AE 258 abc, AE 271 abc.
The experimental analysis of typical problems involving vibrations in mechanical systems, such as a study of the characteristics of a vibration isolation system, or a determination of the transient strain in a machine member subjected to impact loads. The measurement of strains, accelerations, frequencies, etc. in vibrating systems, and the interpretation of the results of such measurements. Consideration is given to the design, calibration, and operation of various types of instruments used for the experimental analysis of dynamics problems.
Instructor: Hudson.

ME 210 abc. **Science of Metals.** 9 units (3-0-6); first, second, third terms.
Prerequisites: ME 110.
A study of the atomic structure of metals in relation to properties, criteria for the formation of intermetallic compounds and solid solutions, plastic properties of single crystals and polycrystalline media, creep, internal friction, diffusion in metals, recrystallizatin, crystal structure, and special studies.
Text: References and lecture notes.
Instructor: Clark.

ME 211 abc. **Metallography Laboratory.** 8 units (1-6-1); first, second, third terms.

Prerequisite: ME 110.

Pyrometry, thermal analysis, preparation of metallographic specimens, photomicrography, macroscopy, carburizing, heat treatment, grain size, hardenability, structure of welded and brazed joints, and special problems.

Text: *Principles of Metallographic Laboratory Practice,* Kehl.

Instructor: Clark.

ME 215. **Internal Combustion Engines.** 9 units (3-0-6); one term.

Prerequisites: ME 15 abc, ME 16.

Advanced study of: engine cycles with real fuel-air mixtures, combustion processes, fuels, detonation, octane and cetane rating, engine performance, and design.

Instructor: Daugherty.

ME 216 ab. **Refrigeration and Air Conditioning.** 9 units (2-3-4); two terms.

Prerequisites: Heat Power (class and laboratory)

Principles of vapor and absorption refrigeration; composite cycles. Deep freezing and liquifaction of gases. Reversed cycles.

Principles of air conditioning: properties of air-water vapor mixtures, air conditioning cycles. Comfort air conditioning (residence, trains, airplanes), industrial air conditioning (food, photographic, textile, paper industries).

Instructor: Kyropoulos.

ME 217 ab. **Steam and Gas Turbines.** 9 units (3-0-6); two terms.

Prerequsites: ME 15 abc, ME 16.

(a) Steam Turbines: cycles, reheat factor, condition curve, construction features, operating characteristics, and design. (b) Gas Turbines: cycles, compressor design and performance, fuels and combustion chamber design nozzles, blading, cooling problems, and plant output and overall efficiency.

Instructor: Daugherty.

ME 218 ab. **Aircraft Power Plants (Reciprocating Engines).** 9 units (3-0-6); two terms.

Prerequisites: Heat power and internal combustion engines (class and laboratory).

Range of application of reciprocating aircraft engines. Thermodynamics and performance of spark ignition engines at altitude. Blower and exhaust turbine performance. Cruising contact. Flight testing cooling and cowling. Special design problems (injection, carburetion, lubrication, ignition).

Instructor: Kyropoulos.

ME 219. **Experimental Background of Engine Research.** 4 units (2-0-2); one term.

Prerequisites: ME 215, or to be taken concurrently.

Survey of combustion research in spark and ignition engines. Flame front observation. High speed indicators, detonation indicators. Study of experimental methods of fuel injection problems and droplet formation. Carburetion and direct injection in spark ignition engines. Hydrocarbon thermodynamics. Reaction kinetics. Measurement of ignition quality of spark and compression ignition fuels. Standard methods (ASTM-CFR). Power measurement at sea level and altitude.

Preparation of power charts and cruising charts. Measurement of exhaust composition and temperature. Measurement of cooling requirements and performance.

Texts: *Science of Petroleum* (Oxford Press). *I. C. Engines*, Pye (Oxford Press), *The Chemical Background of Engine Research* (Interscience Publishers).

Instructor: Kyropoulos.

ME 220. **Lubrication.** 6 units (2-0-4); one term.

Prerequisites: Internal combustion engines, machine design, hydrodynamics.

Hydrodynamic theory of lubrication. Application to actual bearings. Boundary lubrication. Interaction between bearing surface and lubricant. Extreme pressure lubricants, detergent oils. Lubricant performance in the engine.

Flow of viscous fluids (Reynolds, Sommerfeld) viscosity and friction. Pressure distribution and load carrying capacity of theoretical and actual bearing. Dimensional analysis of the problem. Partial bearings, thrust bearings. Temperature rise and heat dissipation. Bearings for high speed. Clearances. Gear tooth lubrication.

Boundary lubrication, problem, theory experiment. Interaction between surface and lubricant. Constitution of lubricating oils. Addition agents, detergents, extreme pressure lubricants. Property control of lubricants. Lubricant behaviour in the engine, corrosion, sludge formation.

Bearing metals; tin, lead, silver, etc.

Texts: *Theory of Lubrication*, M. D. Hersey (Wiley, 1939); *Lubrication*, A. E. Norton, (McGraw-Hill, 1942).

Instructor: Kyropoulos.

ME 300. **Thesis.**

METEOROLOGY

My 104. **Structure of the Atmosphere.** 3 units (1-0-2); third term.
Constituents of the atmosphere and their distribution, theories underlying the probable structure and temperature of the atmosphere. Radiation and absorption. Meteors, auroras and clouds of the stratosphere.
Instructor: Gutenberg.

My 105. **Climatology.** 6 units (2-0-4); third term.
Climatic controls and elements; general circulation, temperatures, precipitation, evaporation, condensation forms, the hydrologic cycle. Uses and sources of climatic data. Climatic classifications.
Instructor: Rempel.

My 201 abc. **Weather Forecasting and Practice.** 9 units (3-0-6) first, second terms; 6 units (2-0-4) third term.
A course in basic meteorology coordinated with My 202 abc. Techniques used in the preparation of 8, 24 and 48 hour short term forecasts. Modern theory on structure of extratropical cyclone, general circulation of the atmospheric air mass. Use of upper air soundings in synoptic analysis and forecasting. Detailed discussion of weather forecasting by means of frontal and air mass analysis supplemented by upper constant pressure analyses. Forecasting local weather phenomena such as fog, thunderstorms and icing with particular emphasis on their relationship to aircraft operations. Trans-oceanic forecasting.
Instructors: Krick, Ruch.

My 202 abc. **Meteorological Laboratory.** 15 units (0-15-0); first, second, third terms.
Decoding of synoptic and radiosonde reports; plotting and analysis of synoptic and constant pressure charts. Current data available through C.A.A. teletype facilities are used to simulate actual forecasting practice. Students prepare forecasts for various localities and airways routes.
Instructors: Blewett, Krick, Ruch, Stone.

My 203 abc. **Meteorological Instruments and Observations.** 4 units (1-3-0); first, second, third terms.
A thorough course in meteorological instruments and their use in addition to instruction in the making of visual observations and station operation. In the second and third terms students operate the weather station on a regular schedule. Thermometers, psychrometers, barometers, altimeters, anemometers, precipitation gages, nephoscopes, recorders. Theodolites and radiosonde transmitter-recorders.
Instructor: Blewett.

My 206. **Meteorological Geography.** 2 units (1-0-1); first term.
Physical geography of North America with emphasis on the meteorological significance of topography.

My 207. **Meteorological Thermodynamics and Kinematics.** 9 units (3-0-6); second term.
Atmospheric hydrostatics, barometric altimetry, stability of dry and moist air masses, thermodynamic diagrams, energy of thermal currents. Kinematics of the surface pressure chart, velocity and acceleration of isobars, highs, lows, fronts, frontogenesis.
Instructor: Stewart.

My 230 abc. **Meteorological Seminar.** 1 unit; first, second, third terms.
Reviews and discussions of current meteorological literature and problems.
In charge: Krick, Ruch.

My 240 ab. **Meteorological Research.** 3 units, second term; 6 units, third term.

Selected problems in meteorology research assigned to meet the needs of advanced students.

In charge: Elliott, Krick, Ruch.

My 251 abc. **Extended Forecasting, Theory and Practice.** 9 units (3-0-6) first, second terms; 6 units (2-0-4) third term.

Prerequisite: My 201 abc.

Modern methods used in the preparing of 5 and 7 day extended forecasts. Application of extended forecasts to problems of Industry, Agriculture, Commerce and Conservation.

Instructors: Elliott, Krick, Rempel, Ruch, Stone.

My 252 abc. **Advanced Meteorology Laboratory.** 15 units (0-15-0); first, second, third terms.

Prerequisite: My 202 abc.

Application of modern methods in the preparing of extended forecasts. Utilization of the Northern Hemisphere Synoptic Weather Types in the selection of analogues. Application of the 5 day method in the preparing of extended forcasts. Students prepare and verify extended practice forecasts.

Instructors: Elliott, Krick, Rempel, Ruch, Stone.

My 255. **Climatology.** 6 units (2-0-4); first term.

Prerequisite: My 105.

Climates of the continents. Micro-climatology. Methods of analysis of climatic data.

Instructor: Rempel.

My 257 abc. **Dynamic Meteorology.** 6 units (2-0-4); first, second, third terms.

The application of hydrodynamics to the study of atmospheric motions. Equations of motion and continuity, vorticity and circulation, geostropic winds, gradient winds, thermal winds, slopes of frontal surfaces, effects of viscosity, winds near the earth's surface, atmospheric diffusion, dissipation of kinetic energy, wave motion in the atmosphere.

Instructor: Stewart.

My 258. **Meteorological Statistics.** 6 units (2-0-4); second term.

Prerequisite: Ma 12.

Studies in time series: Periodicities, harmonic analysis, correlation spectra and the application to forecasting. Analytical treatment of time series. Multivariate statistical analysis and stochastic processes in meteorology.

Instructor: Darling.

PHYSICS

UNDERGRADUATE SUBJECTS

Ph 1 abc. **Mechanics, Molecular Physics, Heat and Sound.** 12 units (3-3-6); first, second, third terms.

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

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

Text: *Mechanics, Molecular Physics, Heat and Sound,* Millikan, Roller and Watson.

Instructors: Watson, Strong and Teaching Fellows.

Ph 2 abc. **Light, Electricity and Electron Physics.** 12 units (3-3-6); first, second, third terms.

Prerequisites: Ph 1 abc, Ma 1 abc, or their equivalents. A continuation of Ph 1 abc to form a well-rounded two-year course in general physics. A comprehensive examination covering the two-year course is given at the end of the third term.

Instructors: Neher and Teaching Fellows.

Ph 5 abc. **Introduction to Mathematical Physics.** 12 units (4-0-8); first, second, third terms.

Prerequisites: Ph 1 abc, 2 abc; Ma 2 abc.

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

Text: *Principles of Mathematical Physics,* Houston.

Instructor: Anderson.

Ph 6 abc. **Introduction to Mathematical Physics and Differential Equations.** 15 units (5-0-10); first, second, third terms.

Prerequisites: Ph 1 abc, 2 abc; Ma 2 abc.

An introduction to the application of mathematics, including vector analysis and differential equations, to physics; and practice in the solution of problems.

Text: *Principles of Mathematical Physics,* Houston.

Instructor: Anderson.

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

Prerequisites: Ph 1 abc, 2 abc; Ma 2 abc.

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

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

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

Prerequisite: Ph 6 abc.

A special course open only to students who have completed Ph 5 abc or Ph 6 abc.

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

Ph 9. **Electrical Measurements.** 6 units (0-6-0); first or second term.

Prerequisites: Ph 1 abc, 2 abc; Ma 2 abc.

An advanced course in precision electrical measurements at d.c. and low frequencies, measurement of impedance, voltage, current, frequency, etc.

Text: *Advanced Electrical Measurements,* Michels.

Instructors: Pickering and Teaching Fellows.

Ph 10. **High Frequency Measurements.** 8 units (0-6-2); second term.
A continuation of Ph 9 at radio frequencies.
Instructors: Pickering and Teaching Fellows.

Ay 1. **Introduction to Astronomy.** 9 units (3-1-5); third term.
This subject is intended to give the student sufficient familiarity with general astronomy to enable him to read with ease most of the semi-popular books dealing with various phases of the subject.
Text: *Astronomy*, Baker.
Instructor: Johnson.

UNDERGRADUATE OR FIFTH YEAR SUBJECTS

Ph 92 abc. **Introduction to Mathematical Physics and Differential Equations.** 10 units; first, second, third terms.
Prerequisites: Ph 1 abc, 2 abc; Ma 2 abc.
This subject is the same as Ph 6 abc but with reduced credit for graduate students.
Instructor: Anderson.

Ph 101 abc. **Electricity and Magnetism.** 9 units (3-0-6); first, second terms: 12 units (4-0-8); third term.
Prerequisite: An average grade of C in Ph 5 abc, or Ph 6 abc.
A problem course in electricity, magnetism and electromagnetic waves, intended primarily as a preparation for graduate work in science.
Text: *Static and Dynamic Electricity*, Smythe.
Instructor: Smythe.

Ph 103 abc. **Analytical Mechanics.** 12 units (4-0-8); first, second, third terms.
Prerequisite: Ph 5 abc, or Ph 6 abc.
A study of the laws of motion as formulated by Newton, d'Alembert, Lagrange, Euler, Jacobi, Hamilton, etc. Integration of the differential equations of mechanics by exact methods and by methods of successive approximations. Theory of small oscillations around statically and dynamically stable states; normal modes. Elementary theory of hydrodynamics and elasticity. Applications of the tensor calculus to mechanical problems.
Text: *Dynamics*, Webster.
Instructor: Davis.

Ph 105. **Optics.** 12 units (4-0-8); first term.
Prerequisite: Ph 5 abc, or Ph 6 abc.
A problem subject dealing with the fundamental principles of geometrical optics, of diffraction, interference, etc., and their experimental verification.
Text: *Theory of Optics*, Drude.
Instructor: Fowler.

Ph 106. **Optics Laboratory.** 6 units (0-6-0); first term.
Advanced laboratory work in light, consisting of accurate measurements in diffraction, dispersion, interference, polarization, spectrophotometry.
Text: *Manual of Advanced Optics*, Taylor.
Instructor: Fowler.

Ph 107. **Spectroscopy.** 9 units (3-0-6); second term.
Prerequisite: Ph 5 abc, or Ph 6 abc.
A discussion of observed spectra in terms of atomic structure theory.
Instructor: Bowen.

Ph 108. **Spectroscopy Laboratory.** 3 units (0-3-0); second term.
Laboratory work in the measurement and classification of spectral lines to accompany Ph 107.
Instructor: Bowen.

Ph 109 abc. **Atomic and Nuclear Physics.** 9 units (3-0-6); first, second, third terms.
Prerequisite: Ph 5 abc, or Ph 6 abc.
A problem and lecture course in the experimental and theoretical basis of modern atomic and nuclear physics. The properties of the fundamental particles are treated in detail as well as current concepts of the structure of atoms and nuclei. Nuclear disintegrations are considered at some length.
Instructors: Lauritsen and Fowler.

