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VOLUME 53 NUMBER 4

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

CATALOGUE NUMBER *for* 1944-1945

PASADENA · CALIFORNIA · NOVEMBER, 1944

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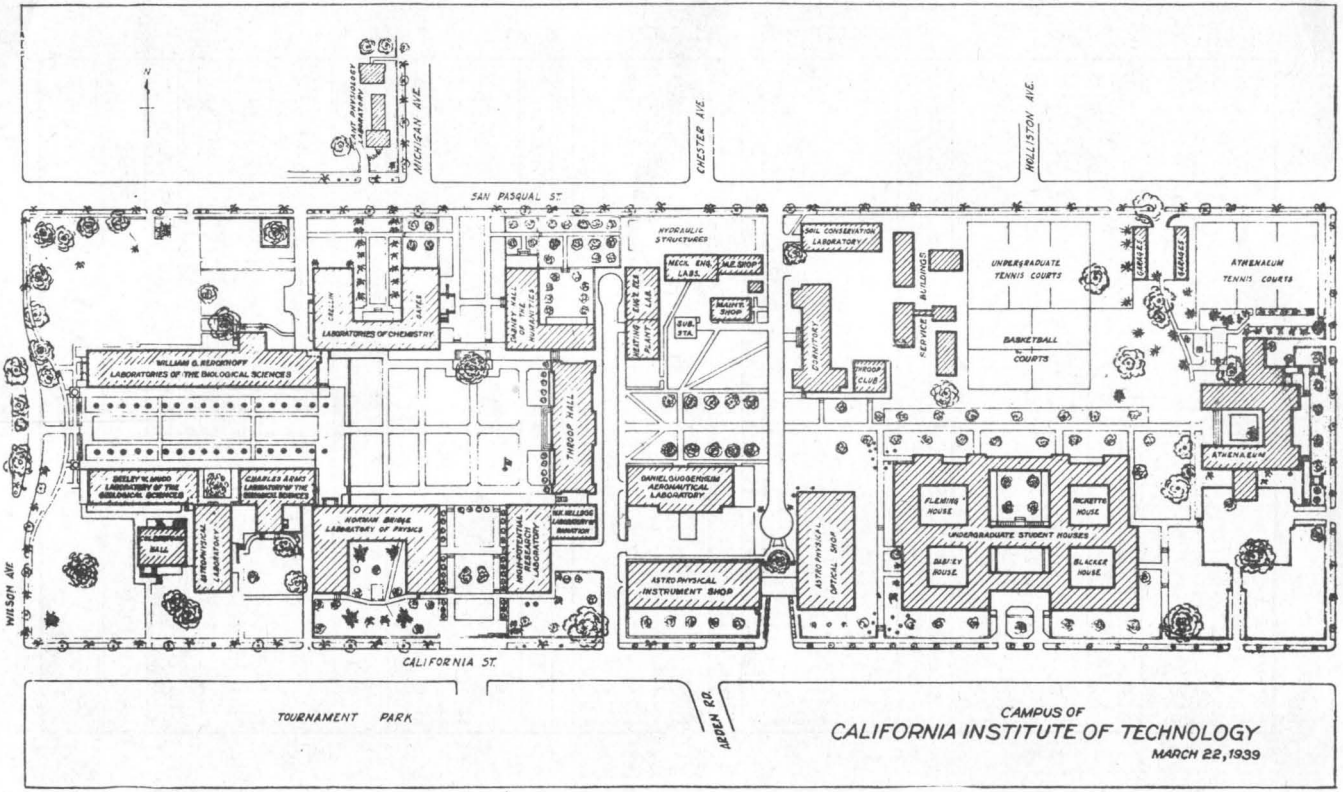

CAMPUS OF
CALIFORNIA INSTITUTE OF TECHNOLOGY
MARCH 22, 1939

CALENDAR

1944

JULY

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1945

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OCTOBER

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NOVEMBER

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DECEMBER

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CALENDAR

FIRST SEMESTER, 1944-45

November 2-4, 1944	Registration of V-12 Seamen, not previously in attendance—9:00 A.M.
November 4	Registration of Transfer Students—9:00 A.M.
November 6	Registration of Entering Civilian Freshmen—1:00 P.M.
November 6-7	Registration of V-12 Seamen, previously in attendance—9:00 A.M.
November 7	Registration of Civilian Upperclassmen, Transfer Students and Graduate Students—9:00 A.M.
November 8	Beginning of Instruction.
December 1	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
December 2	Examinations for the removal of conditions and incompletes.
December 2	Last day for adding courses.
December 22	Christmas vacation—4:00 P.M. to Dec. 26, 8:00 A.M.
December 23	Mid-Semester.
December 27	Mid-Semester grades due in the Registrar's Office—9:00 A.M.
January 1, 1945	New Year's Day Holiday.
January 2	Meeting of Freshman Registration Committee.
January 3	Meeting of Upperclass Registration Committee.
January 20 and 27	Examinations for admission to the Freshman Class, March, 1945.
January 20	Last day for dropping courses.
February 2	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
February 19-24	Final examinations.
February 23 and 24	Examinations for admission to the Sophomore class.
February 24	Last day for applications for candidacy for the degree of Doctor of Philosophy in June, 1945.
February 24	End of first semester 1944-45, 12 M.
February 26	Final grades due in Registrar's Office—9:00 A.M.
March 2	Meeting of Freshman Registration Committee.
March 3	Meeting of Upperclass Registration Committee.

SECOND SEMESTER, 1944-45

March 5 and 6	Registration of V-12 Seamen—9:00 A.M.
March 5	Registration of Entering Freshmen—1:00 P.M.
March 6	Registration of Civilian Upperclassmen, Transfer Students and Graduate Students—9:00 A.M.
March 7	Beginning of Instruction.
March 17	Last day for announcing candidacy for the degree of Bachelor of Science and of Master of Science in June, 1945.
April 6	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
April 7	Examinations for the removal of conditions and incompletes.
April 7	Last day for adding courses.
May 5	Mid-Semester.
May 5 and 12	Examinations for admission to the Freshman class, July, 1945.
May 7	Mid-Semester grades due in the Registrar's Office at 9:00 A.M.
May 14	Meeting of Freshman Registration Committee.
May 15	Meeting of Upperclass Registration Committee.
May 26	Last day for dropping courses.

June 8	Last day for final oral examinations and presenting of theses for the degree of Doctor of Philosophy.
June 9	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
June 11-16	Final examinations for Seniors and Graduate students.
June 15 and 16	Examinations for admission to Upperclasses.
June 18	Final grades for Seniors and Graduate students due in Registrar's Office—9:00 A.M.
June 18-23	Final examinations for Undergraduate students.
June 20	Meeting of Committees on Course in Science and in Engineering—10:00 A.M.
June 20	Faculty Meeting—2:00 P.M.
June 21	Class Day.
June 22	Commencement.
June 23	End of Second Semester 1944-45, 12 M.
June 25	Final grades of Undergraduate students due in Registrar's Office—9:00 A.M.
June 29	Meeting of Freshman Registration Committee.
June 30	Meeting of Upperclass Registration Committee.

FIRST SEMESTER, 1945-46

July 2	Registration of V-12 Seamen not previously in attendance—9:00 A.M.
July 2	Registration of Entering Civilian Freshmen—1:00 P.M.
July 2 and 3	Registration of V-12 Seamen previously in attendance—9:00 A.M.
July 3	Registration of Civilian Upperclassmen, Transfer Students and Graduate Students—9:00 A.M.
July 4	Beginning of Instruction.
July 27	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
July 28	Examinations for the removal of conditions and incompletes.
July 28	Last day for adding courses.
August 25	Mid-Semester.
August 27	Mid-Semester grades and blue slips due in Registrar's Office—9:00 A.M.
September 3	Meeting of Freshman Registration Committee.
September 4	Meeting of Upperclass Registration Committee.
September 15	Last day for dropping courses.
September 15 and 22	Examinations for admission to the Freshman class.
October 6	French and German examinations for admission to candidacy for the degree of Doctor of Philosophy.
October 12 and 13	Examinations for admission to Upperclasses.
October 15-20	Final examinations.
October 20	Last day for applications for candidacy for the degree of Doctor of Philosophy in February, 1946.
October 20	End of First Semester 1945-46—12 M.
October 22	Final grades due in Registrar's Office—9:00 A.M.
October 26	Meeting of Freshman Registration Committee.
October 27	Meeting of Upperclass Registration Committee.

SECOND SEMESTER, 1945-46

October 29 and 30	Registration of V-12 Seamen—9:00 A.M.
October 29	Registration of Entering Freshmen—1:00 P.M.
October 30	Registration of Civilian Upperclassmen, Transfer Students, and Graduate Students.
October 31	Beginning of Instruction.

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(For the academic year of March 1 to October 20, 1944)

ROBERT ANDREWS MILLIKAN, PH.D., LL.D., SC.D., NOBEL LAUREATE
Professor of Physics, Director of the Norman Bridge Laboratory of Physics, Chairman of the Executive Council.
1640 Oak Grove Avenue, San Marino

MAX MASON, PH.D., LL.D., SC.D.
Chairman of the Observatory Council, Member of the Executive Council.
1505 Circle Drive, San Marino

THOMAS HUNT MORGAN, PH.D., LL.D., SC.D., NOBEL LAUREATE
Professor of Biology, Emeritus; Member of the Executive Council, Emeritus.
1149 San Pasqual Street

WILLIAM BENNETT MUNRO, PH.D., LL.D., LITT.D. 268 Bellefontaine Street
Edward S. Harkness Professor of History and Government, Member of the Executive Council.

RICHARD CHACE TOLMAN, PH.D., SC.D.* 345 South Michigan Avenue
Professor of Physical Chemistry and Mathematical Physics, Dean of the Graduate School, Member of the Executive Council.

REAR ADMIRAL RALSTON S. HOLMES, USN (Ret.) Huntington Hotel
Navy Department Liaison Officer with National Defense Research Committee

CAPTAIN H. L. KELLEY (MC), USN (Ret.) 1216 East Orange Grove Avenue
Medical Officer, Navy V-12 Unit

CAPTAIN JAMES L. KING, USN (Ret.) 443 East Calaveras Street, Altadena
Office of the Naval Liaison Officer, NDRC

CAPTAIN WENTWORTH H. OSGOOD, USN (Ret.) 1520 Charlton Road, San Marino
Commanding Officer, Navy V-12 Unit

COMMANDER C. E. HAUGEN, USN (Ret.) 1821 Pepper Drive, Altadena
Office of the Naval Liaison Officer, NDRC

COMMANDER EUGENE W. MANTEL, USN (Ret.) 649 East California Street
Commanding Officer, Navy V-12 Unit (Transferred October 14, 1944)

LIEUTENANT-COMMANDER HARVEY E. BILLIG, JR. (MC), USNR
Medical Research for the Navy Department 1118 Fremont Avenue, South Pasadena

LIEUTENANT THOMAS A. BARNUM, USNR 2049 Casa Grande Street, Altadena
Resident Inspector of Naval Material

LIEUTENANT JAMES D. DESANTO, USNR Athenæum
Navy Proof Officer (Transferred April 30, 1944)

LIEUTENANT RONALD W. LEE (DC), USNR 549 North Hart Street, Temple City
Dental Officer, Navy V-12 Unit

LIEUTENANT EBON B. MCGREGOR (MC), USN (Ret.) 951 Poppy Street, Altadena
Medical Officer, Navy V-12 Unit (Transferred April 17, 1944)

LIEUTENANT MILES E. MORGAN, USNR 625 Twenty-second Street, Santa Monica
Executive Officer, Navy V-12 Unit

LIEUTENANT STANLEY F. MURPHY, USNR 786 South Mentor Avenue
Administrator, Physical Fitness Program, Navy V-12 Unit (Transferred September 22, 1944)

*On leave of absence.

LIEUTENANT THEODORE W. TURNER, USNR — 95 South Los Robles Avenue
Officer in Charge, Naval Training School (Aeronautical and Aerological Engineering) (Transferred June 5, 1944)

LIEUTENANT CLAUDE L. YEOMAN (DC), USNR — 235 East Holly Street
Dental Officer, Navy V-12 Unit

LIEUTENANT (JG) W. MELVILLE GARTON, JR., USN (Ret.) — 912 Glen Oaks Boulevard
Officer in Charge, Naval Training School (Aerological Engineering) (Transferred June 5, 1944)

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Physical Training Program, Naval Training School (Aeronautical and Aerological Engineering) (Transferred June 5, 1944)

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MAJOR ROBERT B. STAVER, USA† — 492 South Hudson Avenue
Army Ordnance Department Liaison Officer

CAPTAIN JACOB CHAITKIN, AC — 73 South Meredith Avenue
Translation Unit of Long Range Research

CAPTAIN GERRIT DAAMS, AC — 200 North Hidalgo Avenue, Alhambra
Long Range Research

FIRST LIEUTENANT JEROME S. DUCREST, AC† — 258 South Hudson Avenue
Adjutant, Training Detachment, Army Air Forces Technical Training Command

FIRST LIEUTENANT IVER A. LUND, AC — 368 North Carmelo Avenue
Long Range Research

FIRST LIEUTENANT BLAKEMORE E. THOMAS, AC — 395 South Mentor Avenue
Station Weather Officer

SECOND LIEUTENANT DANIEL L. ENGLANDER, AC
Assistant Station Weather Officer — 1222 Spruce Street, South Pasadena

SECOND LIEUTENANT HAROLD M. SELM, AC† — Constance Hotel
Assistant Adjutant, Training Detachment, Army Air Forces Technical Training Command

SECOND LIEUTENANT PHILLIP R. STINCHFIELD, AC — 1371 San Pasqual Avenue
Assistant Station Weather Officer

CARL DAVID ANDERSON, PH.D., SC.D., NOBEL LAUREATE*
Professor of Physics — 249 South Berkeley Avenue

EDWARD CECIL BARRETT, B.A. — 942 North Chester Avenue
Comptroller

HARRY BATEMAN, PH.D. — 1107 San Pasqual Street
Professor of Mathematics, Theoretical Physics, and Aeronautics

STUART JEFFERY BATES, PH.D. — 2011 Rose Villa Street
Professor of Physical Chemistry

*On leave of absence.
†Until June, 1944.

ERIC TEMPLE BELL, PH.D. Professor of Mathematics	434 South Michigan Avenue
JAMES EDGAR BELL, PH.D. Professor of Chemistry	R. D. 1, Box 639, Pasadena
HENRY BORSOOK, PH.D., M.D. Professor of Biochemistry	1121 Constance Avenue
IRA SPRAGUE BOWEN, PH.D.* Professor of Physics	394 Bonita Avenue
JOHN PETER BUWALDA, PH.D. Professor of Geology	2103 San Pasqual Street
W. HOWARD CLAPP, E.M. Professor of Mechanism and Machine Design, Emeritus	95 South Mentor Avenue
ROBERT L. DAUGHERTY, M.E. Professor of Mechanical and Hydraulic Engineering	373 South Euclid Avenue
ROSCOE GILKEY DICKINSON, PH.D. Professor of Physical Chemistry, Acting Dean of the Graduate School	530 Bonita Avenue
PAUL SOPHUS EPSTEIN, PH.D. Professor of Theoretical Physics	1484 Oakdale Street
PHILIP SHEARER FOGG, M.B.A.* Professor of Business Economics	1977 Midlothian Drive, Altadena
ROBERT D. GRAY, B.S. Professor of Economics and Industrial Relations, Director of Industrial Relations Section	942 Dale Street
BENO GUTENBERG, PH.D. Professor of Geophysics	399 Ninita Parkway
ARIE JAN HAAGEN-SMIT, PH.D. Professor of Biology	416 South Berkeley Avenue
WILLIAM VERMILLION HOUSTON, PH.D.* Professor of Physics	3207 Lombardy Road
CLINTON KELLY JUDY, M.A. Professor of English Language and Literature	1325 Woodstock Road, San Marino
THEODORE VON KÁRMÁN, PH.D., DR. ING., SC.D. Professor of Aeronautics, Director of the Daniel Guggenheim Laboratory	1501 South Marengo Avenue
IRVING PARKHURST KRICK, PH.D.* Professor of Meteorology	2174 San Pasqual Street
WILLIAM N. LACEY, PH.D. Professor of Chemical Engineering	2024 Minoru Drive, Altadena
GRAHAM ALLAN LAING, M.A. Professor of Economics and Business Administration	1642 Pleasant Way
CHARLES CHRISTIAN LAURITSEN, PH.D.* Professor of Physics	1444 Blanche Street
FREDERICK CHARLES LINDVALL, PH.D.* Professor of Electrical and Mechanical Engineering	2006 Allen Drive, Altadena
HOWARD JOHNSON LUCAS, M.A. Professor of Organic Chemistry	95 North Holliston Avenue
JOHN ROBERTSON MACARTHUR, PH.D. Professor of Languages; Acting Dean of Freshman	195 North Euclid Avenue

*On leave of absence.