Ph 110 ab. **Kinetic Theory of Matter.** 9 units (3-0-6); first and second, or second and third terms.
Prerequisites: Ph 1 abc, Ma 2 abc.
During the first term, the fundamental concepts of the molecular theory of *matter are treated from the theoretical, experimental and technical viewpoints* (Clausius, Maxwell, Boltzman, van der Waals, Knudsen equations). During the second term, advance problems of the constitution of matter as well as practical applications are discussed (such as the thermodynamics of low temperature phenomena, liquifaction of gases, phase relations, specific heats, crystallization, plasticity.)
Instructor: Goetz.

Ph 111. **Physics of Electron Tubes.** 6 units (2-0-4); first or second term.
Prerequisite: Ph 5 abc, or Ph 6 abc.
Study of behavior of electron streams at both low and high frequencies, including the production of noise by electrons and effects of space charge.
Instructor: Neher.

Ph 112. **Microwave Circuits.** 6 units (2-0-4); second or third term.
Prerequisite: EE 15 ab.
A study of wave guides, cavities and their applications to high frequency *measurements.*
Instructor: Neher.

Ph 113. **Principles of Quantum Mechanics.** 9 units (3-0-6); first term.
Prerequisite: Ph 5 abc, or Ph 6 abc.
An outline, developed by means of problems, of the experimental and theoretical basis of quantum mechanics, including the idea of states, principle of indetermination, the Schrodinger equation, methods of approximate solution, electron spin, and Pauli principle.
Instructor: Oppenheimer.

Ph 117 ab. **X-Rays.** 9 units (3-0-6).
Prerequisite: Ph 5 abc, or Ph 6 abc.
A course covering the generation of X-rays and their interactions with matter in theory and in practical applications to research physics; including the early history of X-rays in atomic research, X-ray tubes and high voltage power supplies, generation of continuous and characteristic X-rays in targets, X-ray intensity *measurements, polarization, absorption, diffraction,* refraction, scattering, X-ray spectroscopy spectroscopic methods and instrumentation, the X-ray photoelectric effect, Compton effect, dynamical theory of X-ray diffraction, the Auger effect, scattering by liquids and gases, metallurgical applications, and relation of X-rays to atomic constants. During the latter part of the course, class members will be assigned topics to report from the literature.
Instructor: DuMond.

Ph 119. **History of Modern Physics.** 9 units (3-0-6); first term.
Prerequisites: Ph 1 abc, Ph 2 abc.
Instructor: Millikan.

Ph 120. **Seminar on the History of Physics.** 4-9 units; first, second, third terms.

Assigned reading and written and oral reports on selected topics in the history of physics. Students will be expected to make the acquaintance of as many as possible of the original memoirs of the great physicists and to study at least one such memoir very thoroughly. Reports will consist of illustrated lectures, biographies, critical studies, translations, bibliographies, etc. Recommended for all students who expect to teach.

Texts: *History of Science,* Dampier; *Rise of Modern Physics,* Crew.
Instructor: Watson.

Ph 142. **Research in Physics.** Units in accordance with the work accomplished. Approval of the department must be obtained before registering.

GRADUATE SUBJECTS

Ph 211. **Thermodynamics.** 12 units (4-0-8); first term.
Prerequisites: Ph 1 abc, 2 abc; Ma 2 abc.

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

Instructor: Epstein.

Ph 212 ab. **Mechanics of Continuous Media.** 12 units (4-0-8); second and third terms.
Prerequisite: Ph 103 abc.

Hydrodynamics of non-viscous fluids. Equations of Euler and Lagrange. General integrals and special problems. Tensor theory of deformations and of stresses. Hydrodynamics of viscous fluids. Equations of Stokes-Navier with applications to special problems. Fundamental equations of the theory of elasticity. Applications to static deformations of solids. Theory of elastic oscillations in space and in plates.
Instructor: Epstein.

Ph 223. **Theory of Electromagnetic Waves.** 12 units (4-0-8); second term.
Prerequisite: Ph 101 abc.

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

Instructor: Epstein.

Ph 225. **Theory of Electrons.** 12 units (4-0-8); third term.
Prerequisites: Ph 101 abc, Ph 223.

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

Instructor: Epstein.

Ph 226. **Heat Radiation and Quantum Theory.** 12 units (4-0-8); second term.
Prerequisites: Ph 103 abc, Ph 211.

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

Instructor: Epstein.

Ph 228. **Modern Aspects of the Quantum Theory.** 12 units (4-0-8); third term.

Prerequisites: Ph 103 abc, Ph 109 abc, Ph 229.

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

Instructor: Epstein.

Ph 229. **Quantum Mechanics.** 12 units (4-0-8); second and third terms.

Prerequisites: Ph 103 abc, Ph 109 abc.

Schrodinger's equation and matrix calculus. Applications to spectroscopy and atomic structure. Transformation theory. Dirac's electron equation. Fundamentals of the theory of the electromagnetic field and second quantization.

Instructor: Epstein.

Ph 232. **Dispersion and Absorption of Ultra-Short Electromagnetic Waves.** 6 units (2-0-4); first term.

Propagation of waves. Maxwell's dispersion and absorption in semi-conductors and metals. Electronic and dipolar dispersion and absorption in dielectrics. Dispersion and absorption in electrolytes. Waves along wires and dispersion in magnetic substances.

Experimental results on dispersion and absorption of ultra-short waves in dielectrics, electrolytes and magnetic substances.

Instructor: Potapenko.

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

Methods of measurements in the field of high and ultra-high frequencies.

Instructor: Potapenko.

Ph 236 abc. **Introdutcion to the Theory of Relativity.** 6 units (2-0-4); first, second and third terms.

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

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

Instructor: Tolman.

Ph 237 abc. **Selected Topics in Thermodynamics.**

Prerequisite: Previous work in thermodynamics.

Introduction to theromdynamics. Relation of thermodynamics to statistical mechanics. Thermodynamic properties of matter and radiation. Applications to steady and other non-equilibrium states.

Instructor: Tolman.

Ph 238. **Seminar on Theoretical Physics.** 4 units; first, second and third terms.

Recent developments in theoretical physics for specialists in mathematical physics.

In charge: Epstein.

Ph 239. **Seminar on the Solid State.** 4 units; first, second and third terms.

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

In charge: Goetz.

Ph 240. **Seminar on X-Radiation.** 4 units; second and third terms.

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

In charge: DuMond.

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

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

In charge: Epstein.

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

Opportunities for research are offered to graduate students in all the main branches of physics. The students should consult the department and have a definite program of research outlined before registering.

DEGREES AND CERTIFICATES CONFERRED, OCTOBER 20, 1944

Doctor of Philosophy

Stephen Winchester Dana *(Geophysics)*, A.B., Oberline College, 1940; M.S., University of Southern California, 1942

Jacob William Dubnoff *(Biology)*, A.B., University of California at Los Angeles, 1931; M.A., University of California, 1933

Ch'eng-Yi Fu *(Geophysics)*, B.S., National Tsing Hua University, 1933, M.S., McGill University, 1941

Chao-Wang Hsueh *(Physics)*, B.S., National University of Peking, 1931; M.S., California Institute, 1939

Joseph Frank Manildi *(Electrical Engineering)*, B.S., California Institute, 1940, M.S., 1942

John Wilder Miles *(Electrical Engineering)*, B.S., California Institute, 1942; M.S., 1943

Knox Millsaps *(Mathematics)*, B.S., Alabama Polytechnic Institute, 1940

Te-Hsien Pi *(Physics)*, B.S., Yenching University, 1932; M.S., 1934

Edward Rosenthall *(Mathematics)*, B.S., McGill University, 1937; M.S., 1938

Jurg Waser *(Chemistry)*, Certificate of Maturity, University of Zurich, 1935

Aeronautical Engineer

Harry James Heimer, S.B., *Massachusetts Institute of Technology, 1941*

Rudolph William Hensel, S.B., and S.M., Massachusetts Institute of Technology, 1942

John Laufer, B.A., Louisiana State University, 1942; M.S., California Institute, 1943

John Wilder Miles, B.S., California Institute, 1942; M.S., 1943

Civil Engineer

Joseph Bernard Franzini, Jr., B.S., California Institute, 1942; M.S., 1943

Master of Science in Science

GEOLOGY

Fernando Nieri-Castagnino, Civil Engineer, Catholic University of Peru, 1943

PHYSICS

Samuel Pope Morgan, Jr., B.S., California Institute, 1943

Master of Science in Engineering

AERONAUTICS

Ralph L. Geisberg, B.M.E., The Clemson Agricultural College, 1937

CIVIL ENGINEERING

Robert Lee Janes, B.S., California Institute, 1936

Carl Burdett Johnson, B.S., California Institute, 1938

John Kachig Minasian, B.S., California Institute, 1938

MECHANICAL ENGINEERING

Mehmet Nuri Berkant, B.S., Robert College, 1943

Ertugrul Birlik, B.S., California Institute, 1944

Ethem Ozkaragoz, B.S., Robert College, 1943

Sureyya Rafet Tanyildiz, B.S., California Institute, 1944

Bachelor of Science

SCIENCE

John Robert Nicholas
Philip Bartlett Smith
Robert McMaster Weidman

ENGINEERING

Phillip L. Adams
Rasit Hilmi Alpan
Edward McKean Atchison
Robert Pearson Brodie
Kenneth Grant Brown, Jr.
Robert Brydolf
Joseph Stanley Buller
Thomas Arthur Carter, Jr.
Joseph Howard Chadwick
Leonard Ivan Chang
Frank Byron Clendenen
Leo R. Coda
Louis George Dameson, Jr.
Ilif Ross Dana, Jr.
William R. Davis
Douglas George Dethlefsen
Weldon Roger Donsbach
Joseph Benjamin Earl, II
Almeron J. Field
Earle K. Fisher
Maurice Earl Ford, Jr.
James Robert Freeman, Jr.
John Howard Gardner
John Jepson Garland, Jr.
Donald Theodore Greenwood
Wilbur Lee Hall
William Robert Hamilton
Horace M. Higgins
Warren David Hinton, Jr.
Lawrence Urquhart Hudson
Richard Albert Hudson
Thomas Allan Hudson
Thomas Ernest Hudson
John Charles Huggins
Stephen D. Hurst
Ronald Stafford Johnson
Henry Clay Judd
Ferdinand Herman Karstedt
James Gilchrist Kerr
Leon Knopoff
Fred William Kruse, Jr.
Richard Eli Kuhns
Robert Frank Laabs
Robert Enos Lauterbach
Raymond Ralph Lochhead
Richard Henry Lockett
William Ellison Lockwood, Jr.
Neville Stuart Long
Francis Edward MacDonald, Jr.
Joseph Karl Mann
Robert Wallace Mapel
Robert Guthrie McAnlis
George DeWald McDonald, Jr.
Richard Vincent McGarrity
Ruben Fred Mettler
Charles Bradford Miller
John Alexander Mitchell
Thomas Wiley Norsworthy
George Mierow Osgood
Raymond Jefferson Palmer
Ralph Babcock Pastoriza
Donald Worthen Pendery
Joseph Mansfield Phelps
Eugene Fisher Pischel
Leonard Ernest Popp
Longueville Howe Price, Jr.
Robert Oram Randall
Richard Bradshaw Riddell
William Frederick Roberts
Alfred D. Robinson
Kirk H. Sadler
George Reamer Saunders
Harold W. Schaar
David Rice Shefchik
Philip Herbert Smith
John "J" Sogorka, Jr.
Wilbur Milton Swanson
Garland Staveley Taylor
William Anderson Tookey
Clemons C. Turner
John Robert Ukropina
Asim Mustafa Unayral
David Fenton Walker
George Mason Wood
George Ke-Wu Yik
William Brewster Young

Senior Certificates

(In recognition of the satisfactory completion of the minimum requirements of the Navy V-12 Engineering Specialist Program)

Dudley Earl Bennett
Robert Francis Blocker
William George Bongardt
Andrew Berrien Campbell
Robert Paul Cappadona
Carl Charles Coulson, Jr.
George Bainbridge Krause
John Arthur Langford
LeVal Lund, Jr.
Return Francis Moore
Robert Bruce Rosecrance
Marcelino Rueda
Roy William Wirta

DEGREES AND CERTIFICATES CONFERRED, FEBRUARY 24, 1945

Geophysical Engineer

Sulhi Yungul, B.S., Montana School of Mines, 1943; M.S., California Institute, 1944; Geophysical Engineer, 1945

Master of Science in Science

BIOLOGY

Barbarin Arreguin-Lozano, M.S., California Institute, 1945
Max L. Panzer, B.S., California Institute, 1944; M.S., 1945

PHYSICS

William Alvin Baum, A.B., University of Rochester, 1943; M.S., California Institute, 1945

Master of Science in Engineering

AERONAUTICS

John Robert Boyd, B.S., University of Illinois, 1942; M.S., California Institute, 1944

MECHANICAL ENGINEERING

Necat Turkbas, B.S., Robert College, 1943; M.S., California Institute, 1945

Bachelor of Science

SCIENCE

Charles Warren Hunt, III

ENGINEERING

Albert Nathaniel Baxter, Jr.
Raymond Finley Berbower
George Stanley Budney
John Stephen Davis
William Franklin Gulley
John Arnold Heinz
Richard Nathaniel Jasper
Richard Albert Berndt Knudsen
Edward Kenneth Lowe
Bradley Garsed Morison
John Francis Whitmore
Lawrence Edwin Wilferth, Jr.
Clarence James Woodard

Senior Certificates

(In recognition of the satisfactory completion of the minimum requirements of the Navy V-12 Engineering Specialist Program)

John Dwight Holmgren
Gordon Lloyd Johnson
Lucien Arthur Pascoe
Harry Van Akin

DEGREES AND CERTIFICATES CONFERRED, JUNE 22, 1945

Doctor of Philosophy

James Wallace Daily *(Mechanical Engineering)*, A.B., Stanford University, 1935; M.S., California Institute, 1937
Walter Beach Dandliker *(Biology)*, B.S., Rollins College, 1940
William Henry Eberhardt *(Chemistry)*, B.A., Johns Hopkins University, 1941
Andrej Fejer *(Aeronautics)*, M.E., Czechoslovak University for Technical Studies, Prague, 1936; B.S., California Institute, 1939
Walter Frederick Hiltner *(Civil Engineering)*, B.S., University of Washington, 1934; S.M., Massachusetts Institute, 1935
Yung-Huai Kuo *(Aeronautics)*, B.A., National University of Peking, 1935; M.A., University of Toronto, 1941
Shih-Wei Loo *(Biology)*, B.S., National Sun-Yat Sen University, 1931
Warren Orval Wagner *(Civil Engineering)*, B.S. CE, Washington State University, 1934; M.S., University of Michigan, 1936
Ernest Bevier Wright *(Biology)*, B.S., Yale University, 1938

Aeronautical Engineer

Charles Edward Gibson, B.S., United States Naval Academy, 1937
Elton Lewis Knapp, B.S., United States Naval Academy, 1938
Otis Ewing Lancaster, B.S., Central Missouri State Teachers College, 1929; M.A., Missouri University, 1934; PhD., Harvard University, 1937
Charles Nathaniel Levy, B.S., Massachusetts Institute, 1939
John Koebig Leydon, B.S., United States Naval Academy, 1938
Walter Bernard Miller, B.S., United States Naval Academy, 1939
Roger Blake Woodhull, B.S., United States Naval Academy, 1937

Master of Science in Science

CHEMISTRY

John H. Bryden, B.S., College of Idaho, 1942
Bertram Keilin, B.A., New York University, 1942

GEOLOGICAL SCIENCES

Harry William Carlson, Engineer of Mines, Colorado School of Mines, 1942
Bernardo Grossling Freudenburg, B.S., University of Chile, 1935; C.E., University of Chile, 1941; E.E., University of Chile, 1944

PHYSICS

Frederic Harley Coensgen, B.S., Montana State College, 1941
Carl Paul Wiedow, A.B., Occidental College, 1933; M.S., University of Southern California, 1935

Master of Science in Engineering

AERONAUTICS

Bruno Wilhelm Augenstein, Sc.B., Brown University, 1943
Walter Samuel Bradfield, B.S., Purdue University, 1941
Harry Frank Bunze, B.S., United States Naval Academy, 1940
Raymond Lu-Po Chuan, B.A., Pomona College, 1944
Gerhardt Christopher Clementson, B.S., United States Naval Academy, 1942

Gage Houston Crocker, S.B., Massachusetts Institute, 1943
Walter Kinsman Deacon, B.S., Worcester Polytechnic Institute, 1942
Thomas Atherton Dickey, B.S.E., Princeton University, 1940; M.E., Princeton University, 1941
Thomas Francis Dixon, B.E., Vanderbilt University, 1938; B.S.E., University of Michigan, 1939
Elwin Herklas Eddy, B.S., United States Military Academy, 1931
Franklin Sproles Edwards, B.S., Mississippi State College, 1936
Lawrence Daniel Ely, B.S., University of Michigan, 1932
Frederick Hartman Felberg, B.S., California Institute, 1942
John Dean Foster, B.S., University of Tulsa, 1942
Elmer Sherwood Franklin, B.S., California Institute, 1933; M.S., University of Southern California, 1937
Raymond Oswald Fredette, B.A., Holy Cross College, 1944
Charles Edward Gibson, B.S., United States Naval Academy, 1937
Thomas Parker Goebel, B.S., Iowa State College, 1944
Jeremiah Collins Hege, B.S., University of Maryland, 1942
Robert LeRoy Jackson, B.S., Texas Technological College, 1940
Joseph Kelley, Jr., Ae.E., University of Cincinnati, 1940
Elton Lewis Knapp, B.S., United States Naval Academy, 1938
Norman Edward Knapp, B.S.E., University of Michigan, 1932
John Koebig Leydon, B.S., United States Naval Academy, 1938
Wallace A. Lien, B.M.E., University of Minnesota, 1939; B.Bus.Ad., University of Minnesota, 1939
Arthur Leon Lowell, B.S., Massachusetts Institute, 1941
Herman Miller, B.S., California Institute, 1943
Walter Bernard Miller, B.S., United States Naval Academy, 1938
Dino A. Morelli, B.E., University of Queensland, 1938; M.E., University of Queensland, 1943
Roland Robert Morin, B.S., Rhode Island State College, 1943
Mason Whitney Nesbitt, B.S. (AE), Tri-State College of Engineering, 1935; B.S. (ME), Tri-State College of Engineering, 1935
Charles E. Neyland, B.S., Louisiana State University, 1944
Louis Gordon Pooler, A.B., Columbia College, 1920; A.M., Columbia University, 1921; PhD., Columbia University, 1930
Norman Charles Reucl, B.S., Georgia School of Technology, 1940
Jack Lynwood Ridley, B.S., University of Oklahoma, 1939
Emil Leonard Sorenson, B.Ae.E., University of Minnesota, 1941
William Francis Tiernan, Jr., B.S., Haverford College, 1936; B.S. (ME), Massachusetts Institute, 1938
Rayson Sung Tseu, B.S., Massachusetts Institute, 1941
Merritt Alvin Williamson, B.E., Yale Engineering School, 1938; M.S., Yale Graduate School, 1940
Roger Blake Woodhull, B.S., United States Naval Academy, 1937
Jesse Henry Zabriskie, B.S., University of Colorado, 1933
Louis Basil Zambon, B.S., University of Vermont, 1940

CIVIL ENGINEERING

Leonard Ivan Chang, B.S.(Ph), Holy Cross College, 1943; B.S.(Eng.), California Institute, 1944
Roland Luther Hummel, B.S., The Pennsylvania State College, 1941

METEOROLOGY

Chung Pen Ho, B.Sc., National Tsing-Hua University, 1932

Certificate in Engineering

AERONAUTICS

Jack Lawrence Shoenhair, University of California at Los Angeles, 1933-34, 1936-37

Bachelor of Science

SCIENCE

William George Bade
Donald Charles Dodder
Donal Baker Duncan
Brian Boru Dunne, Jr.
George Samuel Fein
Burton Edgar Freeman
James Warren Hadley
Albert R. Hibbs
Richard Churchill Honey
Joseph Frederick Hook
Robert Bernard Jordan
John Ballachey Lyon, Jr.
John Marshall Slye
Chester Roxy Stone
Don Richard Swanson
Theodore Brewster Taylor

Bachelor of Science

ENGINEERING

Allan James Acosta
Adrian Campbell Anderson
Kenneth Gale Anderson
Dale Harlan Austin
Halcyon Ball
David Collins Banks
Wesley Fuller Barnes
Donald Howbert Bates, Jr.
Robert Royce Bennett
Charles Andrew Bergman
Eugene Wright Bolster
Howard Alfred Booth, Jr.
Charles Walter Bozarth, Jr.
Fred Melvelle Briggs
Harry W. Brough, III
Billy Frank Burke
James Donahue Burke
William Robert Burns
Kenneth Ray Burrell, Jr.
Linden Robert Burzell
John Dewey Cardall, Jr.
Glenn Allan Cato
Stanley Dimock Clark
William Larry Collins
William Herbert Cook
Paul Robert Crawford, Jr.
Charles Russell Cutler
Charles Melville Davis
Louis Henry Davy
Frank Miles Day
Richard Albert Dean
Frank John Dore, Jr.
James Hughes Drake
Sidney Lewis Elicks
Edward Robert Elko
William James Elliott
Albert Armen Erkel
Martin Carl Fanz
Norman B. Fjeldsted
Harold Harrison Ford, Jr.
Harrison William Fox
William Ensign Frady
Donald Lowell Francis
Lawrence Eugene Fuller
Albert Stewart Fulton
Paul Revere Gardner, Jr.
Raymond Clyde Gerber, Jr.
John Mitchell Gerty
James Billy Green
Theodore Grossberg
Lawrence G. Hall
Jerome Smyth Harrington
Clifford O. Harvey, Jr.
William Edwin Heller
Richard Val Henry
Paul Luther Horrer
George Marvel Howe
Robert Milton Howe
Clive Tanner Jackson
Robert Power Jenkins
Ivan Whitfield Keith
Robert John Kieckhefer, Jr.
Roy Garfield Killian
Harry Pearce Kling
Robert Vernon Knox
Paul William Kohlhaas
Charles Eugene Lamar
John Lyman Leech
Donald McCloud Leinweber
Robert Emmet Leo
Leslie Howard Levin
Donald Duncan MacDougall
Norman James Magneson
John Ward Maloney
Warren Monroe Marshall, III
Marshall Edward McElhannon
John Dill McKenney
Wayne Taylor McMurray
Duane Torrance McRuer
Burton Gershon Mendelson
Max Henry Moore
James Herbert Moran
John Austin Morgan
Walter Lee Murphy
William Alexander Myers
James Keith Nason
Richard Fulcher Neerken
John Frederick Nichols

Bachelor of Science—Continued

John Henry Nichols, Jr.
Lewis Calvin Norton
Lloyd Edward Ott
Warren Harvey Parker, Jr.
Jerome Wesley Parks
Lowell C. Parode
William Fred Paulsen
William Reese Perkins
Robert Edward Phillips
Robert Charles Poolman
Terry Macbeth Prudden
Richard J. Reed
Jonathan Frederick Rice
Charles Arthur Rickard
Wayne Arthur Roberts
Carl Frederick Romney, Jr.
Robert Young Scapple
Alfred Dale Scarbrough
Robert Fredrick Schmoker
Harris McIntosh Schurmeier
Eugene Llewellyn Scott
Kenneth Melville Shauer
Donald Wesley Sinclair
Dudley Burcham Smith
Raymond James Smith
William H. Smith
Donald Clinton Snyder
Richard Earl Springer
John Junior Stefanoff
John Louis Stern
Donald Hanly Sweet
William Stacy Tatlock
Edward C. Taylor, Jr.
Charles Arthur Teets
Richard Clark Teitsworth
Donald Calvin Tillman
Robert Clarence Tookey
Robert Glenwood Trout
Bruce Rolff Vernier
Merle Gordon Waugh
John Vernon Werme
Hugh Sloan West
Raymond Croasdale Wheeler, Jr.
Arthur Curtner Wilbur
George McIntosh Wilhelm
Robert Edwin Wilkinson
Robert William Williams
Melvin Noble Wilson, Jr.
Ralph D. Winter
Frank Andrew Yank
Thayne Harwood Young, Jr.

Senior Certificate

(In recognition of the satisfactory completion of the minimum requirements of the Navy V-12 Engineering Specialist Program)

Rolland Sanford Asher
Max Merton Aydelott
Richard Stephen Barna
Edward Alfred Bohjanen
Joseph Michael Caprio
Frederick Henry Davis
Harold Frederick Deppe
Eugene Freedman
Paul Gibson
Willard Samuel Houston, Jr.
John William Huggins
Alvin Hyman
Robert Murray Kendall
Edward Joseph King
Eugene Adolph Liekhus
Edward Wilson Miller
Roland Holgate Nielsen
Raymond Lloyd Olson
David Russell Opperman
Paul Leonard Pecchenino
John Andrew Pryor
Wilfred Joseph Remillard
William Bliss Rogers
Jerrell Lloyd Sanders
William Arnold Selby
George Donald Shipway
Stanford Grant Stiles
Roger Dean Stuck
Warren Stanley Torgerson

DEGREES AND CERTIFICATES CONFERRED, OCTOBER 26, 1945

Master of Science in Science

CHEMISTRY

James Albert Seneker, A.B., Greenville College; M.S., California Institute, 1945

PHYSICS

Walter William Garvin, B.S., Massachusetts Institute, 1944; M.S., California Institute, 1945

Burton L. Henke, A.B., Miami University, Ohio, 1944; M.S., California Institute, 1945

William Frank Hornyak, B.E.E., College of New York, 1944; M.S., California Institute, 1945

Master of Science in Engineering

CIVIL ENGINEERING

Victor A. Ari, B.S., Tomas Frias University, 1943; M.S., California Institute, 1945

Bachelor of Science

SCIENCE

John Sterling Jackson, Jr.

ENGINEERING

Leland Irwin Auslender
Dean L. Bryner
Truland H. Carter
Billy Ray Dotson
Stanley Eugene Farmer
Wallis Taylor Fleming
John Henry Gerpheide
Richard Warren Hall
Jack Dewey Krause
Mark M. Macomber
Robert Doelter Mason
William Carl McDonell
Emanuel Jacques Miller
Paul Glen Rasmussen
Bertram Joseph Rodgers, Jr.
K. Martin Stevenson, Jr.
Grant Dexter Sullivan
Robert Wilson Taylor
Donald Kenneth Traverse
Ralph Simpson White, Jr.

Senior Certificate

(In recognition of the satisfactory completion of the minimum requirements of the Navy V-12 Engineering Specialist Program)

Robert Combs Belyea
Norman Ray Lee
Donald Ransom Lindsay
Henry William Schroeder
Robert Lawrence Walker

DEGREES AND CERTIFICATES CONFERRED, FEBRUARY 22, 1946

Doctor of Philosophy

David Ronald Howton *(Chemistry)*, B.S., California Institute, 1942
Dino A. Morelli *(Civil Engineering)*, B.E., University of Queensland, 1938; M.E., University of Queensland, 1943; M.S., California Institute, 1945
Maurice M. Rapport *(Chemistry)*, B.S., College of City of New York, 1940
John William Sease, A.B., Princeton University, 1941

ELECTRICAL ENGINEER

Jennings Roy David, B.S.E.E., University of Colorado, 1940; M.S., California Institute, 1942

Master of Science in Science

CHEMISTRY

Luther Axtell Richard Hall, B.A., Wesleyan University, 1944
Terrell C. Myers, A.B., Whittier College, 1942

GEOLOGY

John Franklin Lance, B.A., College of Mines and Metallurgy, Texas, 1938
Samuel Theodore Martner, A.B., University of California, 1940

METEOROLOGY

Warren Walt Berning, B.A., University of Cincinnati, 1942
Edmund Bromley, Jr., A.B., New York State College for Teachers, 1938
Fletcher Lynn Brooks, B.S., Trinity University, 1941
James Vital Doyel, B.A., Henderson State Teachers College, 1941
Allan Binford Elliott, B.B.A., University of Cincinnati, 1942
Arthur E. Marshburn, B.A., Whittier College, 1941
Olav Njus, B.A., Concordia College, 1937
Robert Wilfred Pentney, B.A., Willamette University, 1942
Carl Koenig Salbach, A.B., Fresno State College, 1939
Harvey Franklin Smith, Jr., B.A., La Verne College, 1941
George Philip Weber, B.S., *(Chemistry)*, University of Illinois, 1937; B.S. *(Agriculture)*, University of Illinois, 1940
Ralph Curtis Williams, La Verne College, 1940-1941

PHYSICS

E. Richard Cohen, A.B., University of Pennsylvania, 1943
Leon Knopoff, B.S., California Institute, 1944
Rev. James Donald O'Reilly, B.S., St. Patrick's College, Eire, 1938; B.Theo., St. Patrick's College, Eire, 1940

Master of Science in Engineering

MECHANICAL ENGINEERING

Thomas Ernest Hudson, B.S., California Institute, 1944

Bachelor of Science

SCIENCE

James Albert Cullen
Lincoln Kearney Durst
Robert Alexander Golding
Edwin Sheldon Gould
John William Gryder
Serge Lang
John Sheldon Showell
Carroll Aubrey Webber, Jr.