SAMUEL STEWART MACKEOWN, PH.D. Professor of Electrical Engineering	1240 Arden Road
ROMEO RAOUL MARTEL, S.B. Professor of Structural Engineering	809 Fairfield Circle
ARISTOTLE D. MICHAL, PH.D. Professor of Mathematics	2002 Oakdale Street
CLARK BLANCHARD MILLIKAN, PH.D. Professor of Aeronautics	1500 Normandy Drive
SEELEY G. MUDD, M.D. Professor of X-Ray Therapy	1550 Oak Grove Avenue
J. ROBERT OPPENHEIMER, PH.D.* Professor of Theoretical Physics	Athenæum
LINUS PAULING, PH.D., SC.D. Professor of Chemistry	3500 East Fairpoint Street, Sierra Madre Villa
BRUCE HORNBROOK SAGE, PH.D. Professor of Chemical Engineering	1410 La Solana Drive, Altadena
WILLIAM RALPH SMYTHE, PH.D. Professor of Physics	674 Manzanita Avenue, Sierra Madre
THEODORE GERALD SOARES, PH.D., D.D.* Professor of Ethics, Emeritus	1542 Morada Place, Altadena
ROYAL WASSON SORENSEN, E.E., D.SC.* Professor of Electrical Engineering	384 South Holliston Avenue
J. E WALLACE STERLING, PH.D. Professor of History	520 Jackson Street
CHESTER STOCK, PH.D. Professor of Paleontology	1420 San Pasqual Street
ALFRED HENRY STURTEVANT, PH.D. Professor of Genetics	1244 Arden Road
ERNEST HAYWOOD SWIFT, PH.D. Professor of Analytical Chemistry	3140 East California Street
FRANKLIN THOMAS, C. E. Professor of Civil Engineering; Chairman of Division of Civil and Mechanical Engineering, Aeronautics and Meteorology; Dean of Upper Classmen	685 South El Molino Avenue
RAY EDWARD UNTEREINER, J.D., PH.D.* Professor of Economics and History, Dean of Freshman	1089 San Pasqual Street
HARRY CLARK VAN BUSKIRK, PH.B. Professor of Mathematics, Emeritus	390 South Holliston Avenue
MORGAN WARD, PH.D. Professor of Mathematics	265 South Holliston Avenue
EARNEST CHARLES WATSON, PH.B.* Professor of Physics, Chairman of the Faculty Board	1124 Mar Vista Avenue
ALBERT E. WAUGH, M.S.† Visiting Professor of Economics	794 East Walnut
FRITS WARMOLT WENT, PH.D. Professor of Plant Physiology	485 South Madison Avenue
DON M. YOST, PH.D. Professor of Inorganic Chemistry	1025 San Pasqual Street

*On leave of absence.
†Until June 30, 1944.

LASZLO ZECHMEISTER, DR.ING. Professor of Organic Chemistry	Athenæum
FRITZ ZWICKY, PH.D. Professor of Astrophysics	212 West California Street

GORDON ALBERT ALLES, PH.D. Research Associate in Biology	1316 Westhaven Road, San Marino
DINSMORE ALTER, PH.D.* Research Associate in Statistics	Griffith Observatory, Los Angeles
JOHN AUGUST ANDERSON, PH.D.† Research Associate in Astrophysics, Executive Officer of the Observatory Council	978 Poppy Street, Altadena
SAMUEL JACKSON BARNETT, PH.D. Research Associate in Physics	315 South Hill Avenue
GILBERT BRIGHOUSE Visiting Lecturer in Psychology	4689 Eagle Rock Boulevard, Los Angeles
EDWIN R. BUCHMAN, DR.PHIL.NAT. Research Associate in Organic Chemistry	3949 East California Street
WILLIAM H. DAVENPORT, PH.D. Visiting Lecturer in English	524 De Sales Street, San Gabriel
GODFREY DAVIES, M.A. Associate in History	395 South Bonnie Avenue
EDWIN FRANCIS GAY, PH.D., LL.D., LITT.D. Associate in Economic History	2040 San Pasqual Street
ANTONIN HEYTHUM Lecturer in Industrial Design	448 South Hudson Avenue
ALADAR HOLLANDER, M.E. Lecturer in Machine Design	2385 Hill Drive, Los Angeles
JOSEPH BLAKE KOEPFLI, D.PHIL. Research Associate in Chemistry	955 Avondale Road, San Marino
VSEVOLOD NICHOLAS KRIVOBOK, SC.D. Research Associate in Metallurgy	1521 Melwood Drive, Glendale
JOSEPH O. MCCLINTIC, PH.D. Visiting Lecturer in Economics	1080 North Chester Avenue
ROBERT THOMAS MOORE, A.M. Associate in Vertebrate Zoology	Meadow Grove Place, Flintridge
NILES O. MYKLESTAD, PH.D. Research Associate in Aeronautics	651 East California Street
PHILIP NEFF, PH.D. Visiting Lecturer in Economics	3668 Thorndale Road
DONALD P. WILSON, PH.D. Visiting Lecturer in Psychology	3780 Wilshire Boulevard, Los Angeles
HARRY OSCAR WOOD, A.M. Research Associate in Seismology	220 North San Rafael Avenue
LOUIS BOOKER WRIGHT, PH.D. Associate in English Literature	580 South Berkeley Avenue

*On leave of absence.

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

ARCHIBALD B. YOUNG, A.B., B.L. — 808 South San Rafael Avenue
Lecturer in Business Law

ARTHUR HOWLAND YOUNG — Lillingston Canyon, Carpinteria
Lecturer in Industrial Relations

ERNEST GUSTAF ANDERSON, PH.D. — 831 Sunset Boulevard, Arcadia
Associate Professor of Genetics

RICHARD MCLEAN BADGER, PH.D. — 1963 New York Avenue, Altadena
Associate Professor of Chemistry

HUGO BENIOFF, PH.D.* — 4327 Chevy Chase Drive, La Canada
Associate Professor of Seismology

JAMES FREDERICK BONNER, PH.D. — 424 South Chester Avenue
Associate Professor of Plant Physiology

IAN CAMPBELL, PH.D. — 405 South Bonnie Avenue
Associate Professor of Petrology

FREDERICK J. CONVERSE, B.S. — 2167 Lambert Drive
Associate Professor of Civil Engineering

JESSE WILLIAM MONROE DUMOND, PH.D.* — Athenæum
Associate Professor of Physics

HARVEY EAGLESON, PH.D. — 1706 Fair Oaks Avenue, South Pasadena
Associate Professor of English Language and Literature, Director of the Student Houses.

STERLING EMERSON, PH.D. — 1207 Morada Place, Altadena
Associate Professor of Genetics

WILLIAM ALFRED FOWLER, PH.D.* — 1108 Lura Street
Associate Professor of Physics

HORACE NATHANIEL GILBERT, M.B.A.* — 385 South Bonnie Avenue
Associate Professor of Business Economics

ALEXANDER GOETZ, PH.D. — 1317 Boston Street, Altadena
Associate Professor of Physics

ANTHONIE VAN HARREVELD, M.D. — 764 South Oakland Avenue
Associate Professor of Physiology

WILLIAM HUSE, M.A.* — 3676 Yorkshire Road
Associate Professor of English Language and Literature, Editor of Institute Publications

LOUIS WINCHESTER JONES, A.B. — 351 California Terrace
Associate Professor of English Language and Literature, Registrar, Associate Dean of Upperclassmen

ARTHUR LOUIS KLEIN, PH.D. — 2771 Glendower Avenue, Los Angeles
Associate Professor of Aeronautics

ROBERT TALBOT KNAPP, PH.D. — Kinneloa Ranch, Route 1, Box 680, Pasadena
Associate Professor of Hydraulic Engineering

GEORGE RUPERT MACMINN, A.B. — 255 South Bonnie Avenue
Associate Professor of English Language and Literature

WILLIAM W. MICHAEL, B.S. — 388 South Oak Avenue
Associate Professor of Civil Engineering

HENRY VICTOR NEHER, PH.D.* — 1099 South Oakland Avenue
Associate Professor of Physics

CARL GEORGE NIEMANN, PH.D. — 400 South Berkeley Avenue
Associate Professor of Organic Chemistry

*On leave of absence.

GENNADY W. POTAPENKO, PH.D. — 1718 Oakdale Street
Associate Professor of Physics

PAUL E. RUCH, M.S. — 1924 North Craig Avenue, Altadena
Associate Professor of Meteorology

ERNEST EDWIN SECHLER, PH.D. — 2100 Dudley Street
Associate Professor of Airplane Structures

LUTHER EWING WEAR, PH.D. — 2247 Lambert Drive
Associate Professor of Mathematics

CORNELIS A. G. WIERSMA, PH.D. — 1364 Cordova Street
Associate Professor of Physiology

A. PERRY BANTA, M.S.* — 159 Sierra View Road
Assistant Professor of Sanitary Engineering

WILLIAM NOEL BIRCHBY, M.A. — 1500 Sinaloa Avenue
Assistant Professor of Mathematics

FRANCIS DASHWOOD BODE, PH.D.* — 2480 Tanoble Drive, Altadena
Assistant Professor of Geology

DAN H. CAMPBELL, PH.D. — 1154 Mt. Lowe Drive, Altadena
Assistant Professor of Immunochemistry

DONALD SHERMAN CLARK, PH.D. — 665 Canterbury Road, San Marino
Assistant Professor of Mechanical Engineering, Director of Placements

HARDIN CRAIG, JR., PH.D. — 1755 Orangewood Street
Assistant Professor of History; Faculty Associate of Throop Club

ROBERT P. DILWORTH, PH.D. — 751 South Euclid Avenue
Assistant Professor of Mathematics

LOUIS G. DUNN, PH.D. — 3364 Yorkshire Road
Assistant Professor of Aeronautical Engineering

ROBERT D. ELLIOTT, M.S.* — 325 Buena Loma Place, Altadena
Assistant Professor of Meteorology

ROBERT EMERSON, PH.D. — 648 South Arroyo Boulevard
Assistant Professor of Biophysics

HORACE J. FRASER, PH.D.* — 970 Old Mill Road, San Marino
Assistant Professor of Metalliferous Geology and Mineralogy

DONALD E. HUDSON, PH.D. — 270 South Berkeley Avenue
Assistant Professor in Mechanical Engineering

HUGH MARTIN HUFFMAN, PH.D.* — 3280 Mount Curve Avenue, Altadena
Assistant Professor of Biochemistry

ROBERT MINSSEN KLEINPELL, PH.D.†
Assistant Professor of Micropaleontology

ALBERT EATON LOMBARD, JR., PH.D.* — 1277 San Pasqual Street
Assistant Professor of Aeronautics and Mechanical Engineering

GEORGE EBER MACGINITIE, M.A. — Corona Del Mar
Assistant Professor of Biology, In charge of William G. Kerckhoff Marine Laboratory

FRANK JOSEPH MALINA, PH.D. — 800 South Hudson Avenue
Assistant Professor of Aeronautics, Cooperative Agent, Soil Conservation Service

JOHN H. MAXSON, PH.D.* — 1965 Galbreth Road, Altadena
Assistant Professor of Geology

---

*On leave of absence.
†Prisoner of War.

FRANCIS WILLIAM MAXSTADT, PH.D. Assistant Professor of Electrical Engineering	1626 North Grand Oaks Avenue
RAY H. ODELL, M.S. Assistant Professor of Meteorology	2360 Ganesha Street, Altadena
WILLIAM HAYWARD PICKERING, PH.D. Assistant Professor of Electrical Engineering	425 South Craig Avenue
RICHARD POMEROY, PH.D. Assistant Professor of Sanitary Engineering	1490 Carroll Drive, Altadena
WILLIAM H. REMPEL, M.S. Assistant Professor in Meteorology	1811 Harding Avenue, Altadena
CHARLES FRANCIS RICHTER, PH.D. Assistant Professor of Seismology	1820 Kenneth Way
ROGER STANTON, PH.D.† Assistant Professor of English Language and Literature	1672 Poppy Peak Drive
HOMER JOSEPH STEWART, PH.D. Assistant Professor of Aeronautics and Meteorology	2751 North Marengo Avenue, Altadena
NEWTON C. STONE, M.S. Assistant Professor of Meteorology	214 South Wilson Avenue
FOSTER STRONG, M.S. Assistant Professor of Physics	1791 East Mendocino Street, Altadena
JOHN DONOVAN STRONG, PH.D.* Assistant Professor of Physics in Astrophysics	852 South Oakland Avenue
JAMES HOLMES STURDIVANT, PH.D. Assistant Professor of Chemistry	Athenæum
HSUE-SHEN TSIEN, PH.D. Assistant Professor of Aeronautics	360 East Buena Loma Court, Altadena
ALBERT TYLER, PH.D. Assistant Professor of Embryology	817 East Del Mar Street
HOWELL NEWBOLD TYSON, B.S. Assistant Professor of Mechanical Engineering and Engineering Drafting	505 South Wilson Avenue
VITO AUGUST VANONI, PH.D.† Assistant Professor of Hydraulics	386 South Meridith Avenue
VICTOR V. VEYSEY, M.B.A. Assistant Professor of Economics and Industrial Relations	28 Oak Knoll Gardens Drive

CARL F. GRUNEWALD, M.D. Assistant Consulting Physician	1422 Milan Avenue, South Pasadena
EDWARD DUNSTER KREMERS, M.D. Consulting Physician	2125 Mar Vista Avenue, Altadena
MARSHALL YATES KREMERS, M.D.* Assistant Consulting Physician	1946 Midlothian Drive, Altadena
HAROLD Z. MUSSELMAN, A.B. Acting Director of Physical Education and Manager of Athletics	1080 North Holliston Avenue

*On leave of absence.

†Soil Conservation Service, Department of Agriculture.

SECOND LIEUTENANT EDGAR P. ANGEL, AC† Instructor in Meteorology	294 South Wilson Avenue
SECOND LIEUTENANT HORACE L. BETHEL, AC† Instructor in Meteorology	433 North Catalina Avenue
STEPHEN E. BLEWETT, B.S. Instructor of Meteorological Instruments and Observations	145 South Michigan Avenue
LEON BLITZER, PH.D. Instructor in Physics	2361 Cooley Place
DAVID I. BLUMENSTOCK, PH.D. Instructor in Climatology	6927½ Paseo Del Serra, Los Angeles
PAUL BOWERMAN, A.M. Instructor in English Language and Literature	1151 Fifth Avenue, Los Angeles
ROBERT C. BRUMFIELD, PH.D. Instructor in Mechanical Engineering	4980 Twining Street, Los Angeles
SECOND LIEUTENANT REDGNALD D. BUSHELL, AC† Instructor in Meteorology	378 South Mentor Avenue
JOHN S. CAMPBELL, M.S. Instructor in Electrical Engineering	540 South Hill Street
SECOND LIEUTENANT RAY W. CLOUGH, AC† Instructor in Meteorology	105 South Mentor Avenue
ROBERT B. COREY, PH.D. Senior Fellow in Structural Chemistry	352 South Parkwood Avenue
SECOND LIEUTENANT LOREN W. CROW, AC† Instructor in Meteorology	903 East Del Mar Avenue
JAMES WALLACE DAILY, M.S. Instructor in Mechanical Engineering	270 Greenwood Street
SECOND LIEUTENANT GLENN E. DANIELS, AC† Instructor in Meteorology	306 South Michigan Avenue
LEVERETT DAVIS, JR., PH.D. Instructor in Physics	957 East California Street
SECOND LIEUTENANT CHARLES J. DELANCEY, AC† Instructor in Meteorology	1005 South Oak Knoll Avenue
JACOB DUBNOFF, M.A. Instructor in Biology	1865 Brigden Road
WILLIAM H. EBERHARDT, B.A. Instructor in Chemistry	Athenæum
ORHAN M. EMRE, C.E. Instructor in Applied Mechanics	Dormitory
SECOND LIEUTENANT CLARENCE E. ERICKSON, AC† Instructor in Meteorology	929 East California Street
ANDREW FEJER, M.S. Instructor in Aeronautics and Mechanical Engineering	1659 Oakdale Street
JOSEPH B. FRANZINI, JR., M.S.† Instructor in Civil Engineering	294 South Roosevelt Avenue
JOHN M. FRENCH, M.S. Assistant Instructor in Applied Mechanics	1170 Steuben Avenue

†Until June, 1944.