ENGINEERING

Charles William Allison, Jr.
John Arthur Anderson
Benjamin Lewis Austin
George Wendell Barton, Jr.
Stuart Randolph Bates
Philip Henking Benton
Paul George Bissiri
Harvey Hugh Brinkhaus
Elmore Gustav Brolin
Charles Edward Burdg
Roger William Clapp
Earnest Hubert Clark
Robert Hugh Conradt
William Angus Davis
Theodore H. Dehnke
James Edward Densmore
Charles William Dick
Keith Doig
Bertram Wilson Downs, Jr.
Donald Allen Dunn
Douglas Smith Ellis
James Carter Evans
Floyd Clair Fisher
John Eaton Fleming
Robert Warren Foote
Robert Frohman
Thomas Lester Fuller
Donald Guy Furst
George Sanderson Gill
Norman Arnold Gottlieb
Donald James Hass
Donald Beery Hicks
William Franklin Horton
George Hufford
Jerold Robert Ireland
Jack Leonard Jensen
Louis Koehler Jensen
Philip Everett Jenson
Howard Ellsworth Jessen
Paul John Jurach
Calvin Ernest Kempton
Albert Odgers Klein
Richard Perry Lagerstrom
Frank Hamilton Lamson-Scribner, Jr.
William Hoogs Libbey
Hal Dane McCann
James Lee McCarthy
Cassius Richard McEwen
George Donald Meixner, Jr.
Edward George Neale, Jr.
David Beers Nielsen
Stanley Reed Nixon
Vincent Wilford Nurre
George Robert Pool, Jr.
Eberhardt Rechtin
Fremont Easton Reichwein
Jerry H. Rice
Kenneth Walter Robinson
Willard Everett Root
Willard Allen Ross
Harold Leland Sarmento
Richard Philip Schuster, Jr.
John Dorrington Seagrave
Robert Ford Sensibaugh
Elmer Ralph Shepard
Richard Allen Smith
Alan Riley Stearns
Elliott Owen Stephenson
William Chapman Stookey
John Sutyak
John Everett Taber
Orison Wade
Richard Calvin Warner
George Raymond Watt
Milton Gene Webb
Rev. L. Clyde Werts, S.J.
Teck Albert Wilson
Harry Lawrence Wolbers, Jr.

Senior Certificate

(In recognition of the satisfactory completion of the minimum requirements of the Navy V-12 Engineering Specialist Program)

Rexford Raymond Cherryman
Harold Comlossy, Jr.
Jerome Packard Dyson
Richard Grant Levin
James Adams Lewis
George Wilson Lyon
Stanley Harold Mendes
Paul Joseph Muzychenko
Herbert Nathan Royden
Jacob Francis Wozniak, Jr.

GRADUATE STUDENTS

(†) following a student's name indicates that he has been admitted to candidacy for the degree of Doctor of Philosophy. Asterisk indicates Teaching Fellow or Graduate Assistant.

Name	Major Subject	Home Address
Adams, Raymond Voiles, Jr. B.S., Kansas State College, 1941	Ph	Whittier
Adams, Robert Train B.S., University of California, 1942	Ch	Berkeley
Agnew, Haddon Wilson B.A., University of British Columbia, 1934	Ge	Vancouver, B. C.
Aldrich, Jerry Frederick Lewis A.B., University of California at Los Angeles, 1944	Ma	Campbell
Alford, Jack Leland* B.S., California Institute, 1942	ME	San Marino
Allen, Thomas Lofton B.S., University of California, 1944	Ch	Cupertino
Alperin, Morton B.S., New York University, 1939	AE	Jackson Heights, New York
Altseimer, John Henry B.S., University of Wisconsin, 1941	AE	Milwaukee, Wisconsin
Altshuler, Saul A.B., University of California at Los Angeles, 1943	Ph	Los Angeles
Anderson, John Berwick, Lt. Comdr., U.S.N. B.S., United States Naval Academy, 1939	AE	Richmond, Virginia
Andrew, Alan H. (†) B.S., University of Nebraska, 1942; M.S., California Institute, 1944	Ph	St. Joseph, Missouri
Andrews, Clyde Cecil, Lt. Comdr., U.S.N. Kansas Junior College	AE	Kansas City, Kansas
Arguedas, Jose Antonio B.S., Georgia School of Technology, 1944	CE	San Jose, Costa Rica
Ari, Victor A. B.S., Tomas Frias University, 1943; M.S., California Institute, 1945	Ge	Potosi, Bolivia
Arreguin-Lozano, Barbarin (†) National University of Mexico; M.S., California Institute, 1945	Bi	Silao Gto, Mexico
Ashkenas, Harry Israel B.S., University of California, 1944	AE	Los Angeles
Astrahan, Morton Michael B.S., Northwestern Technological Institute, 1945	EE	Chicago, Illinois
Auerbach, Charles Edward B.S., University of California, 1942	Ch	San Francisco
Baer, Oliver Albrecht A.B., Stanford University, 1943	ME	Sacramento
Baird, Hugh Adamson B.S., California Institute, 1942	ChE	Pasadena
Barden, Kenneth Perrin, Lt., U.S.N.R. University of Arkansas	AE	Pocahontas, Arkansas
Barnes, John Winthrop, Major, U.S.A. B.S., United States Military Academy, West Point, 1942	AE	Washington, D. C.
Bate, George Lee* A.B., Princeton University, 1945	Ph	Newton Falls, Ohio
Beatty, Charles Graydon B.S., Massachusetts Institute of Technology, 1942	EE	Tulsa, Oklahoma

Name	Major Subject	Home Address
Begovich, Nicholas Anthony* B.S., California Institute, 1943; M.S., 1944	EE	San Francisco
Behroon, Khosrow M.S., Tehran University, 1938	EE	Tehran, Iran
Bennett, Edward Leigh* B.A., Reed College, 1943	Ch	Hood River, Oregon
Berning, Warren Walt B.A., University of Cincinnati, 1942; M.S., California Institute, 1946	My	Cincinnati, Ohio
Bhattacharya, Probhat Kumar M.S., Calcutta University, 1942	Ge	Calcutta, India
Billman, Glenn Wagner B.S., California Institute, 1941; M.S., 1942	ChE	Long Beach
Blaker, Robert Hockman* A.B., Berea College, 1942	Ch	Blue Sulpher Springs, W. Virginia
Boettcher, Richard Arns B.S., University of Wisconsin, 1938	CE	Milwaukee, Wisconsin
Bonner, Robert Dilworth, Lt., U.S.N.R. B.S., Rice Institute, 1943	ME	Forth Worth, Texas
Bonner, Walter Daniel, Jr.* (†) B.S., University of Utah, 1940	Bi	Salt Lake City, Utah
Bourus, George Jesse B.S., Villanova College, 1940	ChE	San Diego
Bowen, Dwain Burns B.S., California Institute, 1942	Ph	La Crescenta
Bowen, John Thomas B.S., California Institute, 1942	ME	Los Angeles
Bowie, James Monfort, Lt., U.S.N.R. Long Beach Junior College	AE	Chelan, Washington
Boyer, George Leo B.S., Georgetown University, 1942	Ph	Edgewood, Rhode Island
Braithwaite, James William B.S., California Institute, 1940	AE	Pasadena
Brennan, Patrick Joseph B.S., Purdue University, 1941	ME	Yorktown, Indiana
Bresler, Boris* B.S., University of California, 1941	AE	San Francisco
Briglio, Anthony, Jr. B.S., California Institute, 1943	ChE	Los Angeles
Brockman, John A., Jr.* B.S., California Institute, 1942	Ch	Reno, Nevada
Brooks, Richard F.* A.B., Brown University, 1941	Ge	Ithaca, New York
Brown, David Henry B.S., California Institute, 1942	Ch	Altadena
Brown, Francis Barton A.B., Stanford University, 1935	ME	Los Angeles
Brown, Raymond Allen B.S., Wagner College, 1941	Ch	Staten Island, New York
Browning, Frank Horace, Comdr., U.S.N. B.S., University of Washington, 1936	AE	Seattle, Washington
Buffington, Edwin Conger* B.A., Carleton College, 1941	Ge	Duluth, Minnesota
Buhler, Rolf D. B.A.E., University of Minnesota, 1943; M.S., California Institute, 1944	AE	Pasadena
Burger, Glenn William, Lt. Comdr., U.S.N.R. Colorado University	AE	Rosemead

Name	Major Subject	Home Address
Burket, Stanley Campbell B.A., Linfield College, 1939; M.A., University of Kansas, 1943	Ch	Lawrence, Kansas
Butler, William Walker B.S., Iowa State College, 1940 Resident Associate in Blacker House	EE	Mason City, Iowa
Cambel, Ali Bulent B.S., Robert College, Istanbul, 1942	ME	Ankara, Turkey
Carhart, Richard Raymond* B.A., University of California at Los Angeles, 1940	Ph	Coronado
Cartwright, Kenneth Orlando B.S., Purdue University, 1941	EE	Anderson, Indiana
Chang, Chieh-Chien B.A., National Northeastern University, China, 1932; M.S., California Institute, 1941	AE	Shangtung, China
Charlu, Paul Krishnama B.E., College of Engineering, India, 1944	EE	Tiruvannamalai, South India
Charyk, Joseph Vincent (†) B.S., University of Alberta, 1942; M.S., California Institute, 1943	AE	Alberta, Canada
Chase, Patrick Stanley B.S., California Institute, 1943	AE	Altadena
Chen, Ke-Yuan B.S., Northeastern University, China, 1933	EE	Liao-Ning, China
Childers, Kenan Clark, Jr., Lt. Comdr., U.S.N. B.S., United States Naval Academy, 1939	AE	Albuquerque, New Mexico
Chung, Ta-San B.S., Tsing-Hwa University, 1938	My	Hunan, China
Clarke, Donald Walter B.S., University of Alberta, 1941; M.S., 1943	Ch	Alberta, Canada
Clay, William Loring, Lt. Col., U.S.A. B.S., United States Military Academy, 1940	AE	Bridgeport, Connecticut
Cleland, George Horace B.A., Occidental College, 1942	Ch	Los Angeles
Cline, Robert Fairbank B.A., University of Toronto, 1936	EE	Pasadena
Cohen, Emanuel Richard* A.B., University of Pennsylvania, 1943; M.S., California Institute, 1946	Ph	Philadelphia, Pennsylvania
Cole, Charles Willard B.A.E., University of Minnesota, 1940	AE	St. Paul, Minnesota
Cole, Julian David M.E., Cornell University, 1944	AE	Brooklyn, New York
Coleman, Thomas F., Lt., U.S.A. B.S., University of Michigan, 1943	AE	Highland Park, Illinois
Corrsin, Stanley (†) B.S., University of Pennsylvania, 1940; M.S., AeE, California Institute, 1942	AE	South Pasadena
Corcoran, William Harrison B.S., California Institute, 1941; M.S., 1942	ChE	Pasadena
Cortes-Guzman, Daniel Jose Agr.Eng., National Agricultural School, Mexico, 1945	CE	Mexico City, Mexico
Cowan, Eugene Woodville, Jr. B.S., University of Missouri, 1941; M.S., Massachusetts Institute of Technology, 1943	Ph	Columbia, Missouri
Cox, Charles Shipley* B.S., California Institute, 1944	Ph	Honolulu, Hawaii
Cox, Richard Horton* B.S., California Institute, 1942	CE	Honolulu, Hawaii
Crum, John Oliver, Major, U.S.A. B.S., Massachusetts Institute of Technology, 1940	AE	Pasadena
Curtis, Cyril Dean B.S., McKendree College, 1943	Ma	Albion, Illinois

Name	Major Subject	Home Address
Dacey, George Clement* B.S., University of Illinois, 1942	Ph	Arcadia
Daniels, Jerry Forest, Jr., Lt. Comdr., U.S.N. *University of Wichita*	AE	Wichita, Kansas
Darling, Donald Allan* A.B., University of California at Los Angeles, 1941	Ma	Pasadena
Davis, Charles Melville* B.S., California Institute, 1945	EE	Pasadena
Davis, William Edgar, III, Lt., U.S.N.R. B.S., University of Pennsylvania, 1942	AE	Ambler, Pennsylvania
Davis, William Richard B.S., California Institute, 1944	Ph	Glendale
Deeds, William Edward A.B., Denison University, 1941; M.S., California Institute, 1943	Ph	Granville, Ohio
Dennis, Paul Arthur B.S., California Institute, 1938	Ph	Manhattan Beach
Denson, Mayette Elner, Jr. B.S., Montana State College, 1941	Ge	Shelby, Montana
Deodati, Joseph Benjamin, Lt. Comdr., U.S.N. B.S., Texas A & M, 1939	AE	San Antonio, Texas
Dewald, Jacob F.* *B.S., Haverford College, 1943*	Ch	New York City, New York
Dicke, Leonard H. B.S., Illinois Institute, 1931	CE	San Bernardino
Ditch, William Earl, Lt., U.S.N.R. Independence Junior College	AE	Independence, Kansas
Dobbins, Willis E. *B.S., California Institute, 1941*	EE	Jamestown, New York
Dore, Frank John B.S., California Institute, 1945	AE	Balboa Island
Dougherty, Charles Bullard B.S., Iowa State College, 1945	Ph	Creston, Iowa
Douglas, Volney M. B.S., University of Arizona, 1932	Bi	South Pasadena
Dowd, Munson White* B.S., California Institute, 1938	CE	El Centro
Drewry, Guy Humphrey, Jr., Capt., U.S.A. B.S., Virginia Military Institute, 1941	AE	Washington, D. C.
Dubbs, Clyde Andrew (†) * B.S., California Institute, 1943	Bi	Pasadena
Durst, Lincoln Kearney* B.A., University of California (Los Angeles), 1945; B.S., California Institute, 1946	Ma	Santa Monica
Durup, Paul Christian, Lt., U.S.N. Northeastern University	AE	Wollaston, Massachusetts
Edmundson, James William A.B., Stanford University, 1941	Ge	Laguna Beach
Eilertsen, Ernest Benson A.B., University of California, 1933; M.A., 1935	Ma	Modesto
Ellis, Albert Tromly B.S., California Institute, 1943	Ph	Pasadena
El-Sum, Hussein Mohammed Amin B.S., Fouad I University, 1941	Ph	Cairo, Egypt
Emre, Orhan Mehmet* (†) B.S., Robert College, 1934; M.S., University of Illinois, 1936; C.E., California Institute, 1942	CE	Istanbul, Turkey

Name	Major Subject	Home Address
Engelder, Paul Oscar B.S., California Institute, 1939; M.S., 1940 Resident Associate in Ricketts House	Ge	Long Beach
Farmer, Howard Norman, Jr.* B.S., California Institute, 1943	ME	Fallbrook
Farquhar, John Percival (†) B.S., Harvard College, 1935; M.S., California Institute, 1941	Bi	Pasadena
Farrington, Paul Stephen B.S., California Institute, 1941	ChE	Pasadena
Fateh, Hassan Fathelmolk M.E., Honar Sara University, Iran, 1944	ME	Hamadan, Iran
Fayram, Richard Allison A.B., Stanford University, 1945	ME	Pasadena
Feigen, George Alexander A.B., University of California, 1938	Bi	Pasadena
Fenn, George Samuel* B.S., California Institute, 1945	EE	Los Angeles
Fletcher, James Chipman* A.B., Columbia University, 1940	Ph	Summit, New Jersey
Flores-Covarrubias, Luis C.E., National University of Mexico, 1937	Ge	Mexico City, Mexico
Follin, James Wightman, Jr.* B.S., Massachusetts Institute of Technology, 1940	Ph	San Marino
Fong, Conrad Tuck Onn* (†) B.S., University of Hawaii, 1939	Bi	Honolulu, T. H.
Fossier, Mike Walter B.S., Louisiana State University, 1945	AE	New Orleans, Louisiana
Foster, Donald S. B.S., Miami University, 1938	My	Farmersville, Ohio
Foster, Richard Bruce, Lt., U.S.N.R. B.S., Newark College of Engineering, 1939	AE	Jersey City, New Jersey
Fujimura, Yoshiyuki J. B.S., University of Nebraska, 1943	EE	Hawthorne
Fung, Yuan-Cheng B.S., National Central University, China, 1941; M.S., 1943	AE	China
Garner, Harold Karl* B.S., California Institute, 1943	Ch	Salem, Oregon
Garvin, Walter William* B.S., Massachusetts Institute of Technology, 1944; M.S., California Institute, 1945	Ph	New York City, New York
Gebhart, Arthur Fletcher, Jr. B.S., University of Utah, 1943	ME	Salt Lake City, Utah
Geisberg, Ralph L. B.M.E., Clemson College, 1937; M.S., California Institute, 1944	AE	Los Angeles
Gephart, Harry Lane, Major, U.S.A. B.S., New Mexico State Teachers College, 1937	AE	Pasadena
Giamboni, Louis B.S., University of California at Los Angeles, 1941	Ph	Los Angeles
Gifford, Richard Joseph, Major, U.S.A. B.S., Iowa State College, 1942	AE	Dayton, Ohio
Gillette, Edmond Stephen, Jr., Lt. Comdr., U. S. N. B.S., United States Naval Academy, 1940	AE	Santa Monica
Gillihan, Marion Elbert B.E., University of Southern California, 1945	EE	Long Beach
Gilmore, Forrest Richard* B.S., California Institute, 1944	Ph	Whittier
Glanville, James William B.S., Rice Institute, 1944	ChE	Dallas, Texas

Name	Major Subject	Home Address
Golding, Bert Henry B.S., California Institute, 1944	Ch	Long Beach
Goodman, Theodore Robert B.A., Rensselaer Polytechnic Institute, 1945	AE	New York City, New York
Goodwin, Walter Hardenbroecke B.A., University of British Columbia, 1942; B.S., 1943	ME	Vancouver, B. C.
Green, Leon B.S., California Institute, 1944	EE	Chicago, Illinois
Greene, Howard Mell, Jr. B.S., Southwest Texas State Teachers College, 1938	Ph	Pasadena
Griffing, Charles Wing, Lt. Comdr., U.S.N.R. B.S., University of Florida, 1940	AE	Miami, Florida
Griswold, Lee Martin B.S., Principia College, 1943	ID	Hollywood
Grossling, Bernardo F. (†) B.S., University of Chile, 1935; C.E., 1941; E.E., 1944; M.S., California Institute, 1945	Ge	Santiago, Chile
Gryder, John William B.S., California Institute, 1946	Ch	*Los Angeles*
Guthrie, George Boardman, Jr.* B.A., Reed College, 1940; M.S., Oregon State College, 1941	Ch	Portland, Oregon
Hagelbarger, David William* (†) A.B., Hiram College, 1942	Ph	Mansfield, Ohio
Hagenmaier, Carl Frederick, Lt., U.S.A. B.S., Purdue University, 1945	AE	Indianapolis, Indiana
Hall, Robert Noel* B.S., California Institute, 1942	Ph	Albany
Halvorson, George Grandchamp, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1941	AE	Long Beach
Hammock, Edward Woodrow A.B., Lynchburg College, 1937	*Ch*	*Pasadena*
Hannum, Richard W. M.E., Rensselaer Polytechnic Institute, 1935	Ph	Media, Pennsylvania
Harbottle, Garman* B.S., California Institute, 1944	Ch	Dayton, Ohio
Harrington, Walter Delburt B.S., University of California, 1939	ChE	Carmel
Hayes, Wallace Dean* B.S., California Institute, 1941; AcE, 1943	Ph	Palo Alto
Hayward, Philip* B.S., University of Arizona, 1941	Ch	Kewanee, Illinois
Hedberg, Kenneth Wayne B.S., Oregon State College, 1943	Ch	Berkeley
Hege, Douglas Warwick, Capt., U.S.A. B.S., Duke University, 1942	AE	Durham, North Carolina
Heidt, Herman B.S., Colorado University, 1944	ID	Ordway, Colorado
Heifetz, Harold Maurice A.B., University of Illinois, 1941	Bi	Hollywood
Hendricks, Daniel Nathan, Jr. B.S., Texas A & M, 1942	ME	Houston, Texas
Henke, Burton L.* A.B., Miami University, Ohio, 1944; M.S., California Institute, 1945	Ph	Madeira, Ohio
Hindall, Lawrence D'Arle* B.S., Carnegie Institute of Technology, 1942	Ph	Muncie, Indiana
Hines, Marion Ernest B.S., California Institute, 1940; B.S. in My, California Institute, 1941	*EE*	*Long Beach*

Name	Major Subject	Home Address
Ho, Chung-Pen B.S., National Tsing-Hua University, 1932; M.S., California Institute, 1945	My	Liao-Nin, China
Hock, Robert Carmody, Lt., U.S.A. B.S., Georgia School of Technology, 1943	AE	Miami, Florida
Hoffman, Charles Calvin, Lt. Comdr., U.S.N. B.S., Northwestern State Teachers College, 1936	AE	Claremore, Oklahoma
Holden, Robert Bronson A.B., University of Missouri, 1944	Ch	Ferguson, Missouri
Holser, William Thomas* B.S., California Institute, 1942	Ge	Los Angeles
Holzman, George* B.S., California Institute, 1942	Ch	Pasadena
Hopkins, Robert Clarke A.B., College of Emporia, 1935	EE	San Bernardino
Hornyak, William* B.E.E., College of New York, 1944; M.S., California Institute, 1945	Ph	New York City, New York
Hsueh, Chi-Hsun B.S., National Central University, 1937	My	Chungking, China
Huang, Ea-Qua Technische Hochschule, Berlin	AE	Washington, D. C.
Hudson, Thomas Ernest B.S., California Institute, 1944; M.S., 1946	ME	Monterey Park
Huestis, Gerald Stephen, Lt., U.S.N.R. University of California	AE	Lockeford
Humphrey, George Louis* B.A., Marietta College, 1943	Ch	Belleville, West Virginia
Ilfeld, Robert Max B.S., Massachusetts Institute of Technology, 1944	Ph	Taos, New Mexico
Ingham, John Stanley, Lt., U.S.A. B.S., Worcester Polytechnic Institute, 1941	AE	Ludlow, Massachusetts
Inn, Edward Chang Yul B.S., University of Hawaii, 1939; M.S., 1942	Ph	Honolulu, T. H.
Ismail, Hassan Mohammed B.S., Fouad I University, 1938; M.S., 1944	CE	Cairo, Egypt
Jackson, Tom Cleland, Capt., U.S.A. B.S., University of Kentucky, 1942	AE	Lebanon, Kentucky
Jacobsen, John Ralph, Capt., U.S.A. B.S., Purdue University, 1941	AE	Roselle, New Jersey
Jamele, Patrick Robert A.B., Columbia College, 1927	My	Waterbury, Connecticut
James, Robert Clarke* (†) B.A., University of California at Los Angeles, 1940	Ma	Van Nuys
Jarvis, David Holbrook B.S., University of Utah, 1937; M.S., University of Colorado, 1942	ME	Santa Monica
Johnson, Paul Bennett* B.A., University of Washington, 1938; M.S., 1944	Ma	Los Angeles
Johnson, Philip Ord B.S., California Institute, 1942; M.S., 1943	AE	Sierra Madre
Johnston, Harold Sledge* A.B., Emory University, 1941	Ch	Woodstock, Georgia
Jones, Hal Joseph* B.S., Louisiana State University, 1945	Ge	Cincinnati, Ohio
Jordan, Charles Borromeo (†) B.S., California Institute, 1936; M.S., 1937	Ph	Los Angeles
Kamath, Mundkur Vasudev B.S., Madras University, 1938	ID	Nileswar, South India

Name	Major Subject	Home Address
Kamptner, Gustav Joseph E.M., Colorado School of Mines, 1941	Ge	Denver, Colorado
Kaye, John B.S., California Institute, 1939	ME	San Marino
Keck, Henry Chapman B.A., Dartmouth College, 1943	ID	Manasquan, New Jersey
Keilin, Bertram B.A., New York University, 1942; M.S., California Institute, 1945	Ch	Bronx, New York
Kendrick, James Benjamin B.S., Massachusetts Institute of Technology, 1934; M.S., 1937	AE	Burbank
Kenny, George Scott* B.S., Seattle Pacific College, 1941	Ph	Monrovia
Kerkering, Stanley William, Lt. Comdr., U.S.N. B.S., United States Naval Academy, 1939	AE	Long Beach
Kettler, Jack Raymond B.S., California Institute, 1944	ME	Huntington Beach
Keuffel, Jack Warran* A.B., Princeton University, 1941	Ph	Essex Fells, New Jersey
King, Charles Henry Jr., Capt., U.S.A. B.S., Massachusetts Institute of Technology, 1941	AE	Bronxville, New York
King, Emmett Thomas B.S., University of California, 1933; M.S., 1936	ID	Long Beach
Kinney, William Edward, Lt. Col., U.S.A. B.S., University of Dayton, 1940	AE	Springfield, Ohio
Kleiss, Norman Jack, Comdr., U.S.N. B.S., United States Naval Academy, 1938	AE	Coffeyville, Kansas
Kleissas, John B.S., University of Pittsburgh, 1943	AE	East Pittsburgh, Pennsylvania
Knopoff, Leon* B.S., California Institute, 1944; M.S., 1946	Ph	Los Angeles
Koenig, Nathan Hart B.S., University of Chicago, 1937	Ch	Venice
Kronmiller, George Hannibal, Lt. Comdr., U.S.N. B.S., United States Naval Academy, 1940	AE	San Marino
Kyropoulos, Peter Rudolf University of Göttingen, 1937; M.S., California Institute, 1938	ME	Pasadena
Lall, William Glen B.S., Punjab College of Engineering & Technology, 1944	EE	Lahore, India
Lambertus, Harold, Lt., U.S.N.R. B.S., Purdue University, 1942	ME	Indianapolis, Indiana
Lance, John Franklin B.A., Texas College of Mines, 1938; M.S., California Institute, 1946	Ge	El Paso, Texas
Lanni, Frank (†) B.S., Rensselaer Polytechnic Institute, 1940	Bi	Pasadena
Larsen, Harold Cecil, Lt., U.S.A. B.S., University of Utah, 1941	AE	Salt Lake City, Utah
Lass, Harry* B.A., University of California (Los Angeles), 1938; M.A., 1940	Ma	Los Angeles
Latter, Richard B.S., California Institute, 1942	Ph	Pasadena
Laue, Eric Gilbert B.S., California Institute, 1940	EE	Glendale
Laufer, John (†) B.S., Louisiana State University, 1942; M.S., California Institute, 1943; AeE, 1944	AE	Pasadena

Name	Major Subject	Home Address
Lebovits, Morris B.S., University of Illinois, 1940	AE	Los Angeles
Leighton, Robert Benjamin (†) B.S., California Institute, 1941; M.S., 1944	Ph	Pasadena
Lemaire, Henry B.S., Massachusetts Institute of Technology, 1942	Ch	New York, New York
Leo, Rannzo B.S., National Chiao-Tung University, 1937	Ph	Sui-an, Chekiang, China
Lerman, Leonard Solomon B.S., Carnegie Institute of Technology, 1945	Ch	Pittsburgh, Pennsylvania
Levitt, Bernard Barclay* B.S., University of Colorado, (Boulder), 1941	AE	Denver, Colorado
Lewis, Charles Hadley A.B., Whittier College, 1944	My	Whittier
Lewis, Frederick James, Lt., U.S.N.R. B.S., St. Edward's University (Austin), 1940	AE	Norfolk, Virginia
Lind, David Arthur* (†) B.S., University of Washington, 1940; M.S., California Institute, 1943	Ph	Kirkland, Washington
Lipscomb, William Nunn, Jr. (†) B.S., University of Kentucky, 1941	Ch	Lexington, Kentucky
Lowery, Byron Ordway A.B., Whitman College, 1938; Certificate in My, California Institute, 1942	My	Walla Walla, Washington
MacAllister, Robert V. A.B., Wartburg College, 1934	Ch	Clinton, Iowa
Mallery, Jesse Carl B.S., University of South Dakota, 1931	CE	Glendale
Martin, Charles Coleman, Jr., Lt., U.S.A. B.S., U. S. Military Academy, 1944	AE	Hot Springs, New Mexico
Martin, Harold Clifford B.S., New York University, 1934; M.S., 1937	AE	Monrovia
Martner, Samuel Theodore* A.B., University of California, 1940; M.S., California Institute, 1946	Ge	Pasadena
Maske, Edmund Blake, Jr. B.S., Louisiana State University, 1942	AE	Lafayette, Louisiana
Maun, Eugene Kingery* B.S., University of Illinois, 1945	Ch	Urbana, Illinois
Maxwell, Frederick William, Jr., Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1941	AE	West Palm Beach, Florida
McConnaughhay, James William, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1939	AE	La Junta, Colorado
McCurdy, John William, Lt., U.S.A. B.S., University of Pittsburgh, 1943	AE	Pittsburgh, Pennsylvania
Menard, Henry W., Jr. B.S., California Institute, 1942	Ge	Los Angeles
Mendenhall, Alfred Lewis B.A., Miami University, 1937	Ph	Dayton, Ohio
Miller, Herman B.S., California Institute, 1943; M.S., 1945	AE	Long Beach
Miller, Jack Naylor, Lt. (jg), U.S.N.R. B.S., University of Missouri, 1940	AE	Gallatin, Missouri
Miller, Julian Malcolm* B.S., University of California, 1944	Ch	Pasadena
Mills, Mark Muir* B.S., California Institute, 1940	Ph	Pasadena
Milne, Henry Bayard B.S., Oregon State College, 1937; M.S., Northwestern University, 1939; PhD, 1941	Ch	Corvallis, Oregon