THOMAS A. GAFFNEY, B.S. Instructor of Meteorological Instruments and Observations	207 South Michigan Avenue
JACK E. GOULD, A.B. Instructor of Meteorology Laboratory	502 South Hudson Avenue
EDWARD O. GUERRANT, PH.D.* Instructor in History	2233 Santa Rosa Avenue, Altadena
CLARENCE E. GUSÉ, M.S. Instructor in Electrical Engineering	4820 Palm Drive, La Canada
SECOND LIEUTENANT ROY L. HILLYARD, AC† Instructor in Meteorology	1067 San Pasqual Street
WALTER F. HILTNER, S.M. Instructor in Hydraulics	105 South El Molino Avenue
WILLIAM A. HOOD, M.A. Instructor in Mathematics	138 South Wilton Drive, Los Angeles
ROBERT JANES, M.S. Instructor in Civil Engineering	1785 Las Lunas Street
CARL B. JOHNSON, M.S. Instructor in Civil Engineering	4241 Wawona Street, Los Angeles
WALTER L. JOHNSON, M.S. Instructor in Applied Mechanics and Machine Design	2056 Lambert Drive
DAVID JUDD, A.B.† Instructor in Physics	Athenæum
GEOFFREY KEIGHLEY, PH.D. Instructor in Biology	237 West Las Flores Drive, Altadena
E. HARRISON KING, JR., C.E. Instructor in Hydraulics	Dormitory
PETER KYROPOULOS, M.S. Instructor in Mechanical Engineering	1938 Mill Road, South Pasadena
HARRY LASS, J.A. Instructor in Mathematics	1170 Steuben Street
GEORGE W. LIND, JR., M.S.† Instructor in Civil Engineering	529 South El Molino Avenue
PAUL A. LONGWELL, M.S. Instructor in Chemical Engineering	121 North Hudson Avenue
SECOND LIEUTENANT ELMO W. MCCLENDON, AC† Instructor in Meteorology	449 South Hudson Avenue
SECOND LIEUTENANT EDWARD C. MCEOWEN, AC† Instructor in Meteorology	Constance Hotel
ROBERT C. MCMASTER, PH.D. Instructor in Electrical Engineering	376 South Mentor Avenue
WILLIAM P. MELLEN, M.S. Instructor in Meteorology	265 South Oakland Avenue
DANIEL C. MILLER, B.S. Instructor in Engineering Drafting	426 South Hudson Avenue
WILLIAM F. NASH, JR., PH.D. Instructor in Physical Metallurgy	1320 Fay Place

*On leave of absence.
†Until June, 1944.

JOHN M. O'GORMAN, B.S. Instructor in Chemistry	110 North Michigan Avenue
JOSEPH L. H. PAULHUS, M.S. Instructor in Meteorological Instruments	306 South El Molino Avenue
SECOND LIEUTENANT RICHARD E. PENTONEY, AC† Instructor in Meteorology	1005 South Oak Knoll Avenue
DAVID PRESSMAN, PH.D. Senior Fellow in Immunochemical Research	4743½ Baltimore Avenue, Los Angeles
ROLF H. SABERSKY, M.S. Assistant Instructor in Mechanical Engineering	324 South Cliffwood Avenue, Los Angeles
SECOND LIEUTENANT LESLIE D. SANDERS, AC† Instructor in Meteorology	695 South Mentor Avenue
BRADLEY T. SCHEER, PH.D. Instructor in Biology	Corona Del Mar
VERNER SCHOMAKER, PH.D. Senior Fellow in Chemical Research	115 North El Molino Avenue
MARK SERRURIER, M.S. Instructor in Mechanics	1010 North Holliston Avenue
LESLIE ARTHUR SHANNON, MET. ENG. Instructor in Meteorology	407 South Michigan Avenue
ROBERT L. SHIPMAN, M.S. Instructor in Meteorology Laboratory	381 East Las Flores Drive, Altadena
THEODORE B. SMITH, M.S. Instructor in Meteorology	Athenæum
STANLEY C. SNOWDON, PH.D. Instructor in Physics	406 South Chester Avenue
FRANCES HALSEY SPINING Librarian	1067 North Catalina Avenue
GEORGE B. SUTTON, M.S. Assistant Instructor in Mechanical Engineering	296 South Mentor Avenue
STANLEY M. SWINGLE, PH.D. Instructor in Chemistry	75 North Wilson Avenue
SECOND LIEUTENANT HOWARD E. TAYLOR, AC† Instructor in Meteorology	Constance Hotel
SECOND LIEUTENANT BLAKEMORE E. THOMAS, AC† Instructor in Meteorology	929 East California Street
E. ARTHUR TRABANT, A.B. Instructor in Mathematics	389 South Craig Avenue
S. E. URNER, PH.D. Instructor in Mathematics	821 North Mariposa, Los Angeles
EBENEZER VEY, C.ENG. Instructor in Applied Mechanics	181 South Hudson Avenue
EDWARD M. WALES, M.B.A. Instructor in Economics	861 North Raymond Avenue
RALPH H. WALTERS, M.A. Instructor in Electrical Engineering	916 North Mariposa, Los Angeles
JURG H. E. WASER, PH.D. Instructor in Chemistry	118½ North Chester Avenue
DAVID F. WELCH, INDUS. DESIGNER Instructor in Engineering Drafting	986 East California Street

†Until June, 1944.

SECOND LIEUTENANT RODNEY S. WHEELER, AC† Instructor in Meteorology	599 South Mentor Avenue
NATHANIEL W. WILCOX, A.B. Instructor in Engineering Drawing and Design Techniques	917 North Granada Avenue, Alhambra
J. NORTON WILSON, PH.D.† Instructor in Applied Chemistry	388 Dearborn Street
GEORGE G. WRIGHT, PH.D. Senior Fellow in Immunochemistry	2617 Pina del Vista Drive, Altadena
CLAYTON M. ZIEMAN, M.S. Instructor in Electrical Engineering	368 South Parkwood

LEE R. BRANTLEY, PH.D. Research Fellow in Physics	412 South Chevy Chase Drive, Glendale
ARTHUR L. COHEN, PH.D. Research Fellow in Biology	214 South Catalina Avenue
JOHN E. CUSHING, JR., PH.D. Research Fellow in Chemistry	1417 Capinero Drive
JUSTUS G. KIRCHNER, PH.D.[2] Research Fellow in Biology	120 North Mentor Avenue
KARL J. KORPI, PH.D. Research Fellow in Chemical Engineering	505 North Sierra Madre
SPIRO KYROPOULOS, PH.D. Research Fellow in Physics	1936-A Mill Road, South Pasadena
HANS W. LIEPMANN, D. PHIL. Research Fellow in Aeronautics	2595 Lambert Drive
KLAUS J. MAMPELL, PH.D. Research Fellow in Biology	397 South Catalina Avenue
C. Y. MENG, PH.D. Research Fellow in Physics	344 South Catalina Avenue
SETH H. NEDDERMEYER, PH.D.* Research Fellow in Physics	306 South El Molino Avenue
RICHARD M. NOYES, PH.D. Research Fellow in Chemistry	961 Cornell Road
ANDOR POLGAR, PH.D. Research Fellow in Chemistry	Dormitory
LLOYD C. PRAY, M.S. Research Fellow in Petrography	986 East California Street
ELIZABETH ROBOZ, PH.D. Research Fellow in Biology	703 Lakewood Place
SAM ROSENFELD, PH.D.[2] Research Fellow in Biology	5446 Monroe, Hollywood
PAUL R. SAUNDERS, PH.D.[2] Research Fellow in Biology	136 North Madison Avenue
PHILIP A. SHAFFER, JR., PH.D. Research Fellow in Chemistry	1060 East Del Mar Avenue
RALPH G. SIU, PH.D.[3] Research Fellow in Bio-Organic Chemistry	330 South Wilson Avenue
ARTHUR G. R. STRICKLAND, PH.D. Research Fellow in Biology	664 South Oak Knoll Avenue

*On leave of absence.
†Until June, 1944.
[2]Vegetable Dehydration Fellow.
[3]U. S. Rubber Fellow.

MARTIN SUMMERFIELD, PH.D. Research Fellow in Aeronautics	314 South Michigan Avenue
DAVID TYLER, PH.D. Research Fellow in Biology	1206 Mar Vista Avenue
DOUGLAS C. WARNER, PH.D. Research Fellow in Physics	221 Country Club Drive, San Gabriel
J. PAUL YOUTZ, M.S. Research Fellow in Physics, Lecturer in Industrial Design	1477 North Holliston Avenue

RUTH BATES, B.A. Research Assistant in Biology	2011 Rose Villa Avenue
HUGH S. BELL, A.B. Research Assistant in Hydraulics	1050 North Holliston Avenue
DAVID BRINK, B.A. Research Assistant in Physics	7966 Woodrow Wilson Drive, Hollywood
SAMUEL BROADWELL, PH.D. Research Assistant in Physics	526 Baltimore Street, Monterey Park
ROBERT E. DORLAND, B.S. Research Assistant in Biology	399 South Mentor Avenue
JACOB DUBNOFF, PH.D. Research Assistant in Biology	1865 Brigden Road
ALBERT W. FRENKEL, PH.D. Research Assistant in Biology	230 South Catalina Avenue
EUSTACE L. FURLONG Curator in Vertebrate Paleontology	270 South Roosevelt Avenue
FRANCIS LEHNER Research Assistant in Seismology	1610 Casitas Avenue
CHIA-CHIAO LIN, PH.D. Research Assistant in Aeronautics	281 South Chester Avenue
JOHN M. NORDQUIST, M.S. Research Assistant in Seismology Laboratory	1695 Corson Street
ROBERT H. OLDS, M.S. Research Assistant in Chemical Engineering	Pasadena Athletic Club
GERTRUD OPPENHEIMER, PH.D. Research Assistant in Microchemistry	33 South Mentor Avenue
WILLIS P. POPENOE, PH.D. Curator in Invertebrate Paleontology	446 South Hudson Avenue
HARLAN K. PRATT, B.S. Research Assistant in Biology	923 East California Street
ALLAN E. PUCKETT, M.S. Research Assistant in Aeronautics	1735 Maple Street
H. HOLLIS REAMER, M.S. Research Assistant in Chemical Engineering	294 South Wilson Avenue
ANDREW RECSEI, PH.D.* Research Assistant in Chemistry	1429 Greenfield, Los Angeles
DAN RICE, B.A. Research Assistant in Chemistry	2044¾ North Vermont, Los Angeles

*Until September 1, 1944.

JAMES T. ROSTRON, B.S. — 1721 North Allen Avenue
Research Assistant in Hydraulics

PETER V. H. SERRELL, M.S. — 350 Glen Summer Road
Research Assistant in Aeronautics

JOSEPHINE G. WILLIAMS, B.A. — 616 Montana Avenue, Monrovia
Research Assistant in Biology

ERNEST B. WRIGHT, B.S. — 785 South El Molino Avenue
Research Assistant in Biology

FLOYD L. HANES, D.O. — 2115 Layton Avenue
Track Coach and Physical Trainer

AUDRE L. STONG, M.S. — 2051 Jefferson Drive
Director of Institute Band

TEACHING FELLOWS AND GRADUATE ASSISTANTS

ANDREW, ALAN H. . . . . Physics
B.S., University of Nebraska, 1942

BALLER, HOWARD . . . . . Electrical Engineering
B.S., California Institute, 1940; M.S., 1941

BEGOVICH, NICHOLAS ANTHONY . . . . . Electrical Engineering
B.S., California Institute, 1943

BENTON, ROBERT FRANCIS . . . . . Mathematics
B.S., California Institute, 1943

BONNER, WALTER DANIEL, JR. . . . . Biology
B.A., University of Utah, 1940

BOYD, JOHN ROBERT . . . . . Aeronautics
B.S., University of Illinois, 1942; M.S., California Institute, 1944

BROWN, JAMES ROY . . . . . Physics
B.S., Allegheny College, 1944

BRYDEN, JOHN H. . . . . Chemistry
B.S., College of Idaho, 1942

BUHLER, ROLF DIETRICH . . . . . Aeronautics
B.A.E., University of Minnesota, 1943; M.S., California Institute, 1944

CARTER, WILLIAM WALTON . . . . . Physics
B.S., Carnegie Institute of Technology, 1943

CHARYK, JOSEPH VINCENT . . . . . Aeronautics
B.S., University of Alberta, 1942; M.S., California Institute, 1943

CHASE, PATRICK STANLEY . . . . . Aeronautics
B.S., California Institute, 1943

COENSGEN, FREDERIC HARLEY . . . . . Physics
B.S., Montana State College, 1941

CORRSIN, STANLEY . . . . . Aeronautics
B.S., University of Pennsylvania, 1940; M.S., California Institute, 1942; A.E., 1942

CURTIS, THOMAS GREY . . . . . Civil Engineering
B.S., California Institute, 1942

DANA, STEPHEN WINCHESTER . . . . . Geology
A.B., Oberlin College, 1940; M.S., University of Southern California, 1942; Ph.D., California Institute, 1944

DANDLIKER, WALTER BEACH . . . . . Biology
B.S., Rollins College, 1940

DARLING, DONALD ALLAN . . . . . Mathematics
B.A., University of California at Los Angeles, 1939

DAVID, JENNINGS ROY . . . . . Electrical Engineering
B.S., University of Colorado, 1940; M.S., California Institute, 1942

DONOHUE, JERRY . . . . . Chemistry
A.B., Dartmouth College, 1941; M.A., 1943

DUBBS, CLYDE ANDREW . . . . . Biology
B.S., California Institute, 1943

EBERHARDT, WILLIAM HENRY . . . . . Chemistry
B.A., Johns Hopkins University, 1941

EMRE, ORHAN M. . . . . Civil Engineering
B.S., Robert College, 1934; M.S., University of Illinois, 1936; C.E., California Institute, 1944

ESTABROOK, FRANK BEHLE . . . . . Physics
A.B., Miami University, 1943

FONG, CONRAD TUCK ONN . . . . . Biology
B.S., University of Hawaii, 1939

FRANZINI, JOSEPH BERNARD, JR. . . . . Civil Engineering
B.S., California Institute, 1942; M.S., 1943; C.E., 1944

FU, CHENG-YI . . . . . Geology
B.Sc., National Tsing Hua University, 1933; M.Sc., McGill University, 1941; Ph.D., California Institute, 1944

GAYER, MARTIN ROGER . . . . . Civil Engineering
B.S., California Institute, 1942; M.S., 1944

GOLDING, BERT HENRY . . . . . Chemistry
B.S., California Institute, 1944

HAGELBARGER, DAVID WILLIAM . . . . . Physics
A.B., Hiram College, 1942

HENKE, BURTON LEHMAN . . . . . Physics
B.A., Miami University, 1944

HORNYAK, WILLIAM FRANK . . . . . Physics
B. of E.E., College of the City of New York, 1944

HUMPHREY, GEORGE LOUIS . . . . . Chemistry
B.A., Marietta College, 1943

INN, EDWARD CHANG YUL . . . . . Physics
B.S., University of Hawaii, 1939; M.S., 1944

JOHNSON, PHILIP ORD . . . . . Aeronautics
B.S., California Institute, 1942; M.S., 1943; A.E., 1944

JUDD, DAVID LOCKHART . . . . . Physics
A.B., Whitman College, 1943

KEILIN, BERTRAM . . . . . Chemistry
B.A., New York University, 1942

KUO, YUNG-HUAI . . . . . Aeronautics
B.A., National University of Peking, 1935; M.A., University of Toronto, 1941

LAUFER, JOHN . . . . . Aeronautics
B.S., Louisiana State University, 1942; M.S., California Institute, 1943; A.E., 1944

LEVY, CHARLES NATHANIEL . . . . . Aeronautics
S.B., Massachusetts Institute of Technology, 1939

Loo, Shih-Wei . . . . . Biology
B.S., National Sun-Yat University, 1931

Manildi, Joseph F. . . . . Electrical Engineering
B.S., California Institute, 1940; M.S., 1942; Ph.D., 1944

Miller, Herman . . . . . Aeronautics
B.S., California Institute, 1943

Millsaps, Knox . . . . . Mathematics
B.S., Alabama Polytechnic Institute, 1940; Ph.D., California Institute, 1944

Mislow, Kurt Martin . . . . . Chemistry
B.S., Tulare University, 1944

Morgan, Samuel Pope, Jr. . . . . Physics
B.S., California Institute, 1943; M.S., 1944

Pfeiffer, Heinz Gerhard . . . . . Chemistry
B.A., Drew University, 1941; M.A., Syracuse University, 1943

Pi, Te Hsien . . . . . Physics
B.S., Yenching University, 1932; M.S., 1934; Ph.D., California Institute, 1944

Potts, Donald Harry . . . . . Mathematics
B.S., California Institute, 1943

Rasof, Bernard . . . . . Aeronautics
B.S., Illinois Institute of Technology, 1941; M.S., California Institute, 1944

Richardson, Audre Harold . . . . . Aeronautics
B.S., California Institute, 1943

Savit, Carl Hertz . . . . . Mathematics
B.S., California Institute, 1942

Schamberg, Richard . . . . . Aeronautics
B.S., California Institute, 1943; M.S., 1944

Schardt, Alois Wolfgang . . . . . Physics
B.S., California Institute, 1944

Schocken, Victor . . . . . Biology
B.A., New York University, 1942; M.A., Oregon State College, 1943

Sternberg, Joseph . . . . . Aeronautics
B.S., California Institute, 1942; M.S., 1943

Tejada-Flores, Luis Hernan . . . . . Electrical Engineering
B.S., California Institute, 1938; M.S., 1943

Tuddenham, William John . . . . . Biology
B.A., University of Utah, 1943

Vey, Ebenezer . . . . . Civil Engineering
B.S., California Institute, 1941; M.S., 1942; C.E., 1943

Wade, Ernest . . . . . Electrical Engineering
B.S., California Institute, 1943

Wheeler, Donald Bingham, Jr. . . . . Physics
B.S., Lehigh University, 1938

Wilson, Albert George . . . . . Mathematics
B.S., Rice Institute, 1941; M.S., California Institute, 1942

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WAR PROJECT FELLOWS, ASSISTANTS, ETC.

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Weller Johnson, M.S.
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Harold T. Jones, B.A.
Vernon C. Jones
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Lee J. Kavanau, B.S.
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De Virl A. Kunz, B.S.
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Myer I. Lebow
Dale B. Ledyard, B.S.
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Paul E. Lloyd, Ph.D.
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Willys Lemm, B.S.
Richard M. Lemmon, M.S.
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Blaine H. Levadahl, B.S.
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Alvin V. Lewis, B.S.
C. C. Lin, M.A.
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Daniel J. Lingenfelter, B.S.
William N. Lipscomb, Jr., B.S.
Rodney S. Lloyd
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Paul A. Longwell, M.S.
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Margaret Markert, M.A.
Foster Markolf, A.B.
Douglas Marlow, B.S.
Boyd T. Marshall, M.S.
Howard E. Martens, B.S.
Albert E. Martin, M.D.
Richard E. Martin, B.S.
Kathryn J. Mather, B.A.
C. A. Mattson
Nicholas V. Mayall, Ph.D.
William C. Mayfield
James P. McClellan, B.A.
John P. McClellan, B.S.
James N. McClelland, M.A.
John W. McConnell, B.S.
R. S. McLean, B.S.
Robert C. McMaster, Ph.D.
Charles L. McWade, A.B.
Edwin C. Mead
James F. Mead, Ph.D.

Paul Meeks, M.S.
Aden B. Meinel
Aldon L. Melzian, M.S.
Hugo Menghelli, B.S.
W. Deming Merrick, B.S.
Richard M. Merriman, C.E.
John E. Meskell, B.S.
Daniel C. Miller, C.E.
Emmy Lou Miller, A.B.
Iris J. Miller
Julian M. Miller, B.S.
Mark M. Mills, B.S.
Robert L. Mills, B.S.
Hugh Montgomery, B.S.
Robert B. Moran, Jr., A.B.
Antonio Morelli, M.E.
Gerald Mosteller, M.S.
Enver M. Muratzade, C.E.
Terrell Myers, A.B.
Russell H. Neil, A.B.
Lester N. Neufeld, B.S.
Thomas W. Nobles, LL.B.
Robert L. Noland, B.S.
Harry Nott
Richard M. Noyes, Ph.D.
Francis E. Odell, B.S.
Robert H. Olds, M.S.
Edgar W. Olson, B.S.
Fred D. Ordway, Jr., B.S.
John W. Otvos, Ph.D.
Walter H. Padgham
Philip Padva
Raymond L. Page, B.S.
W. K. H. Panofsky, Ph.D.
Charles K. Parks
Theodore C. Parker
Robert M. Peabody, A.B.
Althea J. Pease, A.B.
Myron B. Persons
Jack W. Petty, B.S.
Fred W. Pierce, B.S.
J. D. Pirie
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Floyd W. Preston, B.S.
Edward T. Price, B.S.
Don R. Proctor, B.A.
George J. Prosser
Anne Pruitt, B.S.
Maurice M. Rapport, B.S.
Volney K. Rasmussen, B.S.
R. Ronald Rau, B.S.
Howard L. Reed, B.S.
Carl T. Redemann, A.B.
Louis W. Reeder
George M. Reger
James G. Renno, Jr., B.S.
Lorenzo A. Richards, Ph.D.
Franklin E. Roach, Ph.D.
Edward S. Robbins, B.S.

Charles F. Robinson, Ph.D.
Kenneth H. Robinson, M.S.
E. W. Robischon
Edward Rolle, B.S.
Harold Root
Leonard J. Rose
Sylvan Rubin, B.S.
Bruce Rule, B.S.
David Rutland, B.S.
Palmer Sabin, B.S.
George M. Safonov, B.S.
Cecil D. St. Helen
William A. Sandberg, C.Eng.
Herbert Sargent, Ph.D.
William H. Saylor, B.S.
Warren Schlinger, B.S.
Jacob M. Schmidt, Ph.D.
Samuel Scholl, B.S.
Walter A. Schroeder, Ph.D.
Rene Scott, B.S.
Henry I. Scribner, M.E.
Robert E. Sears
John W. Sease, B.A.
Stuart M. Seeley
H. E. Seifert, Ph.D.
Allen E. Senear, B.A.
James A. Senneker, A.B.
Philip A. Shaffer, Jr., Ph.D.
William Shand, Jr., A.B.
Arthur M. Shapiro
Haskell Shapiro, B.S.
David Shoemaker, B.A.
Leonard H. F. Simpson
Lee S. Sinclair, B.S.
Russell N. Skeeters
Earl Skene, B.S.
Don M. Slaybaugh
Louis B. Slichter, Ph.D.
William N. Sloan
Howard C. Smalley, A.B.
Lionel D. Smiley, B.S.
Joseph R. Snodgrass, B.S.
Conway W. Snyder, B.A.
Albert M. Soldate, A.M.
Allan L. Sorem
Gleb A. Spassky, B.S.
J. Sternberg, M.S.
Robert R. Stokes
Remington Stone
R. C. Stone, B.S.
Peter W. Stoner, M.S.
Conrad D. Swanson, M.A.
Robert E. Tafel
R. Tangren, B.S.
Donald T. Tarr, B.S.
Harry A. Taylor, B.A.
Philip H. Taylor, Ph.D.
Oscar D. Terrell, B.S.
Carl Thiele, M.S.
Frederick W. Thiele, B.S.
Paul Thiene, Jr., B.S.
J. Earl Thomas, Jr., Ph.D.
James S. Thompson, A.B.
Robert G. Thompson
Elizabeth A. Thorne, A.B.
Hallett W. Thorne
Edwin Thorpe
John F. Thurlow, B.S.
John Titus, Ph.D.
Leon Trilling, B.S.
Kenneth N. Trueblood, A.B.
Walter K. Tuller
Erret S. Turner, B.S.
Edward E. Tuttle, LL.B.
N. Van De Verg, B.S.
Garrett Van Pelt
Gustav A. Volby
William J. Wagner, B.S.
Joseph A. Wahler, B.S.
Austin Wahrhaftig, Ph.D.
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Wallace G. Walker
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‡Until September 30, 1944.
§Until August, 1944.

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

For the first few years in its new location, Throop Polytechnic Institute—or Throop College of Technology as it was called after 1913—gave degrees only in electrical, civil, and mechanical engineering. Gradually, however, it was able to add to its objectives. In 1913, Dr. A. A. Noyes, who was founder and director of the Research Laboratory of Physical Chemistry at the Massachusetts Institute of Technology and who had also served as president of that institution, became associated on part-time with the College. In 1916 a chemical laboratory was assured. It was completed in 1917, and instruction and research in chemistry and chemical engineering 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. The setting up of the Executive Council, which was the principal feature of an administrative reorganization, was designed to achieve two results: to avoid the burden of single responsibility which a college presidency usually entails, and to bring about a closer relationship between the Board of Trustees and the faculty. The Executive Council, which under the Board of Trustees administers the affairs of the Institute, is composed of both trustees and faculty members, and as a body it discharges the duties

ordinarily performed both by a college president and the executive committee of a board of trustees.

In the same year, 1921, financial stability was assured by Mr. Arthur H. Fleming's agreement to give the California Institute his personal fortune as permanent endowment. In November of that year, the Board of Trustees formulated in the "Educational Policies of the Institute" an explicit statement of the principles which were to govern the present conduct of the Institute and its future development. Recognition by the Southern California community of the value of these aims has resulted in a steady growth of the physical facilities and has made possible the addition of work in geology, biology, and aeronautics. There has been also, during the past fifteen years, a steady growth in enrollment, both in the undergraduate and graduate groups. But all of these developments have involved no changes of fundamental purpose; they have, in fact, only enabled that purpose to be fulfilled more completely.

Since the summer of 1941, the Institute has 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 has set up a number of special instructional programs for members of the armed forces. Since July, 1943, the Navy has maintained at the Institute a large unit of the Engineering Specialist Option of the V-12 College Training Program.

EDUCATIONAL POLICIES

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

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

(2) The four-year Undergraduate Course in Engineering shall be of a general, fundamental character, with a minimum of specialization in the separate branches of engineering. It shall include an unusually thorough training in the basic sciences of physics, chemistry, and mathematics, and a large proportion of cultural studies; the time for this being secured by eliminating some of the more specialized technical subjects commonly included in undergraduate

engineering courses. It shall include, however, the professional subjects common to all branches of engineering. It is hoped in this way to provide a combination of a fundamental scientific training with a broad human outlook, which will afford students with engineering interests the type of collegiate education endorsed by leading engineers—one which avoids on the one hand the narrowness common among students in technical schools, and on the other the superficiality and the lack of purpose noticeable in many of those taking academic college courses.

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

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

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

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

mature judgment and broad experience; the regular work in these subjects shall be supplemented by courses of lectures given each year by men of distinction from other institutions; and the weekly assemblies, addressed by leading men in the fields of education, literature, art, science, engineering, public service, commerce, and industry, shall be maintained as effectively as possible. Moderate participation of all students in student activities of a social, literary, or artistic character, such as student publications, debating and dramatic clubs, and musical clubs, shall be encouraged; and students shall be required to take regular exercise, preferably in the form of intramural games or contests affording recreation.

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

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

BUILDINGS AND FACILITIES

THROOP HALL, 1910.

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

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

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

Culbertson Hall, 1922.

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

Norman Bridge Laboratory of Physics: first unit, 1922; second unit, 1924; third unit, 1925.

The gift of the late Dr. Norman Bridge.

High-Potential Research Laboratory, 1923.

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

Engineering Research Laboratory and Heating Plant, 1926.

Erected with funds provided in part by the late Dr. Norman Bridge and in part from other sources.

Dabney Hall of the Humanities, 1928.

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

Seismological Research Laboratory (of the Division of the Geological Sciences), 1928.

Daniel Guggenheim Aeronautical Laboratory, 1929.

Erected with funds provided by the Daniel Guggenheim Fund for the Promotion of Aeronautics.

William G. Kerckhoff Laboratories of the Biological Sciences: first unit, 1929; second unit, 1938.

The gift of the late Mr. William G. Kerckhoff and Mrs. Kerckhoff, of Los Angeles.

Experimental Station (of the Division of Biology), Arcadia, California, 1929.

Plant Physiology Laboratory (of the Division of Biology), 1930.

William G. Kerckhoff Marine Biological Laboratory (of the Division of Biology), Corona del Mar, California, 1930.

Athenæum, 1930.

The gift of the late Mr. and Mrs. Allan C. Balch, of Los Angeles.

STUDENT HOUSES, 1931.

Blacker House.

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

Dabney House.

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

Fleming House.

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

Ricketts House.

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

ASTROPHYSICAL INSTRUMENT SHOP, 1931.

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

W. K. KELLOGG LABORATORY OF RADIATION, 1932.

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

ASTROPHYSICAL LABORATORY, 1932.

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

HYDRAULIC STRUCTURES LABORATORY, 1932.

ASTROPHYSICAL OPTICAL SHOP, 1933.

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

SOIL CONSERVATION LABORATORY, 1936.

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

CHARLES ARMS LABORATORY OF THE GEOLOGICAL SCIENCES, 1938.

The gift of the late Mr. 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.

FLUID MECHANICS LABORATORY. Under construction; to be completed in December, 1944.

MECHANICAL ENGINEERING LABORATORY. First unit under construction; to be completed in January, 1945.

TEMPORARY BUILDINGS

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

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

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

LIBRARIES

The library of the Institute comprises the General Library, housed in the Norman Bridge Laboratory of Physics, and six departmental libraries for physics, chemistry, geology, biology, aeronautics, and the humanities.

ATHENÆUM

The Athenæum, a structure in the Mediterranean style of architecture, fittingly furnished and equipped, with grounds attractively landscaped, is situated at the Hill Avenue end of the campus. The purpose of the donors, Mr. and Mrs. Allan C. Balch, was to provide a place and opportunity for contact between the distinguished foreign scientists and men of letters temporarily in residence from time to time at the California Institute, the Mount Wilson Observatory, and the Henry E. Huntington Library and Art Gallery, the staffs and graduate students of those institutions, and the patrons and friends of science and education in Southern California making up the California Institute Associates.

The Athenæum contains on the first floor a large and beautiful lounge, a library, a main dining-room, three small dining-rooms, and, adjoining the main dining-room—and planned so that the two rooms can be thrown together for large banquets—a room for scientific and other lectures, known as the "Hall of the Associates." On the upper floors are very attractively furnished rooms and suites, each with private bath, for visiting professors, members of the staffs and graduate students of the three institutions named, and other members of the Athenæum. An attractive writing room and lounge are provided on a mezzanine floor for the exclusive use of women. On the third floor a loggia and dressing rooms provide additional accommodations for graduate students.

STUDENT LIFE

Student Houses. **(Note: At the present time, the facilities of the Student Houses are fully occupied by the Navy V-12 unit).** The four Student Houses are situated on the California Street side of the campus. Planned in the Mediterranean style to harmonize with the Athenæum, they were, like the latter building, designed by Mr. Gordon B. Kaufmann. While the four houses constitute a unified group, each house is a separate unit providing accommodations for about seventy-five students; each has its own dining-room and lounge, but all are served from a common kitchen.

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

The completion of this group of four residence halls marks the initial step in a plan to meet the housing and living problems of undergraduate students. The plan calls eventually for eight residence halls, "each to have its own distinctive atmosphere, each to be the center about which the loyalties developed in student days and the memories of student life shall cluster." Each of the four present houses has its own elected officers; each is autonomous in the matter of allotting rooms to residents, arranging dances and other social events, preserving its own traditions, and promoting the general welfare of the house.

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

Throop Club. The Throop Club is designed to provide for non-resident students the same sort of focus for undergraduate life that the Student Houses provide for resident students. The Throop Club

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

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

Associated Student Body. The undergraduate students are organized as the "Associated Students of the California Institute of Technology, Incorporated." All students who pay their student body fees are automatically members of this organization, which deals with affairs of general student concern and with such matters as may be delegated to it by the faculty. Membership in the corporation entitles each student to (a) admission to all regular athletic or forensic contests in which Institute teams participate, (b) a subscription to The California Tech, (c) 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 fine new baseball stadium, championship tennis courts, a football field, and a track. For basketball and swimming, Institute teams have the use of basketball courts and the pool at the Pasadena Junior College.

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 part-time employment bureau, a loan fund, a used book exchange and a lending library. Its General Secretary is always available to help students with their problems.

STUDENT HEALTH AND PHYSICAL EDUCATION

PHYSICAL EDUCATION

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

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

HEALTH SERVICE

A. PHYSICAL EXAMINATION AND VACCINATION

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

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

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

B. SERVICES OF THE INSTITUTE PHYSICIAN

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

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

C. EMERGENCY HOSPITALIZATION FUND

In addition, in order to meet the hospital and certain other emergency medical and surgical expenses, incurred by students who develop serious illnesses which require immediate attention, or suffer accidents, an emergency hospitalization fee of four dollars ($4.00) 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 Athenæum, or off the Institute grounds. Apart from providing the opportunity for free consultation with the Institute Physician at his office on the Institute grounds between 12:30 and 1:30 p.m. daily, unless otherwise stated, except Sunday, during term time, the Institute bears no responsibility for providing medical attention in case of illness.