Name	Major Subject	Home Address
Mislow, Kurt Martin* B.S., Tulane University, 1944	Ch	New York, New York
Mitchell, Fern Wood, Jr. A.B., University of Alabama, 1938	Ch	Pasadena
Monteath, Edward Berlendis, Lt. Comdr., U.S.N.R. B.S., Washington University St. Louis, 1940	AE	Pasadena
Montgomery, John Osmer B.A., University of Southern California, 1942	My	Los Angeles
Montgomery, Richard Alan* B.A., University of British Columbia, 1940	EE	Vancouver, Canada
Moore, Paul Raymond B.S., University of Arizona, 1942; M.S., California Institute, 1943	My	Riverside
Morgan, Samuel Pope, Jr. (†) B.S., California Institute, 1943; M.S., 1944	Ph	Casa Grande, Arizona
Morikawa, George Kiyoshi B.S., California Institute, 1939; M.S., 1941	AE	Washington, D. C.
Mullane, Leo Wayne, Lt. Comdr., U.S.N.R. B.Ch.E., University of Minnesota, 1940	AE	Pasadena
Mullin, Gordon O. B.S., Montana State College, 1945	ME	Missoula, Montana
Murtaugh, Clyde Richard B.E.E., Ohio State University, 1943	AE	Orrville, Ohio
Naiditch, Sam (†) B.A., University of California (Los Angeles), 1939	Ch	Altadena
Neiswander, Robert S. B.S., California Institute, 1940	EE	Phoenix, Arizona
Nevenzel, Judd Cuthbert B.S., University of Arizona, 1941; M.S., 1942	Ch	Tucson, Arizona
Nickerson, John Charles, Jr., Lt. Col., U.S.A. B.S., U. S. Military Academy, 1938	AE	Paris, Kentucky
Nigra, John Oscar* A.B., University Texas College of Mines, 1937	Ge	Pasadena
Oberbeck, Thomas Edmond* B.A., *Washington University, St. Louis, 1938; A.M., University of Nebraska, 1940*	Ma	Frankfort, Illinois
Odell, Francis Eugene B.S., California Institute, 1944	ME	Glendora
O'Gorman, John Michael (†) B.S., University of California, 1940; M.S., California Institute, 1942	Ch	Pasadena
Olds, Robert Horner (†) B.S., California Institute, 1938; M.S., 1939	Ph	Pasadena
Olsen, Leslie Richard, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1941	AE	Elko, Nevada
O'Meara, Donald John, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1939	AE	Pasadena
Ordway, Fred Delancy, Jr.* B.S., Rensselaer Polytechnic Institute, 1942; M.S., 1943	Ch	Palm Beach, Florida
O'Reilly, Rev., James Donald B.S., St. Patrick's College, Eire, 1938; B. Theo., 1940	Ph	Ballymote, Eire
Palmer, George Marshall, Jr. B.S., Purdue University, 1945	AE	Bluefield, West Virginia
Panzer, Max Ludwig* B.S., California Institute, 1944; M.S., 1945	Bi	Beverly Hills

Name	Major Subject	Home Address
Pardee, Arthur Beck (†) B.S., University of California, 1942; M.S., California Institute, 1943	Ch	Berkeley
Parke, Robert Grier, Capt., U.S.A. B.S., University of Pittsburgh, 1942	AE	Pittsburgh, Pennsylvania
Parker, James Frederick, Comdr., U.S.N. B.S., Georgia School of Technology, 1938	AE	Long Beach
Pauw, Adrian B.S., University of Washington, 1937	CE	Altadena
Perl, William B.S., College of the City of New York, 1938; M.S., 1940	Ph	Cleveland, Ohio
Perlis, Alan J. B.S., Carnegie Institute of Technology, 1942	Ch	Pittsburgh, Pennsylvania
Pinckard, James Howard M.A., Arizona State Teachers College, 1939; B.A., 1938	Ch	Tucson, Arizona
Pinkerton, Charles Clifford, Jr., Capt., U.S.A. B.S., U. S. Military Academy, 1943	AE	Cuyahoga Falls, Ohio
Poizner, Erwin Jacob B.S., Texas Technological College, 1940	Ge	Kansas City, Missouri
Poolman, Robert C. B.S., California Institute, 1945	ME	Glendale
Pollock, Albert David, Jr., Lt. Comdr., U.S.N. B.S., Santa Barbara State, 1938	AE	Pasadena
Ponsford, Henry Thomas A.B., Stanford University, 1944	AE	Los Angeles
Potts, Donald Harry* (†) B.S., California Institute, 1943	Ma	Glendale
Powell, Orville Samuel B.S., Purdue University, 1942	ID	Salem, New Jersey
Powell, Richard W. B.S., California Institute, 1940	EE	Glendale
Prasad, Kadaba Krishna B.S., University of Mysore, 1943; M.S., 1944	EE	Mysore, India
Ramaswamy, Subramanyam G. B.S., College of Engineering, Madras, 1944	CE	Shencottah, South India
Rasmussen, Volney Kinne, Jr. B.S., California Institute, 1939	Ph	Eden, New York
Rasof, Bernard B.S., Illinois Institute of Technology, 1941	AE	West Los Angeles
Rau, Ralph Ronald* (†) B.S., College of Puget Sound, 1941; M.S., California Institute, 1943	Ph	Pasadena
Ray, Kamalesh M.S., Calcutta University, 1935	CE	Rangpur, Bengal, India
Reck, Floyd Francis, Lt. Comdr., U.S.N. University of Minnesota	AE	Hector, Minnesota
Reiserer, Russell Lawrence, Lt. Comdr., U.S.N.R. Leland Stanford University	AE	Redwood City
Retherford, Kenneth Lynn A.B., University of Illinois, 1939; M.S., University of Washington, 1942	Bi	Lakebay, Washington
Richardson, Audre Harold B.S., California Institute, 1943	AE	Hollywood
Richardson, Carl B.E., Yale University, 1943	ME	New Haven, Connecticut
Roberts, Webster Charles, Ens., U.S.N.R. B.S., Case School of Applied Science, 1940; M.S., Lehigh University, 1942	AE	Cleveland Heights, Ohio

Name	Major Subject	Home Address
Roberts, William Brian E.M., Colorado School of Mines, 1943	Ge	San Marino
Robinson, Charles Franklin (†) A.B., Missouri State Teachers College, 1935; B.A., Drury College, 1936 M.S., California Institute, 1938	Ph	Pasadena
Robinson, Leland Perley, Jr. B.S., University of New Hampshire, 1939; M.S., 1940	Ph	Concord, New Hampshire
Robinson, Verne Gilbert* A.B., Wabash College, 1937; M.A., University of Kentucky, 1938	Ma	Hobart, Indiana
Rodriguez-Rozo, Santiago Humberto Universidad del Cauca, Popayan	CE	Popayan, Cauca-Colombia, S. A.
Roesch, William Carl* B.A., Miami University, 1945	Ph	Dayton, Ohio
Rogers, Robert George B.S., University of Texas, 1945	EE	Austin, Texas
Rubin, Sylvan (†) B.S., California Institute, 1939	Ph	Pasadena
Russell, Charles Roberts, Ens., U.S.N.R. B.S., State College of Washington, 1936; M.S., University of Wisconsin, 1939; PhD., 1941	AE	Des Moines, Iowa
Rutland, David Frederick B.S., California Institute, 1944	EE	Pasadena
Sabersky, Rolf Heinrich* B.S., California Institute, 1942; M.S., 1943	ME	Los Angeles
Safonov, George Michael* B.S., California Institute, 1943	Ph	Pasadena
Sanders, Gabriel Bermudez Agri.Eng., Escuela Nacional de Agricultura, 1943	CE	Mexico, D. F.
Sandoval-Landazuri, Alberto Ch., University of Mexico, 1941	Ch	Mexico, D. F.
Saxena, Ram Chandra B.S., Lucknow University, 1940; M.S., 1941	Ph	Budaun, India
Schamberg, Richard (†) B.S., California Institute, 1943; M.S., 1944	AE	Los Angeles
Schettler, John Dean A.B., Evansville Indiana College, 1939	Ph	Stewartsville, Indiana
Schlinger, Warren Gleason B.S., California Institute, 1944	ChE	Glendale
Schneider, Arthur John R. B.S., California Institute, 1943; M.S., 1943	ME	Alameda
Schocken, Victor* B.A., New York University, 1942; M.S., Oregon State College, 1944	Bi	Yonkers, New York
Schrag, Robert Leroy* B.S., Kansas State College, 1945	EE	Burrton, Kansas
Schuch, Adam Frank B.S., Michigan State College, 1930; M.S., 1931	Ch	Bowling Green, Ohio
Schuldberg, Irving I. A.B., University of Southern California, 1937; M.D., 1940	Bi	Los Angeles
Scully, Charles Norman B.S., California Institute, 1938	Ch	Altadena
Senear, Allen Eugene (†) B.A., Williams College, 1941	Ch	Winnetka, Illinois
Serrell, Peter Van Horne B.S., California Institute, 1936; M.S., 1939	ME	Pasadena
Shand, William, Jr.* (†) A.B., Princeton University, 1940	Ch	Lititz, Pennsylvania
Shapiro, Haskell B.S., California Institute, 1942	EE	Los Angeles
Shoemaker, David Powell (†) B.A., Reed College, 1942	Ch	Boise, Idaho

NAME	MAJOR SUBJECT	HOME ADDRESS
Showell, John Sheldon B.S., California Institute, 1946	Ch	Pasadena
Siltanen, John Carl, Major, U.S.A. B.A.E., Guggenheim School of Aeronautics, N.Y.U., 1938	AE	Bellmore, L. I., New York
Skurka, Morris B.S., Illinois Institute of Technology, 1939	EE	Los Angeles
Sledge, Edward Cress, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1940	AE	Memphis, Tennessee
Small, John Gilbert B.S., California Institute, 1941	AE	San Rafael
Small, Richard Brigham B.S., Massachusetts Institute of Technology, 1942	ME	Alhambra
Smith, Marcius Curtis B.S., California Institute, 1943	EE	Los Angeles
Snyder, Conway Wilson* A.B., University of Redlands, 1939; M.S., State University of Iowa, 1941	Ph	Pasadena
Snyder, William B.S., California Institute, 1943	EE	Van Nuys
Sofen, Irving Arnold B.S., University of Colorado, 1943	EE	Los Angeles
Soldate, Albert Mills* (†) A.B., Stanford University, 1941; A.M., 1942	Ch	Alhambra
Soli, Orlan Alton, Lt. Comdr., U.S.N. B.S., River Falls State Teachers College, 1940	AE	River Falls, Wisconsin
Spaulding, Carl Philip B.S., University of Colorado, 1943	EE	Watsonville
Srinivasan, Natesan* B.S., Madras University, 1938	AE	Komal, India
Stegmann, Claudio Federico C.E., University of Buenos Aires, 1936	CE	Buenos Aires, Argentina
Stephenson, Robert Eldon B.S., University of Utah, 1941	EE	Salt Lake City, Utah
Stergis, Basil George, Lt., U.S.A. B.S., Drexel Institute of Technology (Philadelphia, Pa.), 1943	AE	Philadelphia, Pennsylvania
Stevens, Frederick, Jr. A.B., Whitman College (Walla Walla), 1944	EE	Seattle, Washington
Sullivan, John Henry B.A., University of California (Los Angeles), 1943	Ch	Hollywood
Sumrall, Calhoun Winfred* B.S., Louisiana State University, 1945	AE	North Little Rock, Arkansas
Swift, Jonathan Dean* (†) A.B., University of California, 1939	Ma	Lafayette
Taliberti, Augusto Octavio C.E., Escola de Engenharia Mackenzie, Sao Paulo, Brazil, 1944	AE	Sao Paulo, Brazil
Tang, Yu-Wei* B.S., National Central University, Chungking, 1940	Bi	Nantung, China
Tejada-Flores, Luis Hernan B.S., California Institute, 1938; M.S., 1943	EE	LaPaz, Bolivia
Thiele, Frederick William B.S., California Institute, 1941	EE	Pasadena
Thomas, Dudley Watson A.B., University of California, 1942	Ch	Pasadena
Thurlow, John Frank* B.S., Bates College, 1943	Bi	Mechanic Falls, Maine
Tingley, Egbert Moore, Jr. B.S., Purdue University, 1942	EE	Oak Park, Illinois

Name	Major Subject	Home Address
Trabant, E. Arthur, Jr.* (†) B.A., Occidental College, 1940	Ma	Pasadena
Trauger, Robert James, Lt. Comdr., U.S.N. B.S., United States Naval Academy, 1939	AE	Luverne, Iowa
Trilling, Leon* B.S., California Institute, 1944	AE	Los Angeles
Trueblood, Kenneth Nyitray (†) A.B., Harvard University, 1941	Ch	Dobbs Ferry, New York
Tung, Yu-Siu B.S., Nankai University, Tientsin, China	EE	Chungking, China
Tunnell, Richard McClellan, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1939	AE	Mobile, Alabama
Uberoi, Mahinder Singh B.S., Forman Christian, India, 1944	AE	Sialkot City, India
Urquhart, Robert Gordon B.S., Harvard College, 1940; M.S., Harvard University, 1941	AE	Vineyard Haven, Massachusetts
Vaughan, Philip Alfred B.A., Pomona College, 1943	Ch	Pasadena
Verschoor, Jack Dahlstrom* B.S.E., University of Michigan, 1943	ME	Grand Rapids, Michigan
Vey, Ebenezer* B.S., California Institute, 1941; M.S., 1942; C.E., 1943	CE	Grate's Cove, Newfoundland
Vincent, Harry Lansing, Jr., Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1941	AE	Syracuse, New York
Vis, Vincent Almon B.S.Eng., B.S.Ma., University of Michigan, 1941	Ch	Grand Rapids, Michigan
Wan, Pao-Kang B.S., National S. W. Associated University, 1938	My	Chungking, China
Warren, Stuart Allen, Capt., U.S.A. B.S., Oregon State College, 1941	AE	Corvallis, Oregon
Wayne, Lowell Grant B.S., University of California, 1937	Ch	Hynes
Webster, Paul W.* B.S., California Institute, 1942; M.S., 1943	ME	Jungo, Nevada
Weisenberg, Joseph Oscar, Lt., U.S.N.R. B.S., Rockhust College, 1940	AE	Alhambra
Weitzenfeld, Daniel Kehr, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1939	AE	Chicago, Illinois
Weldon, Thomas Franklin, Major, U.S.A. B.S., College of the Holy Cross, 1941	AE	Pasadena
Wendel, James Gutwillig* B.A., Reed College, 1943	Ma	Pasadena
Werts, L. Clyde A.B., Gonzaga University, 1935; M.A., 1936; B.S.T., Alma College, 1942 B.S., California Institute, 1946	EE	Los Angeles
*West, William Junius** B.S., Massachusetts Institute of Technology, 1944	Ph	*Pleasant Grove, Utah*
Wheeler, Donald Bingham, Jr. (†) B.S., Lehigh University, 1938	Ph	Buffalo, New York
Wheeler, Harry Lindsay, Jr. B.A., Stanford University, 1941	Ph	La Canada
White, Robert Carleton A.B., Dartmouth College, 1942	Ge	Redlands