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

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

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

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

REQUIREMENTS FOR ADMISSION TO UNDERGRADUATE STANDING

The war emergency has made necessary many schedule and curriculum changes at the California Institute in order to provide instruction for students in the United States Navy's V-12 College Training Program. The accelerated schedule under which the Institute is currently operating calls for three 16-week semesters per calendar year. Since two semesters constitute an academic year, any of the regular courses leading to the degree of Bachelor of Science can be completed in two calendar years and eight months.

When the Navy V-12 Program terminates, the Institute will return as soon as possible to its former schedule of three 12-week terms per academic and calendar year, with four years required for the completion of any of the courses leading to the degree of Bachelor of Science, and will resume the policy of admitting only 160 Freshmen each year and restricting the total number of undergraduates to approximately 640 students. Until such time as the return to this former schedule is practicable, new students will be admitted at the beginning of each semester (March 1, July 1, and November 1). With the reinstatement of the former schedule, the academic year will begin in September and end in June, and Freshmen will be admitted only in September. Transfer students will be admitted at the beginning of any term as warranted by their preparation. Former Institute students, now on leave of absence, may resume their studies at that point in their courses up to which they have received credit for work done. Special arrangements for war veterans who decide to resume college work are described in part II of this section of the catalogue.

I. ADMISSION TO THE FRESHMAN CLASS

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

HIGH SCHOOL CREDITS. Each applicant must be thoroughly prepared in at least fifteen units of preparatory work, each unit representing one year's work in a given subject in an approved high

school at the rate of five recitations weekly. Each applicant must offer all of the units in Group A and at least five units in Group B.

Group A:	English	3
	Algebra	2
	Plane Geometry	1
	Solid Geometry	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.

Regular entrance examinations will be held at the Institute on the following dates: January 20 and January 27, 1945, for registration March 5, 1945. May 5 and May 12, 1945, for registration July 2, 1945. September 15 and September 22, 1945, for registration November 5, 1945. Applicants should report in the Lounge of Dabney Hall at 8:30 a.m. on the date of the first examination.

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.

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

Completed application blanks and high school records including courses that may be in progress must reach the Registrar's Office at least two weeks in advance of the first examination date for the term in which the applicant desires to enter.

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 30 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). Each accepted applicant will then 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. SPECIAL ADMISSION ARRANGEMENTS FOR VETERANS

In order to offer assistance to veterans who decide to resume college work, the Institute will provide refresher courses in mathematics, physics and chemistry at the freshmen and sophomore levels if the demand warrants. Veterans who have not previously attended the Institute may take the transfer examinations before or after taking the refresher courses offered. If they choose to take the examination without taking the refresher course and fail, they may, if their record warrants it, be admitted to refresher courses and given another opportunity to take the transfer examination. The refresher courses carry no academic credit, and while taking any refresher course a student will be required to carry a load of at least 15 semester units unless permitted to do otherwise.

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.)

After the Institute returns to its normal schedule, examinations for Freshman admission will be held in March. However, as a further accommodation to returning veterans who wish to enter the Institute, twenty places in the first complete Freshmen class of 160 will be reserved for veterans for a period to be determined by the Admissions Committee, but not to extend beyond July 15th. This is an extension of two months beyond the normal date of accepting applications for admission.

III. 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 62 to 66, or as upper classmen in the manner described below. Those who have pursued college work elsewhere, but whose preparation is such that they have not had the substantial equivalent of any two of the following freshman subjects, English, mathematics, physics and chemistry, will be classified as freshmen and must be admitted as such. (See freshman admission requirements on pages 62 to 66. 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 78.

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 time at which the student desires to enter the Institute. 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 127-153), or make up their deficiencies as soon as possible after admission. In case there is a question regarding either the quality or the extent of the previous work, examinations in the subjects concerned may be arranged.

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. In order to be approved for admission to the examinations, a student's

application and a transcript of his record must be on file at least ten days before the date of the examination. Applicants should not come to the Institute expecting to be admitted to the examinations, without first receiving definite permission to take them.

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

Mathematics	9:00 a.m.	February 23, 1945; June 15, 1945
Physics	9:00 a.m.	February 24, 1945; June 16, 1945
Chemistry	1:00 p.m.	February 24, 1945; June 16, 1945

If in the fall of 1945 the accelerated program is continued, entrance examinations will be held early in October; if the accelerated program is discontinued they will be held early in September.

Examinations for admission to the freshman class are held approximately six weeks earlier than the above dates. Students who may have to take one of these examinations should file their application three months before the beginning of the term when they wish to enter.

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 76 and 77. 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 77.

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

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

EXPENSES

The following is a list of student expenses, fixed and estimated, at the California Institute, for the academic year 1944-1945.

Tuition Fee (per semester) $180.00

Registration Fee 10.00

(The registration fee is paid by applicants upon notification of their admission to the Institute and is credited toward the first semester's tuition fee.)

General Deposit 25.00

(Each student is required to make this general deposit to cover possible loss of or damage to 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.)

Emergency Hospitalization Fee (per year) 4.00

(This fee is paid with the tuition fee the first semester of each academic year. The purpose of the fee is explained on pages ... to ... of this catalogue.)

Associated Student Body Dues (1st semester) 2.45

(Student Body dues are $3.00 the second semester. These dues are payable each semester and are budgeted by the Board of Directors of the Associated Student Body for the support of student activities.)

Subscription to the California Tech (1st semester) ..... .55

(The subscription to the undergraduate weekly paper is collected the first semester of each academic year.)

Board (per semester, approximately) 105.00

(This figure is for board at the Institute cafeteria, on the basis of 15 meals per week. In order to secure this rate, the student must sign up for at least a half semester. It is hoped that this rate can be maintained through 1944-1945, but the Institute reserves the right to raise it if such action is made necessary by increase in food and labor costs.)

Room (per semester) ..... 65.00 to 130.00

(Since the Student Houses have been taken over by the Navy V-12 unit, civilian students must find living accommodations in the community. The above figure is based on the present range of $15 to $30 per month for rooms in private homes. For the convenience of students, the Institute maintains a list of available rooms in boarding houses and private homes near the campus. Students must assume all responsibility for finding rooms and making rental arrangements. The Institute listing of rooms is not available for distribution. It may be consulted in the housing Office (Room 210, Mudd Laboratory) by students upon their arrival or by friends or relatives in the vicinity.)

Books and Supplies (per semester, estimated) 25.00

Locker Rent and Sundries (per semester, estimated) 25.00

Students withdrawing from the Institute during the first three weeks of a semester, 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.

SCHOLARSHIPS, PRIZES, AND STUDENT AID

FRESHMAN PRIZE SCHOLARSHIPS

Twelve or more freshman scholarships carrying stipends of $180 or $360 are awarded each year to members of the incoming freshman class. The recipients of these scholarships are selected by the Committee on Freshman Admission from the candidates who have passed the entrance examinations and otherwise satisfied the entrance requirements of the Institute. Since all prospective students taking the entrance examinations are automatically competing for these freshman scholarships, no formal applications for them are necessary.

The scholarships are awarded on the basis of all the information available in regard to the applicants—the results of their examinations, their high-school records and recommendations, the statements submitted as to their student activities and outside interests, and results of personal interviews. The awards are made without reference to financial need; but any successful student with adequate resources may relinquish the money payment in favor of the next most deserving competitor, while retaining the scholarship as an honorary recognition. The winners of these scholarships are designated Blacker Scholars or Drake Scholars, in recognition of the donors of the scholarship funds, Robert Roe Blacker and Nellie Canfield Blacker, or Mr. and Mrs. A. M. Drake.

DRAKE SCHOLARSHIPS

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

SOPHOMORE AND JUNIOR PRIZE SCHOLARSHIPS

The Institute has established about thirty scholarships known as the Sophomore and Junior Prize Scholarships. These scholarships, which carry half tuition, are awarded at the end of each school-year to those students who as the result of their work, during the freshman and sophomore years, are granted honor standing on the basis described on page 78 of this Catalogue. In addition, a smaller number

of tuition grants may be awarded to students of exceptionally high standing who are in need of financial assistance.

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

HARRIET HARVEY SCHOLARSHIP
WALTER HUMPHRY SCHOLARSHIP

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.

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.

LOAN FUNDS

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

In 1923, Mr. Howard R. Hughes, of Galveston, Texas, gave $5,000 to constitute an additional fund for loans to students. Mr. Raphael Herman, of Los Angeles, has provided a like sum to establish the Raphael Herman Loan Fund, which may be used for loans or for scholarships at the discretion of the Institute. A further gift of $5,000 has been made by Mr. and Mrs. Arthur Noble of Pasadena to establish the Noble Loan and Scholarship Fund.

In 1932, Mr. and Mrs. Willard C. Jackson established at the Institute the Thomas Jackson Memorial Loan Fund in memory of their son, a member of the Sophomore class of that year, who died during the fall term, at the beginning of a very promising career. The original gift for this fund was $10,000 and the donors have since added $15,000 to this amount. Loans from the fund are made to undergraduate or graduate students of superior ability who are in need of such assistance to meet the expenses of their education.

Applications for loans should be made to the Comptroller of the Institute.

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.

STUDENT EMPLOYMENT

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

PLACEMENT SERVICE

The Institute in cooperation with the Alumni Association maintains a Placement Office under the direction of a member of the faculty. With the services of a full-time secretary, this office assists graduates and undergraduates to find employment. Graduates who are unemployed or desire improvement in their positions should register with the Placement Secretary. It should be understood that the Institute assumes no responsibility in obtaining employment for its graduates, although the Placement Office will make every effort to find employment for those men who wish to make use of this service.

REGISTRATION REGULATIONS

Registration Dates	*Instruction Begins*	*Fees Payable*
Entering Freshmen, March 5, 1945, 1 p.m.	March 7, 1945	March 5, 1945
Entering Freshmen, July 2, 1945, 1 p.m.	July 4, 1945	July 2, 1945
Entering Freshmen, Oct. 29, 1945, 1 p.m.	Oct. 31, 1945	Oct. 29, 1945
V-12 Seamen, March 5 and 6, 1945, 9 a.m.	March 7, 1945	———
V-12 Seamen, July 2 and 3, 1945, 9 a.m.	July 4, 1945	———
V-12 Seamen, Oct. 29 and 30, 1945, 9 a.m.	Oct. 31, 1945	———
2nd Semester Freshmen, Civilian Upperclassmen, and Transfer Students:		
March 6, 1945, 9 a.m.	March 7, 1945	March 6, 1945
July 3, 1945, 9 a.m.	July 4, 1945	July 3, 1945
Oct. 30, 1945, 9 a.m.	Oct. 31, 1945	Oct. 30, 1945

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 class and assembly exercises for which he is registered, and to satisfy the requirements in each of the courses in such ways as the instructor may determine.

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

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

SCHOLASTIC GRADING AND REQUIREMENTS

SCHOLASTIC GRADING

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

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

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

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

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

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

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, drawing, and field work, 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 54 credits.

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

*Note. Commencing July 1, 1943 the Institute adopted for the duration of the war the system of semester hours in use at many colleges and required by the V-12 Program. Under this system a unit represents an hour a week in class or lecture, or three hours a week in laboratory. The system of grades and credits remains the same. As soon as possible after the war the Institute will return to its former evaluation for the unit. To change semester units to Institute units or vice-versa, multiply semester units by 9/2 or Institute units by 2/9.

†Under the semester unit system, if he fails in the first semester to receive a grade-point average of at least 1.5, and at the end of an academic year a grade-point average taken over both semesters of at least 1.8. Grade-point average is calculated by dividing the total of credits earned in a semester by the total of units taken. Under the paragraph headed "Deficiency" above a student is required to see the Dean before registering if in any semester his grade-point average is below 1.8.

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

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

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

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

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

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

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

Graduation requirement. To qualify for graduation a student must complete the prescribed work in some one option of the course in engineering or of the course in science with an average grade of 1.9.

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

Honor standing. At the close of each school-year the Committee on Honor Students awards *honor standing* to approximately fifteen students who have completed the freshman year, and to ten to fifteen students who have completed the sophomore year. To each of these students is also awarded a *prize scholarship* carrying half tuition. In addition honor standing is awarded to approximately fifteen students who have completed the junior year, but without the award of any scholarship. These awards are based primarily on the scholastic records of the students. Any holder of such a scholarship who in any subsequent term fails to maintain a scholastic standard set by the Committee automatically loses his honor standing and scholarship for the remainder of the school-year.

Honor standing entitles the student to 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 44 credits per semester which result from grades of "A" and "B," provided also that he maintains an average of 43 credits each semester of the senior year. In addition,

*See footnote on preceding page regarding grade-point average requirements under the semester unit system.

†Under semester system, two semesters of not less than 17 units each.

a student may be graduated with honor under joint recommendation of his department and the Honors Committee, and approval of the faculty.

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

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

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

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

CANDIDACY FOR THE BACHELOR'S DEGREE

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

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

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

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

An Observatory Council, comprising four members of the Executive Council of the Institute, and also including Dr. Walter S. Adams, has been placed by the trustees in full charge of the design, construction, and operation of the Astrophysical Observatory and Laboratory. With the approval of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed by the Observatory Council as its Executive Officer, in direct charge of design and construction. The organization of the Observatory Council and the personnel of its advisory committees are shown on page 43 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.

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

The graduate work is chiefly in the fields of biochemistry, bio-organic chemistry, biophysics, animal physiology, plant physiology, genetics, and embryology. These subjects are grouped in a single division, rather than in the traditionally separate ones (botany, 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 course, for positions involving the management and development of chemical industries on the chemical engineering side. For students who desire to enter the field of chemical research, for which there are now professional opportunities on both the scientific and applied sides, 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.

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 pages 172 and 173.

The fifth-year course in chemical engineering leads to the degree of Master of Science in Chemical Engineering. This fifth-year course contains an intensive problem study of chemical engineering,

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

Although chemical engineering is not offered as a major subject for the degree of Doctor of Philosophy, it may be presented as a minor subject in connection with the doctorate in chemistry or in mechanical engineering. The lines of research being pursued in chemical engineering include engineering thermodynamics, phase equilibrium of hydrocarbons at elevated pressures, thermal transfer, and fluid flow.

GEOLOGICAL SCIENCES

BALCH GRADUATE SCHOOL

Through the generosity of the late Mr. and Mrs. Allan C. Balch the Balch Graduate School of the Geological Sciences was established at the California Institute in 1929. This school comprises the staff offering instruction in the various branches of geology, vertebrate and invertebrate paleontology, geophysics and geophysical prospecting, and seismology.

Graduate courses in the geological sciences may be pursued either by students who have completed the four-year course at the Institute or by students from other colleges who present substantially the same preparation.

The curriculum outlined for undergraduate students provides a broad and thorough preparation in the basic sciences of physics, chemistry, and mathematics and in certain engineering subjects, followed by an introduction to the fundamental principles of geology, paleontology and geophysics. Fifth-year courses lead to the degree of Master of Science. During the senior year of the undergraduate curriculum in the geological sciences and throughout the fifth and later years much time is devoted to investigation and field work. Students desiring to become research workers in the geological sciences or professional geologists, paleontologists, or geophysicists should continue their studies at least two years beyond the bachelor's degree.

NEW GEOLOGICAL BUILDINGS

Two new buildings have recently been completed on the Institute campus for the geological sciences. Both structures are memorials to men who were very active in the mining industry. The eastern of the two buildings is known as the Charles Arms Laboratory of the Geological Sciences and is the gift of the late Mr. and Mrs. Henry M. Robinson in memory of Mrs. Robinson's father. The western of the two structures was given by the late Mrs. Seeley W. Mudd as a memorial to her late husband. Each building has five floors and the total space available for instruction and research in the geological sciences probably exceeds that devoted to these purposes in any other institution in America. The internal arrangement of the buildings is such as to provide suites of rooms adapted to the different branches of the geological sciences. Adequate office space is available for all graduate students in geology, paleontology, and geophysics.

INSTRUCTION AND RESEARCH IN THE GEOLOGICAL SCIENCES

Professional careers comparable to those of physicists, chemists, attorneys, or physicians are open to those who complete successfully the curricula for training geologists, paleontologists, or geophysicists. Students who attain a master's degree in geology are prepared to join the geological staffs of oil or mining companies or federal or state geological surveys. For those desiring more complete training, or preparing for university posts, or planning to be consulting geologists, additional graduate work and research should be undertaken, leading to the doctor's degree.

Exceptional opportunities for research in the geological sciences exist at the Institute. An almost unrivalled variety of rock types, geologic structures, and physiographic forms occurs within convenient reach of Pasadena. The relatively mild climate permits field studies throughout practically the entire year, and consequently field training is an unusually important part of the department program.

Stratigraphic and faunal studies may be pursued in the Cenozoic and Mesozoic sedimentary rocks of the Southern Coast Ranges, in which oil fields are located, and in the Mojave Desert region. Thick sections of Paleozoic sediments in southeastern California remain almost unexplored. Structural and physiographic problems in the Coast and Basin Ranges and along the coastal front await critical investigation and frequently involve an interpretation of folding and faulting on a large scale. The many productive oil fields in southern California afford exceptional opportunities to students interested in economic geology. Moreover, the gold, silver, quicksilver,

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

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

A very wide range of graduate courses is offered in both theoretical geophysics and in geophysics as applied to prospecting for oil and other mineral substances. The geophysical staff comprises five members, devoting themselves to different phases of the subject. 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. Geophysical researches of various types are in progress.

SEISMOLOGICAL LABORATORY

The Seismological Laboratory of the California Institute is located about three miles west of the campus on a granite ridge affording firm bedrock foundation for the instrument piers. The investigations at the laboratory relate mainly to earth movements originating within a radius of about two hundred miles. The seismograms from 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.

The general program of research is outlined by a committee consisting of J. P. Buwalda, chairman, and Messrs. J. A. Anderson, Beno Gutenberg, (executive officer of the laboratory), and H. O. Wood.

TEACHING AND RESEARCH FELLOWSHIPS

Fellowships are available for properly qualified students who desire to pursue advanced work in geology, paleontology and geophysics, as in other branches of science; see pages 117 and 118.

MATHEMATICS

Study and research in pure mathematics leading to the degree of Doctor of Philosophy were initiated by the Institute in 1926-1927. Candidates for the degree are expected to acquire a reasonable familiarity with some of the major applications of mathematics to the physical sciences. The attention of those intending to take advanced courses in mathematics is particularly directed to the foreign language requirements for mathematical work beyond the bachelor's degree.

PHYSICS

UNDERGRADUATE WORK

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

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

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

GRADUATE WORK

Graduate students should complete as soon as possible the courses required for admission to candidacy for the doctor's degree. (See pages 110-117.) 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 are two general seminars or research conferences per week which are regularly attended by all research workers and all graduate students. In addition, there is a weekly theoretical seminar conducted for the benefit of those interested primarily in mathematical physics and several seminars on special fields of work such as x-radiation, nuclear physics, metals, physics of solids, and ultra-short electromagnetic waves.

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.

*Some of the facilities described are not available during the war emergency.

STUDY AND RESEARCH IN ENGINEERING

Courses are offered in chemical, civil, electrical, and mechanical engineering, and in aeronautics, applied chemistry, industrial design, and meteorology.

The plan of instruction in engineering embodies a four-year course for the degree of Bachelor of Science, and a fifth year of graduate study, quite definitely outlined within the selected field, leading to the degree of Master of Science. A sixth year leads to the degree of Aeronautical Engineer, Chemical Engineer, Civil Engineer, Electrical Engineer, Industrial Designer, Mechanical Engineer, or Meteorologist. Additional work is offered (except in chemical engineering and in industrial design) leading to the degree of Doctor of Philosophy. 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 alternating currents, heat engines and hydraulics. The divergence between the different branches occurs in the third and fourth years, when the study of the professional subjects of specialized nature is introduced. Subjects in the humanities—English, history, and economics—are included in each year of the curriculum.

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

AERONAUTICS

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.

METEOROLOGY

Since September, 1940, the Meteorology Department has conducted special meteorology courses for the training of Army Air Force cadets and Navy Ensigns. Although the curricula were based on courses previously offered in the Graduate School, numerous additions and modifications have been made. Present indications are that during the next two academic years curricula will be further modified to meet the requirements of Navy V-12 aerology.

V-12 and civilian students satisfactorily completing prescribed courses beginning July 1, 1944, and March 1, 1945, will be granted the degree of Bachelor of Science in Meteorology. The course beginning July 1, 1944, is designated as a special aerology and meteorology course to which will be admitted V-12 and civilian students having two and a half years of college credits and the necessary prerequisites for admission to meteorology. These basic prerequisites are mathematics through differential and integral calculus, and two years of college physics. This course will be of three 16-week semesters' duration.

The meteorology course beginning March, 1945, consisting of four 16-week semesters, will be open to V-12 and civilian students who have satisfactorily completed two years of college and who possess the above indicated prerequisites for admission to meteorology.

By special arrangement graduate students will be admitted and may be candidates for any of the advanced degrees in meteorology. For satisfactory completion of graduate work in meteorology the degrees of Master of Science, the professional degree of Meteorologist and the degree of Doctor of Philosophy are granted.

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

1. A course in meteorology with special reference to the problems of weather forecasting for aeronautical and military operations. This course includes an introduction to modern dynamic meteorology and the theory and practice of synoptic and upper air analysis as applied to short term forecasting. An introduction to long term forecasting is included.
2. Experimental and theoretical research:
   (a) meteorological problems pertaining to the improvement of short range forecasting techniques;
   (b) the problems of improving existing techniques for the preparation of long term forecasting;
   (c) the development of new and improved instruments for the observing of surface and upper air meteorological data.

Practice work in meteorology is facilitated by the Institute Weather Station, and the Army Air Force Weather Station, both of which are located on the campus. In addition a mobile weather station is operated by students on various week ends at the Marine Laboratory at Corona del Mar. By means of Civil Aeronautics Administration teletype facilities, current weather data are available for use in the synoptic laboratory. A well equipped shop enables students and staff members to develop new designs in the line of instrumental research.

CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

(See pp. 83 to 85)

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 arrange-

ment; 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 undergraduate work, leading to the bachelor's degree, is designed to qualify the student for technical occupations incident to the selection, installation and operation of electrical equipment, the supervision of construction, the testing of apparatus and the further study of electrical specialties. Emphasis is placed on the analytical approach to engineering problems. Laboratory equipment of wide variety is available in both the machinery and electronic fields. Students may select either the power machinery option or the communication option.

The work leading to the degree of Master of Science is designed to supplement the work given in the undergraduate courses. It is particularly valuable for all students expecting to prepare for technical work incident to the design and development of electrical equipment. These courses are open to qualified students who have graduated from the Institute in electrical engineering, or have had substantially the same preparation in other colleges. Courses are offered in the application of mathematical analysis and physical laws to mechanical and electrical problems incident to the design of electrical machinery, electric transients including lightning phenomena, problems relating to the generation and distribution of electric power and in the field of electronics, radio and ultra high frequency.

Students desiring to engage in research work or to become college teachers or professional experts in electrical engineering may continue work for the degree of Doctor of Philosophy. This work stresses the use of modern methods of mathematical and physical analysis in engineering problems. A student working for the doctor's degree is expected to take certain courses in mathematical analysis and electricity and magnetism in addition to selected courses

offered by the Electrical Engineering Department. Before receiving a doctor's degree a student must demonstrate his ability to conduct original research on some problem in electrical engineering.

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 is not at present easily obtainable elsewhere by students of science and engineering. The Institute has also available equipment and laboratories for research work on electronics, radio, ultra high frequency as well as the facilities for research in dynamo-electric machinery.

MECHANICAL ENGINEERING

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

HYDRAULIC ENGINEERING

Due to the recent establishment of research laboratories at the Institute covering several of the broader fields of hydraulic engineering, the opportunities for advanced study and research in such fields are exceptionally good. Researches are now being carried on or are just being completed in these laboratories in cooperation with

the Metropolitan Water District of Southern California, the Bureau of Reclamation of the United States Department of the Interior, the Los Angeles County Flood Control District, and the Soil Conservation Service of the United States Department of Agriculture.

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

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 war-time emergency and post war conditions and developments.

Graduation from a course in civil, electrical, or mechanical engineering, or the equivalent thereof, has been established as the requirement for admission to graduate study in industrial design.

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.
5. Maintenance and enlargement of reference library and specialized documentary files.

THE HUMANITIES

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

The California Institute has been a pioneer in recognizing the desirability of providing for a generous amount of instruction in the

humanities. The faculty, in thorough sympathy with this aim, has cooperated by eliminating some of the more specialized technical subjects commonly included in undergraduate courses. As a result, it has been found possible to require every student to take, in each of his four undergraduate years, one or more courses of a humanistic character. These courses in the Division of the Humanities cover the field of English and foreign literatures, European and American history, philosophy and social ethics, economics (including industrial relations) and government. All of them are so planned and articulated that the student obtains a solid grounding, and not merely the superficial acquaintance which is too often the outcome of a free elective system. The standards of intellectual performance in these studies are maintained on the same plane as in the professional subjects.

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

In 1939 the Industrial Relations Section was established for a five-year experimental period. Financial support is provided by a generous grant from the Earhart Foundation of Detroit and by contributions from more than sixty individuals, industrial concerns, and labor unions. The study of industrial relations was added to the curriculum of the Institute largely because engineers must deal with men as well as with machines and material. The program of the Industrial Relations Sections is fourfold: (1) to provide class instruction; a course for seniors and one for graduate students are now being given; (2) to arrange periodic conferences for the discussion of labor problems; (3) to conduct field and research studies in industrial relations; and (4) to build up a library of material relating to such problems.

In addition to the regular staff of the Institute, several scholars from other institutions are giving instruction or lectures in the Division of the Humanities during the current year. It is anticipated that with the opportunities for research in English Literature and American History which are afforded by the proximity of the Huntington Library, the instruction given at the Institute in these fields will be steadily strengthened by the association of visiting scholars.

INFORMATION AND REGULATIONS FOR THE GUIDANCE OF GRADUATE STUDENTS

A. GENERAL REGULATIONS

I. REQUIREMENTS FOR ADMISSION TO GRADUATE STANDING

1. The Institute offers graduate work leading to 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, 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, morever, 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 117, 118.

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.

II. GRADUATE RESIDENCE

One semester of residence shall consist of one semester's work of not less than 15 units of advanced work in which a passing grade is recorded. If less than 15 units are successfully carried, the resi-

dence will be regarded as shortened in the same ratio; but the completion of a larger number of units in any one semester will not be regarded as increasing the residence.

III. TUITION FEES

The tuition charge for all students registering for graduate work is $360 per academic year, payable in two equal installments of $180 at the beginning of each semester. 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 11 units should petition therefor on a blank obtained from the Registrar. If such reduced registration is permitted, the tuition is at the rate of $135 a semester for 9 to 12 units, and at the rate of $15 a unit for less than 9 units, with a minimum of $50 a semester. 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.

In regard to *fellowships and assistantships,* see pages 117 and 118 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.

*See page 60.

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 160) 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, paleontology, or physics), or of the Committee on Courses in Engineering (in case the work is to be in civil, mechanical or electrical engineering, aeronautics or meteorology); and recommendations to the Faculty for the award of the degree shall be made by the appropriate 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 74 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 17 units but less than 21 units in any semester must have the approval of their department. Registration for more than 20 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. At least two semesters of graduate residence at this Institute subsequent to the completion of the requirements for the baccalaureate degree are required for a master's degree.

2. A minimum of 33 units of graduate work is required for a master's degree.

3. Scholastic requirements for undergraduate students (see page 74) also apply to students working toward the master's degree.

4. 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 77.

5. 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 66.

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 four semesters 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 two 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 tenth week 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 one semester 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 sixth week of the semester in which the degree is to be granted.

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

Before submitting his thesis, the candidate must obtain 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 semester by the department in which the student is doing his major work.

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

With the approval of the Committee on Graduate Study, students are admitted to graduate standing by the department in which they choose their major work toward the doctor's degree. In the case of insufficient preparation, applicants for the doctor's degree may be required to register for the master's degree first. The master's degree, however, is in no sense a prerequisite for the doctor's degree. Students who have received the master's degree and wish to pursue further studies leading towards the doctor's degree must file a new application for admission to graduate standing to work towards that degree.

III. REGISTRATION

1. Students are required to register and file a program card in the Registrar's office at the beginning of each semester 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 three hours a week of work throughout the semester, 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 semester 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 20 units in any one semester. 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 15 units.

IV. GRADES IN GRADUATE COURSES

1. Semester 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 semester.

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 10 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.

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

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

3. *Admission to Candidacy:* Any student admitted to work for the doctor's degree who has been in residence one semester 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 semester of the year in which the degree is to be conferred, and must be followed by one semester 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, 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 semester. 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 writ-

ten 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 resluts obtained.

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

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

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

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

VI. SPECIAL REQUIREMENTS FOR THE DOCTOR'S DEGREE

In agreement with the general requirements for the doctor's degree adopted by the Committee on Graduate Study, as set forth in Section V (pages 105-106), the various divisions and departments of the Institute have adopted the following supplementary regulations.

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 101ab	Electricity and Magnetism
Ph 103ab	Analytical Mechanics
Ph 105ab	Optics

and 10 units selected from the following courses:*

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

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

Ma 101ab	Modern Algebra
Ma 201ab	Modern Analysis
or	
Ma 114ab	Mathematical Analysis

and one semester each of:

Ma 256	Modern Differential Geometry
Ma 102	Introduction to Higher Geometry

and at least one semester of *one* of the following subjects:

Ph 101	Electricity and Magnetism
Ph 103	Analytical Mechanics
Ph 105	Optics

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 101ab	Electricity and Magnetism

and one of the following subjects:

Ph 103ab	Analytical Mechanics
AM 1ab	Applied Mechanics
together with	
AM 1c	Strength of Materials

and one of the following subjects:

Ma 8ab	Advanced Calculus
Ph 5ab	Introduction to Mathematical Physics
Ma 8ab	Advanced Calculus
together with	
Ma 11	Differential Equations

*Such of these courses as are not available during the war emergency may be replaced from the list of graduate subjects, with the approval of the Committee on Graduate Study.

and the following subjects or their equivalents:

EE 120	Alternating Current Analysis
EE 122	Advanced Alternating Current Machinery
EE 144	Transmission Lines
EE 152	Dielectrics
EE 162	Vacuum Tubes

2. An applicant may also satisfy any of the course requirements described above by taking an examination in the subject with the instructor in charge. Every examination of this type will cover the *whole* of the course specified and the student will not be permitted to take it either in parts (e.g. term by term) or more than twice. These so-called candidacy examinations will be given early in the first semester of each academic year and the student must apply for permission to take them before the end of the second week of the semester. 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 semester examinations in a course without actual class attendance.)

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

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

Students registered for the Ph.D. degree who fail to meet at least two-thirds of the candidacy requirements by the end of their first 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 is 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 semester 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

*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.

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.

The examinations are written, except for that in inorganic chemistry, which is usually oral. They cover their respective subjects substantially to the extent that these are treated in the undergraduate chemistry option; the proficiency expected is not less than that acquired by the abler undergraduates. A detailed informational knowledge is not so much desired as an understanding of general principles and a power to apply these to concrete problems. These examinations 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.

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

*The doctor's degree is not awarded in chemical engineering at the present time, but students interested in this field may offer a minor in chemical engineering in connection with a major in chemistry or mechanical engineering.

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 10 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 5 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 3 semesters 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 to the minor subject and to general branches of chemistry, and about six to the branch of chemistry of major interest to the candidate, including his research. The candidate may also include propositions not relating to his major and minor fields. The propositions, prepared by the candidate himself, should display his originality, breadth of interest, and soundness of training; the candidate will be judged on his selection and formulation of the 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, AERONAUTICS, AND METEOROLOGY

1a. *Civil Engineering.* To be recommended for candidacy for the doctor's degree in civil engineering the applicant must pass with a grade of C or better, the subjects prescribed and elected for the

fifth year, or equivalent substitutions satisfactory to the department, and such other advanced subjects related to the contemplated direction of study as the department may require, and must pass special comprehensive oral or written examinations in the 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 11	Differential Equations

and one of the following:

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

and any one of the following three groups:

ME 101ab	Advanced Machine Design
ME 110ab	Science of Metals
ME 111ab	Metallography Laboratory
AE 270a	Elasticity Applied to Aeronautics
ME 120, 121, 122	Heat Engines
Ph 211	Thermodynamics
Hy 100	Fluid Mechanics
Hy 101	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 semester:

AE 257ab	Engineering Mathematical Principles
	or
Ma 114ab	Mathematical Analysis
Ma 14	Vector Analysis

and

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

and one of the following subjects:

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

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

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

Ma 14	Vector Analysis
AE 266ab	Theoretical Aerodynamics I
Ph 211	Thermodynamics

and one of the following subjects:

Ma 114ab	Introduction to Mathematical Analysis
EE 226ab	Engineering Mathematical Physics

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

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

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

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

5. A first draft of the doctoral thesis with data, maps, and illustrations complete must be submitted to the professor in charge at least four months before the date on which the degree is to be conferred. Six weeks before that date, two copies of the final, revised thesis must be filed with the professor in charge, and circulated among the members of the examining committee. At the same time, the candidate must file and circulate a paper, prepared for publication in form acceptable to his examining committee, embodying the results of his research in whole or in part.