Name	Major Subject	Home Address
Whitlow, David Hugh B.S., University of Washington, 1943	AE	Ellenburg, Washington
Whittaker, Arthur Greenville* B.S., Washington University, 1940	Ch	St. Louis, Missouri
Wiedow, Carl Paul A.B., Occidental College, 1933; M.S., University of Southern California, 1935; M.S., California Institute, 1945	EE	Los Angeles
Wilburn, William Clarence, Jr., Lt., U.S.N.R. A.B., Birmingham Southern College, 1941	AE	Moundsville, Alabama
Wilson, Mathew Kent B.S., University of Utah, 1943	Ch	Salt Lake City, Utah
Wilson, Melvin Noble, Jr. B.S., California Institute, 1945	AE	San Diego
Wilts, Charles Harold B.S., California Institute, 1940; M.S., 1941	EE	Los Angeles
Winson, Jonathan* B.M.E., College of the City of New York, 1943; M.A.E., New York University, 1944	AE	New York City, New York
Wood, David Shotwell B.S., California Institute, 1941	ME	Sierra Madre
Wright, Lauren Albert A.B., University of Southern California, 1940; M.A., 1943	Ge	Los Angeles
Wyszpolski, Eugene Frank B.A.E., Rensselaer Polytech Institute, 1945	AE	Brooklyn, New York
Yankauskas, Paul Charles, Jr. B.S., Rhode Island State College, 1943	ID	Worcester, Massachusetts
Ying, Lai-Chao Institute of My, Chungking, China	My	Chungking, China
Young, Richard Davidson B.A., Princeton University, 1945	Ph	Pasadena
Zieman, Clayton Melvin* B.A., University of Wisconsin, 1927; M.S., University of Hawaii, 1939	Ph	Randolph, Wisconsin

UNDERGRADUATE STUDENTS

(For the Academic Year 1945-1946)

SENIOR CLASS

Name	Option	Home Address
Adamson, Phil Allen	EE	San Marino
Ahern, Dennis Joseph*	Aer	Baltimore, Maryland
Atencio, Adolfo Jose	ME	Buenos Aires, Argentina
Bement, Dale Edward*	Aer	Salida, Colorado
Bernatis, Richard Anthony	EE	Leyden, Colorado
Blackman, Wayne Sturge*	EE	Altadena
Blocker, Robert Francis	CE	Los Angeles
Bovarnick, Bennett	ME	Roxbury, Massachusetts
Brandi, Pedro Cesar	ME	Buenos Aires, Argentina
Buford, Phillip Nolen*	EE	Mansfield, Arkansas
Burke, John, Junior	EE	Los Angeles
Burris, Paul Martin*	EE	Newton, Kansas
Calligeros, John Peter*	ME	Bronx, New York
Carr, Edward Elmer*	Aer	Santa Cruz
Chalmers, James Ferguson	CE	La Jolla
Chamberlain, Lloyd William*	Aer	Media, Pennsylvania
Colley, Joseph Page*	CE	San Bernardino
Collins, Harold E.**	ME	Berkeley
Dauwalter, Chadwick Schuyler	ME	Pasadena
Davies, Richard William	Ma	Los Angeles
Davis, Donovan Chester	EE	San Marino
Davis, Herbert Isaac	EE	Arcadia
DeLano, Richard Herbert	EE	North Hollywood
DeSimone, Ralph Earl, Jr.**	ME	New London, Connecticut
Dethier, Bernard Emile*	Aer	Norwood, Massachusetts
Douglas, David Lewis	Ch	Kilmarnock, Virginia
Drake, James Frederick	ME	Pasadena
Dykstra, John Dale	ME	Long Beach
Esner, David Robert	Bi	Pasadena
Essig, Frederick Charles	EE	Los Angeles
Evenson, William Frederick*	ME	San Diego
Fagan, Peter	EE	Bakersfield
Fernandy-Paupy, Roberto Rudicindo	ME	Buenos Aires, Argentina
Field, Jerome Sidney	ME	Venice
Freire, Luis Eduardo	ME	Buenos Aires, Argentina
Gates, Frank Sumner*	ME	Anaheim
Greve, Norman Robert	CE	Arcadia
Grube, Robert Harry*	ME	Los Angeles
Hardy, George Fiske	Ch	Pass-A-Grille, Florida
Hatcher, David Sheridan	CE	South Pasadena
Haupt, Laurence Oliver	EE	Hanford
Hayne, Benjamin Stiles*	ME	Pasadena
Hopkins, Donn Emery*	Aer	Lake Grove, Oregon
Huang, Tsung-Hsiung	ME	Singapore, China
Ida, Edward Stanley*	EE	Chicago, Illinois
Ingram, Wilbur Atwood*	Aer	Chicago, Illinois
Jones, Glenn Robert	ME	Silverton, Colorado
Jorgensen, Frank Carl*	Aer	Los Angeles

*Apprentice Seaman, Navy V-12 College Training Program
**Special Ordnance Training Program

Name	Option	Home Address
Kelly, Thomas Woodward*	Aer	Baltimore, Maryland
King, William Robert, Jr.	Ch	Los Angeles
Knudsen, Chresten Mills*	CE	Redlands
Lewis, David Richard*	Aer	Petersburg, Virginia
Lim, Vicente Hidalgo	EE	Los Angeles
Lincoln, David Colvill	EE	Scottsdale, Arizona
Lockwood, Glynn Husted	ME	Mentone
Long, Walter Alfred	Aer	Valhalla, New York
Macdonald, Norman Joseph*	Aer	Bethesda, Maryland
McDonald, Rob Roy	ME	Long Beach
Misner, William Griffin	ACh	South Pasadena
Moje, William	Ch	Los Angeles
Morgan, Howard Wall*	Aer	Tuckahoe, New York
Newbrough, Robert Lee*	Aer	Barstow
Pecchenino, Paul Leonard	ME	Oakdale
Peeler, Robert Lee, Jr.*	ME	Santa Monica
Platt, Arthur Elvoy	CE	San Diego
Pounder, Edwin	ME	Kokomo, Indiana
Richter, John Edward	CE	Los Angeles
Ricks, Paul Cardon, Jr.*	ME	Pasadena
Robins, Fred Phillip	ME	Anaheim
Ryan, Robert Clifton**	ME	Haverhill, Massachusetts
Schmidt, Louis Vincent	ME	Compton
Schneider, Jerome William*	CE	Jasper, Indiana
Shane, Norman Alvin, Jr.**	ME	Evansville, Indiana
Sheldon, David Butterfield	Bi	Los Angeles
Siegel, Robert Charles*	Aer	Los Angeles
Simmons, George Finlay	Ma	Chicago, Illinois
Steele, Harry Max	ME	Glendale
Stein, Sherman Kopald Babe	Ma	Hollywood
Stensgaard, Conrad Peter, Jr.	EE	Pasadena
Stichka, James Benjamin**	ME	Ontario
Strauss, Milton Arthur*	Aer	Lakemills, Wisconsin
Strong, Herbert William	ACh	Cleveland Heights, Ohio
Stuart, Jay William	ME	Glendale
Taylor, William Clifford	EE	Riverside
Tucker, Robert Ernest*	Aer	Pittsburg
Van Benthuysen, Jack*	EE	Webster Grove, Missouri
Ward, Jerry Dalton	Ma	Beaumont, Texas
Wilson, Thomas Neal	APh	Pasadena
Wise, Robert Campbell*	Aer	Williamsport, Pennsylvania
Woods, Howard Russell*	Aer	Baldwin Park
Zagorites, Jerry Apostoles*	EE	McCloud

JUNIOR CLASS

Name	Option	Home Address
Adams, Gaynor Jefferson	EE	Sheffield, Alabama
Anderson, Reed Macomber	APh	Beaumont
Attias, John Joshua	ME	New York, New York
Austin, George Allen	Ph	Birmingham, Michigan
Baker, Friend Frederick, Jr.	ME	Hollywood
Bearson, Robert	EE	Los Angeles
Bellew, William Rochelle	ME	Los Angeles
Beymer, Ellis Harley	EE	Orange
Blight, Arthur Frederick, Jr.	APh	South Pasadena

*Apprentice Seaman, Navy V-12 College Training Program
**Special Ordnance Training Program

Name	Option	Home Address
Blink, Robert Louis	EE	Burlingame
Bowerman, Francis Robert	CE	Long Beach
Brachfeld, Jonas	Ch	Mexico City, Mexico
Brueggemann, Harry Paul	Ph	Pasadena
Brundred, Latham Loomis, Jr.	ME	Kansas City, Missouri
Caldwell, David Orville	Ph	Los Angeles
Chaffee, Glenn Albert	ME	Alhambra
Clayton, Roderick Keener	Ph	Chicago, Illinois
Conrath, Philip Russell	ME	Webster Groves, Missouri
Cox, Carl Britton	ME	Pomona
Crafts, Cecil Annand	EE	Eugene, Oregon
Critchlow, Arthur Jess	Ph	Baldwin Park
Darling, Rodney Oswald	ME	Victoria, B. C.
Demuth, Orin Jack	ME	Portland, Oregon
Deniston, John Joseph	Ph	Pasadena
Driscoll, Robert Bruce	Ph	Portland, Oregon
Dynes, Wesley Moore	ME	Hollywood
Eggenberger, Byrne	CE	Altadena
Elia, Lewis George	ME	Pasadena
Engel, Harold Leon	Bi	Los Angeles
Froehlich, Jack Edward	ME	Burbank
Fullerton, Paul William	EE	Denver, Colorado
Gammans, George Gordon	ACh	North Hollywood
Gould, Nathaniel	EE	Los Angeles
Granicher, Donald Irving	ACh	San Francisco
Haas, Wendall Max Boas	ME	Hollywood
Hamilton, Thomas Humphries	ACh	Golita
Hamming, Walter John	ME	Chicago, Illinois
Harrison, John William	Ch	Pasadena
Hawthorne, Robert Gray	ME	Los Angeles
Hedrick, Langdon Clyde	EE	Seattle, Washington
Hickey, Yates, Jr.	ME	Seattle, Washington
Hipsh, Harold Marvin	ME	Lakewood, Ohio
Kam, Merle Thayne Keliikapu	ME	Honolulu, T. H.
Kelly, George Guldin	Ph	Bozman, Maryland
Kohler, Henry George	ME	Mexico, D. F., Mexico
Kowan, Joel Marcus	EE	Los Angeles
Krenzien, Carl Henry	ME	Norfolk, Nebraska
Krueger, Robert Edward	ME	Los Angeles
Lawrence, Harvey John	ACh	Los Angeles
Leighton, Thomas Carver	Ph	Santa Monica
Lesovsky, Rodin Voltaire	ME	Los Angeles
Lewis, Howard Kirk, Jr.	ME	Honolulu, T. H.
Lipow, Myron	Ma	Altadena
Locanthi, Bartholomew	Ph	Pasadena
Lundy, William Pearson	CE	Sparks, Nevada
MacLean, Douglas James	ME	Los Angeles
Manning, Ordway Talbot	EE	Los Altos
Mauldin, Lloyd Fuller	ME	Hollywood
Mays, John Molteno	Ch	Hollywood
McDougall, Charles Henry	Ma	San Francisco
Mendenhall, Richard Mason	Ch	Dayton, Ohio
Mon, Donald Dolton	ACh	Long Beach
Myers, Franklin Oliver	ME	Eugene, Oregon
Parkin, Blaine Raphel	ME	Ankeny, Iowa
Peavy, Bradley A.	ME	New York, New York
Pond, Marshall Clarke	ME	Pasadena
Rasmussen, Carl Frithjof	EE	Los Angeles

Name	Option	Home Address
Rock, Frank Charles	ACh	Salem, Oregon
Rose, Eugene Simon, Jr.	ME	Vicksburg, Mississippi
Rosener, Joseph	ME	San Francisco
Schaafsma, Willem	ME	Honolulu, T. H.
Scott, Robert Emmett	Ph	Los Angeles
Shaw, Charles Bergman, Jr.	Ph	Dallas, Texas
Sheriffs, Leigh	Bi	Los Angeles
Shoemaker, Eugene Merle	Ge	Los Angeles
Sinclair, Carter	ME	Pasadena
Stewart, Robert Malcolm	Ph	Arlington, Virginia
Sturdevant, Clayton Robert	ME	Wilmington
Swerling, Peter	Ph	Beverly Hills
Tasker, Raymond Bernard	EE	Van Nuys
Terminel, Ramon Salido	ACh	Sonora, Mexico
Terry, John Phares	EE	Los Angeles
Vadhanapanich, Charoen	Ph	Siam
Valle-Riestra, Joseph Frank	ACh	Beverly Hills
Van Deerlin, David Basil	ME	La Canada
Vieweg, Arthur Francis	EE	Wilmington
Werner, Jerard Ben	ME	Los Angeles
Wiggs, James Stewart	ME	San Dimas
Winters, Edward Byron	EE	San Bernardino
Wolf, Frank J.	ME	Beverly Hills

SOPHOMORE CLASS

Name	Option	Home Address
Allingham, John Wing	Ge	Los Angeles
Alpert, Adelbert Isaac	ME	North San Gabriel
Anderson, Robert Graham	ME	Hollywood
Anderson, Roger Alan	ME	Bishop
Bagley, Alan Stevenson	ME	Twenty-nine Palms
Barker, William Alfred	Ph	Arcadia
Baron, David	ME	Compton
Barraclough, Robert Paul	EE	Los Angeles
Bass, Manuel Nathan	Ch	Houston, Texas
Baugh, Harold Wilfred	Ph	Schofield Barracks, Oahu, T. H.
Bayley, Rupert Morris	EE	Los Angeles
Beder, Earl	ME	Los Angeles
Blair, John Marvin	CE	San Gabriel
Brown, Robert James	Ph	Lawndale
Bruington, Arthur Elwin	EE	Los Angeles
Bruun, Erik George	Ph	San Diego
Burkholder, Joseph Finney	ME	Los Angeles
Burrows, Julian Sage	ME	Houston, Texas
Butler, Stuart Markle	ME	St. Louis, Missouri
Carter, Hugh Clendenin	ME	Omaha, Nebraska
Chambers, Guy Roger	ME	Kelso, Washington
Christopherson, Warren Allen	EE	Martinez
Collins, Burgess Franklin	Ch	Long Beach
Conner, William Michael	EE	Los Angeles
Copeland, Jack	EE	Pasadena
Cox, Arthur Nelson	Ph	Van Nuys
Dahm, Lawrence Philip	ME	Brawley
Dalton, Robert Dock, Jr.	EE	Oakland
Drew, William Atwood	Ma	Chula Vista
Duke, Earl Kenneth, Jr.	ACh	Wichita, Kansas
Eatherly, Walter Pasold	Ph	Decatur, Illinois