1. To be recommended for candidacy for the doctor's degree in biology a student must pass a comprehensive written examination covering advanced work in the major and minor fields at least two terms before the degree is to be conferred. A final oral examination covering principally the work of the thesis will be held at least two weeks before the degree is to be conferred.

2a. *Animal Physiology.* For a major in animal physiology, the subjects in this field and other supplementary subjects of graduate rank must be taken. If there is one minor, it must be taken in Biology; if there are two minors, the second may be taken outside the Division of Biology.

2b. *Biochemistry.* Either the biology or the chemistry option or its equivalent is prerequisite. In either case, examinations in chemical principles and organic chemistry, set by the Division of Chemistry, must be passed satisfactorily; and an examination on biochemistry (based on Bi. 7a, b) must also be passed. Later, more advanced work (Bi. 110 and 102) will be required before the examination for admission to candidacy is taken. At least one of the minors must be in another department of the Division of Biology.

2c. *Bio-organic Chemistry.* For a major in bio-organic chemistry, either the biology or the chemistry option or its equivalent is prerequisite. Those who take the biology option must include Ch. 46a, b (organic chemistry laboratory) as either an undergraduate or a graduate subject. For graduate work in bio-organic chemistry, the subjects Bi. 115 (chemistry of bio-organic substances) and Bi. 141 (plant chemistry) are both required. For the minor some field of biology or chemistry must be chosen.

2d. *Embryology.* For a major in embryology, the biology option or its equivalent is prerequisite. In addition to the subjects and the research in the major and minor fields, advanced work in at least one other department of the Division of Biology will be required. The program of work will depend upon the preliminary training of the student and will be subject to the approval of those in charge of the major work.

2e. *Genetics.* For a major in genetics, the biology option or its equivalent is prerequisite. As a part of the major, Bi. 125 must be taken for at least two years, and other subjects in related fields. For a minor, some other subject or subjects, either in the Division of Biology or in some other division of the Institute, must be taken, subject to the approval of those in charge of the major.

2f. *Plant Physiology.* For a major in plant physiology, the biology option or its equivalent is prerequisite. The major must include Bi. 140, Bi. 141, and related subjects. For a minor, one or two other subjects in the Division must be chosen, with the approval of those in charge of the major. The minor must include Bi. 18 for students who have not taken the equivalent of Bi. 3 and Bi. 5.

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

E. OPPORTUNITIES FOR GRADUATE AND SCIENTIFIC WORK AT THE INSTITUTE

I. FELLOWSHIPS, 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.

Most of the major grants consist in providing board in the Athenaeum (see pages 54 and 121) and lodging in the Athenaeum loggia 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 100) 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. At present, applications are being considered when received. 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.

The Earhart Foundation has contributed funds for the whole program of meteorological research at the Institute, including the development and use of the radiometeorograph.

III. INSTITUTE GUESTS

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

IV. GRADUATE LIFE

The Athenaeum (see page 54) affords opportunity for contact between the Associates of the Institute, distinguished foreign visitors, and members of the staffs and graduate students at the three adjacent institutions, the Mount Wilson Observatory, the Huntington Library and the California Institute. It also provides living quarters for a limited number of men associated with the foregoing institutions.

DESCRIPTION OF THE UNDERGRADUATE AND FIFTH-YEAR COURSES

THE COURSES IN SCIENCE

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

The option in chemistry and the option in physics and the fifth-year courses in chemistry and physics prepare students, on the chemical and physical sides respectively, for research and teaching in universities, colleges, and high schools, and for research positions in governmental laboratories and especially in the research and 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 COURSES IN ENGINEERING

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

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

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

The fifth-year courses in civil, mechanical, and electrical engineering, and aeronautics consist mainly of the engineering subjects that are fundamental in these separate branches of engineering. Thus the civil engineering course deals largely with the analysis, design and

construction of water systems, sanitation works and structures; the mechanical engineering course, with machine design, steam and gas engineering, and power-plant design and operation; the electrical engineering course with the generation, transmission and utilization of electric power and the communication of intelligence by electrical means; and the aeronautics course with the principles of aerodynamics, the design and construction of airplanes, their engines and instruments. Of all these courses, engineering research or design forms an important part.

SCHEDULES OF THE UNDERGRADUATE COURSES

The school year is divided into two semesters. The number of units assigned in any semester to any subject represents the number of hours a week spent in class or laboratory, except that three hours of laboratory are considered the equivalent of one unit. It is expected that approximately two hours of preparation will be required for each hour of class. Laboratory assignments include drawing exercises and field work.

Besides the subjects shown in the course schedules, students are required to take assembly and physical education in each semester 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.

Since July, 1943, the Institute has had a unit of the Navy V-12 engineering specialist course. The subjects prescribed in the three options of this course—civil, electrical, and mechanical engineering —were sufficiently parallel to those formerly taught here so that it was possible to merge the civilian and V-12 courses in the two upperclass years. The present civilian freshman course is the same as in past years. The civilian sophomore course has been altered slightly to permit a transition to the V-12 courses of the third and fourth years. The statements made above apply to the three options of the engineering course only. The options of the science course have been changed only slightly in any year. It will be noted below that in the engineering options two curricula are listed for the senior year. In the academic year 1944-45 all seniors will take the present civilian program. The juniors of that year will take the fully prescribed V-12 curriculum, and will continue on in the V-12 curriculum for their senior year in 1945-46.

As soon after the war as possible the Institute will return to its own curricula in all options. For the benefit of those who may wish to know what such curricula may be like, there has been appended to the list of courses of each option a sample post-war curriculum.

The subject numbers of courses listed below correspond to those given in the description of subjects on pages 161 to 228. Subject numbers followed by the letter "V" indicate V-12 courses, a des-

cription of which will be found in alphabetical arrangement on pages 229 to 238.

KEY TO ABBREVIATIONS

Aeronautics	AE	Geology	Ge
Applied Chemistry	A Ch	History and Government	H
Applied Mathematics	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	Psychology	PS
English	En	Thesis	Th

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 Semester 1st	2nd
Ma 1ab	Mathematics (4-0)*	4	4
Ph 1ab	Physics (3-3)	4	4
Ch 1ab	Chemistry (3-6)	4	4
En 1ab	English (3-0)	3	3
H 1-V, 2-V	Historical Background of Present World War (2-0)	2	2
D 1a	Freehand Drawing (0-3)	1	..
D 1b	Engineering Drafting (0-3)	..	1

*Figures in parenthesis denote hours in class (first figure) and hours in laboratory (second figure).

SCIENCE COURSE, SECOND YEAR, ALL OPTIONS

Second Year—Civilian (November to June, 1944-45)

For students preparing for Astronomy, Biology, Chemistry or Applied Chemistry, Geology, Mathematics, Medicine, Paleontology, and Physics or Applied Physics.

(For First Year see page 127)

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 77.

		Units per Semester	
Subjects common to all options		1st	2nd
Ma 2ab	Mathematics (4-0)	4	4
Ph 2ae	Physics (3-3; 2-3)	4	2
H 1ab	History of European Civilization (4-0)	..	4
Ge 1a	Physical Geology (2-2)	3	..
Bi 1	Elementary Biology (2-3)	3	..
Biology			
Bi 2	Genetics (1-3)	..	2
Bi 4	Invertebrate Zoology (2-1)	..	2
Bi 17	Vertebrate Anatomy (1-6)	..	3
Ch 12a	Analytical Chemistry (2-6)	4	..
Chemistry and Applied Chemistry			
Ay 1	Astronomy (2-1)	..	2
Bi 2	Genetics (1-3)	..	2
Ch 12ab	Analytical Chemistry (2-6)	4	4
Geology			
Ch 12a	Analytical Chemistry (2-6)	4	..
D 5	Descriptive Geometry (0-3)	..	1
Ge 1b	Paleontology (2-1)	..	2
Ge 1c	Historical Geology (2-1)	..	2
	Approved Electives	..	3
Mathematics			
Ay 1	Astronomy (2-1)	..	2
L 32ab	Elementary Scientific German (4-0)	4	4
	Elective	..	2
Physics and Applied Physics			
Ay 1	Astronomy (2-1)	..	2
Ch 11	Quantitative Chemical Analysis (1-6)	..	3
L 32ab	Elementary Scientific German (4-0)	4	4

Probable Post-War Curriculum

Ph 2e replaced by Ph 2b (in subjects common to all options).

BIOLOGY OPTION, THIRD AND FOURTH YEARS

(For First and Second Years, see pages 127 and 128)

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 77.

THIRD YEAR

		Units per Semester 1st	2nd
H 5	Current History (1-0)	1	..
En 7	English (3-0)	..	3
PS 1	Psychology (2-0)	2	..
L 32ab	Elementary Scientific German (4-0)	4	4
Ch 41ab	Organic Chemistry (3-0)	3	3
Ch 45ab	Organic Chemistry Laboratory (0-3)	1	1
Schedule A (March, 1944—October, 1944; July, 1945—February, 1946; etc.)			
Ch 23ab	Chemical Principles (4-0)	4	4
Bi 3	General Botany (2-6)	4	..
Bi 5	Plant Physiology (2-6)	..	4
Schedule B (November, 1944—June, 1945; March, 1946—October, 1946; etc.)			
Bi 12	Histology (1-6)	3	..
Bi 13	Mammalian Anatomy (0-3)	1	..
Bi 6	Embryology (2-6)	..	4
Bi 16	Animal Physiology (2-3)	3	3

FOURTH YEAR

	*Humanities Electives (3-0)	3	3
H 10	Constitution of the U. S. (1-0)	..	1
L 35a	Advanced Scientific German (4-0)	4	..
L 1	Elementary French (4-0)	..	4
Ec 2	Economics (3-0)	..	3
Bi 7	Biochemistry (2-6)	4	..
	Schedule B or Schedule A—whichever was not taken in the third year	7 or 8	7 or 8

*Humanities Electives (the subjects to be offered in any one semester will be announced before the close of the previous semester):

Pl 1	Philosophy	Ec 48	Introduction to Industrial Relations
Pl 4	Ethics	H 4	The British Empire
Pl 5	Sociology	H 7	Modern and Contemporary Germany
En 8	Contemporary Literature	H 8	The History of Russia
En 9	American Literature	H 11	Latin-American History
En 10	Modern Drama	H 12	The History of Europe since 1789
En 11	Literature of the Bible	N 3-V	Naval History and Elementary Strategy
En 17	Technical Report Writing		
L 40	German Literature		

CHEMISTRY OPTION, THIRD AND FOURTH YEARS

(For First and Second Years, see pages 127 and 128)

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.

THIRD YEAR

		Units per Semester 1st	2nd
En 7	English (3-0)	..	3
PS 1	Psychology (3-0)	2	..
L 32ab	Elementary Scientific German (4-0)	4	4
Ch 21ab	Chemical Principles (4-0)	4	4
Ch 41ab	Organic Chemistry (3-0)	3	3
Ch 46ab	Organic Chemistry Laboratory (0-6; 0-9)	2	3
Ec 2	Economics (3-0)	3	..

FOURTH YEAR

	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
L 35a	Advanced Scientific German (4-0)	4	..
L 1	Elementary French (4-0)	..	4
	Approved Electives	10	10

*For the list of Humanities electives, see footnote, page 129.

Probable Post-War Curriculum

In place of the approved electives of the fourth year, certain courses such as Advanced Inorganic Chemistry, Ch 13, Instrumental Analysis, Ch 16, Physical Chemistry Laboratory, Ch 26, Thermodynamic Chemistry, Ch 22, and Surface and Colloid Chemistry, Ch 29, will be required; and other advanced courses in chemistry, physics, and mathematics may be elected.

APPLIED CHEMISTRY OPTION, THIRD AND FOURTH YEARS

(For First and Second Years, see pages 127 and 128)

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.

THIRD YEAR

		Units per Semester 1st	2nd
PS 1	Psychology (3-0)	2	..
L 32ab	Elementary Scientific German (4-0)	4	4
Ch 21ab	Chemical Principles (4-0)	4	4
Ch 41ab	Organic Chemistry (3-0)	3	3
Ch 46ab	Organic Chemistry Laboratory (0-6)	2	2
Ec 2	Economics (3-0)	3	..
A 1, 2	Analytical Mechanics (5-0)	..	5

FOURTH YEAR

	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
L 35a	Advanced Scientific German (4-0)	4	..
L 1	Elementary French (4-0)	..	4
	Approved Electives	10	10

*For the list of Humanities electives, see footnote, page 129.

Probable Post-War Curriculum

In place of the approved electives of the fourth year, certain courses, such as Instrumental Analysis, Ch 16, Physical Chemistry Laboratory, Ch 26, Surface and Colloid Chemistry, Ch 29, Chemical Engineering Thermodynamics, Ch 63, Industrial Chemistry 61 and Electrical Engineering EE 10, 11, will be required.

GEOLOGICAL SCIENCES OPTION, THIRD AND FOURTH YEARS

(For First and Second Years, see pages 127 and 128)

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.

THIRD YEAR

		Units per Semester 1st	2nd
En 7	English (3-0)	..	3
PS 1	Psychology (3-0)	2	..
L 32ab	Elementary Scientific German (4-0)	4	4
CE 1-V	*Surveying (1-6)	3	..
	*Approved Electives	9	10

FOURTH YEAR

	†Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
Ec 2	Economics (3-0)	3	..
L 35a	Advanced Scientific German (4-0)	4	..
L 1	Elementary French (4-0)	..	4
	Approved Electives	7	10

*Geology majors who have had CE 1-V, Surveying, will take 12 units of approved electives.
†For the list of Humanities electives, see footnote, page 129.

GEOLOGICAL SCIENCES OPTION, POST-WAR

Probable Post-War Curriculum

THIRD YEAR

Subjects common to all options		Units per Semester 1st	2nd
PS 1	Psychology (3-0)	2	..
En 7	English (3-0)	..	3
L 32ab	Elementary Scientific German (4-0)	4	4
Ge 14	Geologic Illustration (0-6)	..	2
Ge 21ab	Field Geology (0-6)	2	2
Option A			
Ch 24ab	Physical Chemistry (2-0)	..	2
Ge 3ab	Mineralogy (2-6)	4	4
CE 1-V	*Surveying (1-6)	3	..
Option B			
Ge 3ab	Mineralogy (2-6)	4	4
Bi 3	General Botany (2-6)	4	..
	or		
Bi 13	Mammalian Anatomy (0-3)	1	..
Bi 4	Invertebrate Zoology (2-1)	..	2
	or		
Bi 17	Vertebrate Anatomy (1-6)	..	3
CE 1-V	*Surveying (1-6)	3	..
Option C			
Ph 5ab	Introduction to Mathematical Physics (4-0)	4	4
Ch 24ab	Physical Chemistry (2-0)	..	2
CE 1-V	*Surveying (1-6)	3	..

Summer Camp, Ge 123, 5 units, required for Options A and B.

*Geology majors who have had CE 1-V, Surveying, will take 12 units of approved electives.

GEOLOGICAL SCIENCES OPTION, POST-WAR

Probable Post-War Curriculum

FOURTH YEAR

	Subjects common to all options	Units per Semester 1st	2nd
	*Humanities Electives (3-0)	3	3
Ge 100	Geology Club	1	1
Ge 102	†Oral Presentation	1	1
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
Ec 2	Economics (3-0)	3	..
L 1	Elementary French (4-0)	..	4
L 35a	Advanced Scientific German (4-0)	4	..
Ge 109	Structural Geology (2-0)	2	..
Ge 121ab	Advanced Field Geology	2	2
Option A			
Ge 105	Optical Mineralogy (2-6)	3	..
Ge 106ab	Petrography (2-6)	..	4
Ge 111ab	Invertebrate Paleontology (3-6)	..	5
Option B			
Ge 111ab	Invertebrate Paleontology (3-6)	..	5
Ge 112ab	Vertebrate Paleontology (3-6)	..	5
Bi 3	General Botany (2-6)	4	..
	or		
Bi 13	Mammalian Anatomy (0-3)	1	..
Option C			
Ma 8ab	Advanced Calculus (3-0)	3	3
Ma 10ab	Differential Equations (2-0)	2	2
EE 8	Direct Currents (2-0)	2	..
EE 9	Direct Currents Laboratory (0-3)	1	..
Ge 175	Elementary Geophysics (2-0)	..	2

Summer Camp, Ge 123, 5 units, required for Options A and B.