Name	Option	Home Address
Elder, John Kendall	Ma	San Diego
Fay, Alfred Paul	ME	Ventura
Feferman, Solomon	Ph	Los Angeles
Fisher, Alan Eugene	ME	Pasadena
Flam, Frederick Herbert	EE	Los Angeles
Fletcher, Taylor Crosby	EE	Temple City
Folmer, Peter Jan	EE	Saratoga
Foster, Robert Joe	Ch	San Bernardino
Green, Howard Wendell	Ch	Fort Dodge, Iowa
Griffin, Monty Durar	Ph	Brawley
Gunther, Fred Carl	ME	Escondido
Hammermeister, Orval Eugene	ACh	Los Angeles
Hann, John Philip	ME	Los Angeles
Harris, William Nelson	ME	San Francisco
Harrison, Warren Dearmond	CE	Los Angeles
Hedenberg, John Wesley, Jr.	Ph	Glendale
Hendrickson, James Briggs	Ch	Toledo, Ohio
Hibbard, Don Ernest	Ge	South Pasadena
Holm, Harvey Keith	ME	Sacramento
Howard, Paul John	ME	Whittier
Hsu, Raymond Wen-Yao	Ph	Rio de Janeiro, Brazil
Hybertsen, Horace Martin	CE	South Pasadena
Jarmie, Wilbur Nelson	Ph	Los Angeles
Jones, Bruce Chandler	ME	Monrovia
Kimble, Gerald Wayne	Ma	Bakersfield
King, Robert Ira	ME	Los Angeles
Lambert, Peter Charles	CE	Willows
Lamson, Philip	Ph	San Bernardino
Lang, Thomas Glenn	ME	Redlands
Leavenworth, Cameron Douglas	ME	Boise, Idaho
Levin, Alfred	ME	Mesa, Arizona
Lewis, Howard Bradbury, Jr.	ME	Los Angeles
Lilienthal, Donald Murphy	EE	Spokane, Washington
Link, Richard Forest	Ph	Pasadena
Long, Dennis Vernon	CE	Los Angeles
Macmillan, Robert Smith	Ph	Los Angeles
Markowitz, Irwin Louis	ME	Los Angeles
Marten, Richard Asher	ME	Brooklyn, New York
Martinek, George Adolf	EE	Berwyn, Illinois
Mason, Herman Allen	Ph	Pasadena
Matzdorff, Roger Edward	ME	Pasadena
Maurus, Raymond Anthony	ME	Los Angeles
McClellan, Robert	ME	Grand Rapids, Michigan
McEuen, Albert Harry, Jr.	Ph	Los Angeles
Mehl, Ross Martin	ME	Stockton
Mitchell, Edward Eugene	Ph	Honolulu, T. H.
Mosich, John Thomas	EE	Alhambra
Mullen, John Kingsley	EE	Los Angeles
Murphy, Charles Gordon	EE	Haverford, Pennsylvania
Navarro, Carlos Beeck	ME	Miraflores, Lima, Peru
Needham, Fred Eric	CE	Sacramento
Nicolai, Fred Henry	CE	Redwood City
O'Brien, James Michael	Ph	Dubuque, Iowa
Olson, Norman Eric	ME	Fallbrook
Oswald, Donald Jay	CE	San Gabriel
Otto, Donald Waldo	ME	Fresno
Patterson, Richard LaBarre	ME	South Pasadena
Payne, Paul Gardner	ME	Arbon, Idaho

Name	Option	Home Address
Pedraglia, Robert Martin	ME	Saticoy
Peterson, Philip Erik	ACh	Oklahoma City, Oklahoma
Platzek, Richard Carl	EE	Taft
Puder, Allen Thrasher	ME	Riverside
Quirmbach, Charles Frederick	EE	Alhambra
Rappaport, Harry Porter	Ma	Venice
Rennie, Bruce Bolton	EE	Los Angeles
Ridenour, Carlyle Stuart	EE	Marietta, Georgia
Rigsby George Pierce	Ge	Albuquerque, New Mexico
Roach, John Elliott, Jr.	EE	Texarkana, Texas
Roberson, Harvey Lee	ME	Rocky, Oklahoma
Robinson, Martin Samuel	EE	Los Angeles
Roe, George Winton	CE	Oakland
Roskowski, Edward Frank	ME	Philadelphia, Pennsylvania
Ruddick, Ronald Bryan	ACh	Los Angeles
Rypinski, Chandos Arthur, Jr.	EE	Los Angeles
Scheck, Frank Foetisch	ME	Studio City
Schneider, Fred Carl	EE	Chicago, Illinois
Schuyler, Arent Henry, Jr.	ACh	La Jolla
Seiden, William	ME	*North Hollywood*
Shaller, Charles Houston	CE	El Centro
Shore, Bernard William	Ch	Los Angeles
Silliker, Donal Logan	EE	Alhambra
Simons, William Herbert	ME	San Marino
Sinclair, Rolf Malcolm	Ph	Atlanta, Georgia
Six, Donald Eldon	Ge	Pasadena
Smith, George Duane	APh	Monterey Park
Smyth, William Edwards	EE	Mt. Vernon, New York
Soule, Winsor, Jr.	EE	Santa Barbara
Spalding, Donald Parker, Jr.	EE	San Antonio, Texas
Spellmann, Richard Arthur	ACh	Chico
Spooner, Mike Edward	ME	Grants Pass, Oregon
Staats, William Thomas	EE	*Los Angeles*
Stubbins, Robert Lacey	ME	Crisfield, Maryland
Suhrer, Ferdinand Charles	ACh	Los Angeles
Susskind, Charles	EE	Altadena
Swain, John Sabin	EE	Pasadena
Thomas, John Hunter	Bi	Chuquicamata, Chile
Thorpe, James Ruggles	ME	Santa Fe, New Mexico
Trivus, Sidney	Ch	Bluffton, Indiana
Vail, Thomas Edward	EE	Los Angeles
Vrabec, Arundale	Ph	San Francisco
Walp, Robert McNally	Ph	Claremont
Waters, Alfred Earnest	CE	Pasadena
Webster, Wilton Wells, Jr.	ME	Altadena
Wechsler, Joseph Wolff	ME	New York, New York
Wheeler, Samuel Childs	Ch	Portland, Oregon
Whittlesey, John R. B.	Ph	Los Angeles
Wikle, Charles Douglas	EE	Oak Ridge, Tennessee
Wilson, Robert Lee	ME	Carmel
Worcester, Bruce Alan	ME	Oak Park, Illinois
Wright, Harvey Weston, Jr.	ME	Altadena
Zacharias, Robert	EE	Grand Rapids, Michigan
Zwick, Eugene Balfour	Ph	Hondo

FRESHMAN CLASS

Name	Home Address
Adams, Claude Harris, Jr.	Merced
Albee, Philip Harper	Pasadena
Anderson, Oscar J., Jr.	Roscoe
Archer, William Earl	Long Beach
Bailey, William Howard	South Pasadena
Baird, James K.	Delair, New Jersey
Baumann, Lawrence Irving	Long Beach
Beardsley, Frank Howard	South Pasadena
Beman, Lyman Hilliker	Los Angeles
Bennett, Charles Richard	Cristobal, Canal Zone
Benton, Arthur Robert	Pasadena
Bible, Robert Edward	Abilene, Texas
Bickford, Edward Frank	Vallejo
Blair, Ernest William, Jr.	Fallon, Nevada
Blanton, William Edgar, Jr.	Santa Paula
Bond, Charles Richard	Burbank
Bratnober, Elwood Holt	Altadena
Breiman, Leo	Los Angeles
Brochmann, Michael John	St. Paul, Minnesota
Brow, Raymond Edward	Los Angeles
Brown, George James	Los Angeles
Browne, Davenport, Jr.	Escondido
Cantwell, Joseph Robert	Downey
Carnachan, Robert Shaw	Los Angeles
Carroll, Harry Read	Chicago, Illinois
Cohan, Howard J.	Denver, Colorado
Conover, Joseph Michener	Pasadena
Cootes, William Rudolph	San Pedro
Cuff, Leland Jerome	Glendale
Curtis, Frank Joseph	Westfield, Massachusetts
Danielson, Warren Evald	Santa Ana
Dannan, John Henry	North Hollywood
Darrow, Robert Allen	Playa Del Rey
Davis, Edward Farnum	Los Angeles
Dobrowolski, Joseph Adolph	Tacoma, Washington
Dodson, Denny Denslow	Burbank
Dolan, Edwin John	Portland, Oregon
Drapes, Alex George	Great Falls, Montana
Dunbar, Elton Earl	Seattle, Washington
Duque, Victor Anthony	Los Angeles
Earle, Gardner Wade, Jr.	La Crescenta
Eilau, William Eugene	Irvington, New Jersey
Evans, Don LeRoy	Hollywood
Famularo, Kendall Ferris	La Canada
Fenzi, Guido Cammillo	Santa Barbara
Ferguson, Robert Conrad	Santa Barbara
Ferguson, Robert Howard	Los Angeles
Fletcher, Aaron Nathaniel	Los Angeles
Fong, Samuel	Santa Barbara
Forester, Charles Francis	Riverside
Funk, Robert Bayard	South Gate
Gardiner, Kenneth Wayne	Topeka, Kansas
Gates, Victor	Los Angeles

NAME	HOME ADDRESS
Goodman, Franklin Ralph	La Crescenta
Graham, Fred Brown	Alhambra
Greene, Ronald Crundon	South Gate
Greer, Paul Hayden	Cape Girardeau, Missouri
Grey, Geoffrey Hamline	Sydney, Australia
Griffin, George Theodore	Scarsdale, New York
Guenther, Rhodes Berkeley	San Antonio, Texas
Hall, John Stubbs	Los Angeles
Hamlin, Robert Norman	Glendale
Harris, Andrew VanVleet	Fresno
Harris, John Nathaniel	Downey
Harris, Paul Bernard	El Monte
Hartmann, Dirck Ten Broeck	San Fernando
Haufe, Robert Carroll	San Fernando
Hayward, David Kirkland	Pasadena
Heath, John, Jr.	Los Olivos
Heath, William Clarence	La Mesa
Heggland, Radoy Witt	Altadena
Heyneman, Robert George	San Diego
Hickey, Malcolm VanCleve	Seattle, Washington
Hindsley, Walter Everette	Pasadena
Hockaday, Robert Carroll	Santa Ana
Holcomb, Wade G.	Pasadena
Houghton, William John	Honolulu, Hawaii
Hrebec, George Martin	Houston, Texas
Hummel, James Alexander	Los Angeles
Hunter, Robert Bruce, Jr.	Pasadena
Hurley, Neal Lilburn	Los Angeles
Hylton, Frank George	Pasadena
Johnson, James Edgar	Coronado
Johnson, Roger Christie	Belmond, Iowa
Johnston, William Jerome	Carlyle, Illinois
Johrde, Raymond Arnold	Pasadena
Kachadoorian, Reuben	Fresno
Katz, Eli	Los Angeles
Kemner, John William	Philadelphia, Pennsylvania
Kennedy, Pete Ralph	Pasadena
Kenney, James Theodore, Jr.	Lompoc
Kermeen, Robert Wendell	Los Angeles
Kidder, Paul Howard	Newport Beach
Kincaid, Donald Preston	Bellingham, Washington
Kinkel, John Franklin	Wichita, Kansas
Knight, Charles Henry, Jr.	Compton
Kohnen, Keith Douglas	Pacific Grove
Kono, Edward Hiroshi	Thermal
Kostelac, John Francis	Steelton, Pennsylvania
Krumholz, Irving Leon	Passaic, New Jersey
Kuljian, Maynard John	Los Angeles
Kvammen, Kenneth Royce	Los Angeles
Lane, Claude Allen	Cut Bank, Montana
Lanz, William Thomas	Mandon, North Dakota
Leggett, Elmer Neal, Jr.	Los Angeles
Lehr, Chester Kenneth	Pasadena
Levonian, Edward Puzant	Los Angeles
Linderman, Harold Fay	Garland, Utah
Loggins, Reuben Henry	Alhambra

Name	Home Address
Love, John Richard	Montebello
Lucas, Campbell Macgregor	Long Beach
MacGinitie, Walter Harold	Pasadena
MacGregor, Duncan John	Santa Monica
MacRae, Donald Sparling	South Pasadena
Marshall, John Cotton	Grosse Pointe, Michigan
Matthews, Jerry Orehard	San Gabriel
Mattice, John Arthur	Sierra Madre
McPhate, John Archie	Los Angeles
McShane, Bernard Sylvester	Chicago, Illinois
Miller, Tom Wray	Coronado
Mitchell, Orson Lorenzo	Jamaica, L. I., New York
Moore, Thomas Warner	San Diego
Mooring, Eugene Cameron, Jr.	Temple City
Morgan, George Richard	El Monte
Morrison, Donald Robert	Los Angeles
Muehlberger, Roy Phillip	Los Angeles
Myers, Ridley	Los Angeles
Nelson, Kenneth Laverne	South Pasadena
Niedringhaus, Thomas Key III	St. Louis, Missouri
Orr, Chester Bruce	Los Angeles
Paine, William Overton, Jr.	Pasadena
Parkhurst, Kenneth LeRoy	Berkeley
Parten, Kenneth Marion	Palacios, Texas
Perry, Byrne	Glendale
Perry, Richard Holden	Los Angeles
Petrulas, Thomas George	San Francisco
Petzar, George Michael	Pottstown, Pennsylvania
Pierson, Roland Decker, Jr.	South Pasadena
Poe, John Leslie	Memphis, Tennessee
Pollak, Richard Jack	Los Angeles
Powell, David Owen	Downey
Pratt, Frank Stanley	Lemoore
Prouty, Thomas Parker	Los Angeles
Pyle, William Dalliba	Santa Barbara
Ramsey, William James	Los Angeles
Ross, Cecil John, Jr.	Portland, Oregon
Rudin, Bernard David	Los Angeles
Ryder, Dale Delbert	Los Angeles
Saltman, Paul David	Los Angeles
Satre, Leland Harley	Pasadena
Saunders, Allan MacPherson	Claremont
Savant, Clement Joseph, Jr.	Los Angeles
Smith, Vernon Lomax	Wichita, Kansas
Spaulding, Arthur Ogilvy	Goleta
Spear, Kellogg Emerson	Pasadena
Sprecher, Melvin	Bronx, New York
Stappler, Robert Frederick	Far Rockaway, New York
Stein, Robert Saul	Phoenix, Arizona
Stiles, Keith Leonard	South Pasadena
Stone, Glen Sterling	Los Angeles
Sundsmo, Albert	Bonners Ferry, Idaho
Sykes, Robert Edward	Long Beach
Sylvies, William Ainsworth	Honolulu, Hawaii

Name	Home Address
Taylor, William Charles	Altadena
Team, Robert Bruce	Long Beach
Terriere, Robert T.	Fallbrook
Vestey, Edgar George	San Gabriel
Vetter, George Robert	San Diego
Vickrey, William Tenney	Sacramento
Vogel, Milton C.	San Gabriel
Vreeland, Thad, Jr.	San Marino
Vremsak, Gene Louis	Calexico
Wakeman, Thomas Herbert	San Pedro
Walance, Charles George	Chicago, Illinois
Walquist, Robert Louis	Long Beach
Walter, John Harris	Los Angeles
Ward, Elmer Francis	Pasadena
Waters, Warren Palmer	El Centro
Weir, Kenneth Owen	Los Angeles
Weisbrod, Steven	San Diego
West, Estal Dale	Pasadena
Whitehouse, Gilbert	Mexico City, Mexico
Whiting, Gordon Joseph	Culver City
Wikholm, Wilbur Andrew	Los Angeles
Willig, Herbert Reynolds	San Angelo, Texas
Willson, George Potter	Palm Beach, Florida
Wiren, Jean Folke	Pasadena
Woodbury, Henry Hugh	Altadena
Woodward, George Walter	Glendale

GENERAL INDEX

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PASADENA, CALIFORNIA