*For the list of Humanities electives, see footnote, page 129.

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

MATHEMATICS OPTION, THIRD AND FOURTH YEARS

(For First and Second Years, see pages 127 and 128)

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 77.

THIRD YEAR

		Units per Semester 1st	2nd
En 7	English (3-0)	..	3
PS 1	Psychology (3-0)	2	..
L 35a	Advanced Scientific German (4-0)	4	..
L 1	Elementary French (4-0)	..	4
	Approved Electives	12	10

FOURTH YEAR

	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
Ec 2	Economics (3-0)	3	..
	Approved Electives	11	14

*For the list of Humanities electives, see footnote, page 129.

MATHEMATICS OPTION, POST-WAR

Probable Post-War Curriculum

THIRD YEAR

		Units per Semester 1st	2nd
En 7	English (3-0)	..	3
L 35a	Advanced Scientific German (4-0)	4	..
L 1	Elementary French (4-0)	..	4
Ph 5ab	Introduction to Mathematical Physics (4-0)	4	4
Ma 8ab	Advanced Calculus (3-0)	3	3
Schedule A (given in alternate years)			
Ma 3	Theory of Equations (3-0)	3	..
Ma 4ab	Analytic Geometry (3-0)	..	3
Schedule B (given in alternate years)			
Ma 10ab	Differential Equations (3-0)	3	3

FOURTH YEAR

	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
Ec 2	Economics (3-0)	3	..
Schedule A (given in alternate years)			
Ma 10ab	Differential Equations (3-0)	3	3
Ma 102ab	Higher Geometry (4-0)	4	4
Ma 16	Introduction to Higher Algebra (3-0)	3	..
Ma 111	Elementary Theory of Tensors (3-0)	..	3
Ma 137ab	Real Variables (3-0)	3	3
Ph 114	Quantum Mechanics (3-0)	..	3
Schedule B (given in alternate years)			
Ma 3	Theory of Equations (3-0)	3	..
Ma 4ab	Analytic Geometry (3-0)	..	3
Ma 101ab	Modern Algebra (3-0)	3	3
Ma 106ab	Introduction to Theory of Real Variables (2-0)	2	2
Ma 114ab	Mathematical Analysis (4-0)	4	4

*For the list of Humanities electives, see footnote, page 129.

PHYSICS OR ASTRONOMY OPTION, THIRD AND FOURTH YEARS

(For First and Second Years, see pages 127 and 128)

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 77.

CIVILIAN AND V-12

THIRD YEAR*

		Units per Semester 1st	2nd
En 7	English (3-0)	..	3
PS 1	Psychology (3-0)	2	..
Ch 23ab	Chemical Principles (4-0)	4	4
Ph 5ab	Introduction to Mathematical Physics (4-0)	4	4
Ph 9	Electrical Measurements (0-3)	1	..
EE 3-V	Electric and Magnetic Circuits I (3-6)	5	..
EE 4-V	Electric and Magnetic Circuits II (3-6)	..	5
EE 5b-V	Electron Tubes and Circuits I (1-3)	2	..
EE 6b-V	Electron Tubes and Circuits II (2-3)	..	3

FOURTH YEAR*

(November, 1944, to June, 1945, only)

	†Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
Ph 101ab	‡Electricity and Magnetism (3-0)	3	3
Ma 13	Advanced Differential Equations (2-0)	2	..
Ph 9	Electrical Measurements (0-3)	1	..
EE 62	Electron Tubes (3-0)	3	..
EE 190ab	Ultra-High Frequency Techniques (2-0; 4-0)	2	4
EE 191ab	Ultra-High Frequency Techniques Laboratory (0-3; 0-6)	2	3
L 1	Elementary French (4-0)	..	4

*Students entering the V-12 Program, add Naval Organization, N 1, 2, one unit each semester.

†V-12 students who have not taken N 3, Naval History, must elect this subject. For the list of Humanities Electives, see footnote, page 129.

‡Students may be required to take Ph 8, Electricity and Magnetism, the first semester and an elective the second semester instead of Ph 101ab.

PHYSICS OR ASTRONOMY OPTION, FOURTH YEAR
(1945-1946)

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 77.

FOURTH YEAR

(July, 1945, to March, 1946. This is a continuation of the Third Year Schedule given on page ...)

		Units per Semester 1st	2nd
	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
L 35a	Advanced Scientific German (4-0)	4	..
Ec 2	Economics (3-0)	..	3
Ma 8ab	Advanced Calculus (3-0)	3	3
Ph 101ab	Electricity and Magnetism (3-0)	3	3
EE 7C-V, 8C-V	High Frequency Circuits (4-3)	5	5

*For the list of Humanities electives, see footnote, page 129.

Probable Post-War Curriculum

THIRD YEAR: The electrical engineering load will probably be reduced and Advanced Calculus, German and French included.

FOURTH YEAR: A course in organic chemistry, one in atomic physics and two terms of differential equations will probably be included.

APPLIED PHYSICS OPTION, THIRD AND FOURTH YEARS

(For First and Second Years, see pages 127 and 128)

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 77.

THIRD YEAR *(Civilian)*

		Units per Semester 1st	2nd
En 7	English (3-0)	..	3
PS 1	Psychology (3-0)	2	..
Ch 23ab	Chemical Principles (4-0)	4	4
Ph 5ab	Introduction to Mathematical Physics (4-0)	4	4
Ph 9	Electrical Measurements (0-3)	1	..
EE 3-V	Electric and Magnetic Circuits I (3-6)	5	..
EE 4-V	Electric and Magnetic Circuits II (3-6)	..	5
EE 5b-V	Electron Tubes and Circuits I (1-3)	2	..
EE 6b-V	Electron Tubes and Circuits II (2-3)	..	3

FOURTH YEAR

(November, 1944, to June, 1945, only)

	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
Ma 13	Advanced Differential Equations (2-0)	2	..
Ph 8	Electricity and Magnetism (2-0)	2	..
Ph 9	Electrical Measurements (0-3)	1	..
EE 62	Electron Tubes (3-0)	3	..
EE 190ab	Ultra-High Frequency Techniques (2-0; 4-0)	2	4
EE 191ab	Ultra-High Frequency Techniques Laboratory (0-3; 0-6)	2	3
Ay 1	Astronomy (2-1)	..	2
L 1	Elementary French (4-0)	..	4

*For the list of Humanities electives, see footnote, page 129.

APPLIED PHYSICS OPTION, FOURTH YEAR (1945-1946)

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 77.

FOURTH YEAR

(July, 1945, to March, 1946. This is a continuation of the Third-Year Schedule given on page 139)

		Units per Semester 1st	2nd
	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
L 35a	Advanced Scientific German (4-0)	4	..
Ec 2	Economics (3-0)	..	3
EE 10C-V	Direct Current Machinery (2-3)	3	..
EE 11C-V	Alternate Current Machinery (2-3)	..	3
Ph 8	Electricity and Magnetism (3-0)	3	..
EE 7C-V, 8C-V	High Frequency Circuits (4-3)	5	5
	Elective (Preferably Advanced Mechanics)	..	3

*For the list of Humanities electives, see footnote, page 129.

Probable Post-War Curriculum

THIRD YEAR: The electrical engineering load will probably be altered to include Direct and Alternating Currents, and German and French will be added.

FOURTH YEAR: Courses in Applied Mechanics, Organic Chemistry and Heat Engines will probably be added.

ENGINEERING, ALL OPTIONS, SECOND YEAR CIVILIAN

For students preparing for Civil, Electrical, and Mechanical Engineering and Aeronautics.

(For First Year see page 127)

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 77.

Subjects common to all options		Units per Semester 1st	2nd
Ma 2ab	Mathematics (4-0)	4	4
Ph 2ae	Physics (3-3; 2-3)	4	2
CE 1-V	Surveying (1-6)	3	..
Ge 1a	Physical Geology (2-2)	3	..
D 2	Descriptive Geometry (0-6)	2	..
D 6	Engineering Drafting (0-6)	..	2
A 1-V, 2-V	Analytical Mechanics (5-0)	..	5
ME 3	Materials and Processes (2-1)	2	..
Civil Engineering Option			
CE 2-V	Geodetic Surveying (2-9)	..	5
Electrical Engineering Option			
Ma 11	Differential Equations (2-0)	..	2
Ec 2	Economics (3-0)	..	3
Mechanical Engineering Option			
ME 1-V	Kinematics (1-3)	..	2
Ec 2	Economics (3-0)	..	3

Probable Post-War Curriculum

Ph 2e replaced by Ph 2b (4 units); A 1-V, 2-V replaced by AM lab and moved into third year; CE 1-V replaced by CE 1. H 2ab added.

ENGINEERING, ALL OPTIONS, SECOND YEAR V-12

	*Civil Engineering: Curricula 351 and 451	Units per Semester 1st	2nd
M 5-V, 6-V	Calculus (5-0; 4-0)	5	4
C 1a-V	Chemistry (3-3)	4	..
C 2a-V, C 6-V	Chemistry and Engineering Materials (3-3)	..	4
A 1-V, 2-V	Analytical Mechanics (5-0)	..	5
CE 1-V, 2-V	Plane and Geodetic Surveying (1-6; 2-9)	3	5
N 3-V	Naval History and Elementary Strategy (3-0)	3	..
PS 1-V	Psychology (3-0)	3	..

	*Electrical Engineering: Curricula 355, 455, 356, 456		
M 5-V, 6-V	Calculus (5-0; 4-0)	5	4
M 7-V	Differential Equations (2-0)	..	2
C 1a-V	Chemistry (3-3)	4	..
C 2a-V, C 6-V	Chemistry and Engineering Materials (3-3)	..	4
A 1-V, 2-V	Analytical Mechanics (5-0)	..	5
BA 1-V, 2-V	Principles of Economics (3-0)	3	3
N 3-V	Naval History and Elementary Strategy (3-0)	3	..
EE 1-V	Electricity and Magnetism (2-3)	3	..

	*Mechanical Engineering: Curricula 353, 453, 354, 454		
M 5-V, 6-V	Calculus (5-0; 4-0)	5	4
C 1a-V	Chemistry (3-3)	4	..
C 2a-V, C 6-V	Chemistry and Engineering Materials (3-3)	..	4
A 1-V, 2-V	Analytical Mechanics (5-0)	..	5
BA 1-V, 2-V	Principles of Economics (3-0)	3	3
N 3-V	Naval History and Elementary Strategy (3-0)	3	..
ME 1-V	Kinematics (1-3)	..	2
PS 1-V	Psychology (3-0)	3	..

*Students entering V-12 Program add N 1, 2, Naval Organization, 1 unit each semester.

CIVIL ENGINEERING OPTION, THIRD AND FOURTH YEARS, CIVILIAN AND V-12

(For First and Second Years, see pages 127, 141, and 142)

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 77.

THIRD YEAR

	(Civilian and V-12)*	Units per Semester 1st	2nd
ME 4a-V	Thermodynamics (3-0)	3	..
ME 3a-V	Heat Power (2-3)	..	3
EE 10C-V	Direct Current Machinery (2-3)	3	..
EE 11C-V	Alternating Current Machinery (2-3)	..	3
CE 3-V	Strength of Materials (3-0)	3	..
CE 4-V	Strength of Materials Laboratory (1-6)	..	3
CE 6-V	Fluid Mechanics (2-3)	..	3
CE 10-V	Curves and Earthwork (2-3)	3	..
CE 7-V	Structural Analysis (4-3)	5	..
CE 8-V	Reinforced Concrete (3-0)	..	3
CE 9-V	Elementary Structural Design (1-6)	..	3

FOURTH YEAR

(Civilian and V-12)

(November, 1944—June, 1945, only)

	†Humanities Elective (3-0)	3	..
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
CE 4	Highway Engineering (3-0)	..	3
CE 16	Water Supply (2-0)	2	..
CE 7-V	Structural Analysis (4-3)	5	..
CE 9-V	Elementary Structural Design (1-6)	..	3
CE 8-V	Reinforced Concrete (3-0)	..	3
CE 13	Sanitary Engineering (3-0)	..	3
AM 3	Testing Materials Laboratory (0-3)	1	..
Ec 25	Business Law (2-0)	2	..
Hy 12	Hydraulics Laboratory (0-3)	1	..
ME 20	Heat Engineering (2-3)	3	..
Ec 18	Industrial Organization (2-0)	..	2
CE 14ab	Engineering Conference (1-0)	1	1

*Students entering the V-12 Program add N 1-V, N 2-V, Naval Organization, one unit (1-0) each semester.

†V-12 students who have not taken N 3-V, Naval History, must elect this subject. For the list of Humanities electives, see footnote, page 129.

CIVIL ENGINEERING OPTION, FOURTH YEAR, CIVILIAN AND V-12

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 77.

FOURTH YEAR, CIVILIAN AND V-12

(July, 1945, until V-12 Program is discontinued)

		Units per Semester	
		1st	2nd
CE 11-V, 12-V	Structures (3-6)	5	5
CE 13-V	Sanitary Engineering (2-3)	..	3
CE 14-V	Water Supply (2-3)	3	..
GE 5-V	Contracts and Specifications (2-0)	..	2
CE 15-V	Soil Mechanics (2-3)	3	..
GE 4-V	Technical Reports (2-0)	2	..
CE 16-V	Airport Design (2-3)	..	3
GE 3-V	Industrial Organization (3-0)	..	3
CE 17-V	Highway Engineering (3-3)	4	..
GE 1-V, 2-V	Economics of Engineering (2-0)	2	2

CIVIL ENGINEERING OPTION, POST-WAR

Probable Post-War Curriculum

	THIRD YEAR	Units per Semester 1st	2nd
En 7ab	English (3-0)	3	3
AM 1ab	Applied Mechanics (5-3)	6	6
CE 2	Advanced Surveying (1-6)	3	..
EE 8	Direct Currents (2-0)	2	..
EE 9	Direct Currents Laboratory (0-3)	1	..
EE 10	Alternating Currents (2-0)	..	2
EE 11	Alternating Currents Laboratory (0-3)	..	1
CE 4	Highway Engineering (2-0)	..	2
CE 7	Curves and Earthwork (2-0)	..	2
Hy 2ab	Hydraulics (2-3; 2-0)	3	2
	FOURTH YEAR		
	*Humanities Elective (3-0)	3	..
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
Ch 62	Engineering Chemistry (2-0)	..	2
CE 6	Transportation Engineering (2-0)	2	..
CE 8	Route Surveying (2-0)	2	..
CE 10ab	Theory of Structures (3-3; 3-0)	4	3
CE 12	Reinforced Concrete (2-3)	..	3
Ge 110	Engineering Geology (1-3)	..	2
CE 13	Sanitary Engineering (2-0)	..	2
AM 3	Testing Materials Laboratory (0-3)	1	..
Ec 25	Business Law (2-0)	2	..
Hy 12	Hydraulics Laboratory (0-3)	1	..
ME 20	Heat Engineering (1-3)	2	..
Ec 18	Industrial Organization (2-0)	..	2
CE 14ab	Engineering Conference (1-0)	1	1

*For the list of Humanities electives, see footnote, page 129.

ELECTRICAL ENGINEERING OPTION, THIRD YEAR, CIVILIAN AND V-12

(For First and Second Years, see pages 127, 141, and 142)

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 77.

THIRD YEAR, CIVILIAN AND V-12*

Option C (Communications)		Units per Semester 1st	2nd
EE 3-V	Electric and Magnetic Circuits (3-6)	5	..
EE 4-V	Electric and Magnetic Circuits (3-6)	..	5
ME 4a-V	Thermodynamics (3-0)	3	..
ME 3a-V	Heat Power (2-3)	..	3
CE 3-V	Strength of Materials (3-0)	3	..
CE 4a-V	Strength of Materials Laboratory (1-3)	..	2
EE 5b-V	Electron Tubes and Circuits (1-3)	2	..
EE 6b-V	Electron Tubes and Circuits (2-3)	..	3
EE 9-V	Electrical Measurements (3-6)	5	..
EE 12a-V	D. C. Machinery and Storage Batteries (2-3)	..	3
ME 1-V	Kinematics (1-3)	..	2

Option P (Power)			
EE 3-V	Electric and Magnetic Circuits (3-6)	5	..
EE 4-V	Electric and Magnetic Circuits (3-6)	..	5
EE 12-V	D. C. Machinery and Storage Batteries (3-6)	..	5
ME 4a-V	Thermodynamics (3-0)	3	..
ME 3a-V	Heat Power (2-3)	..	3
CE 3-V	Strength of Materials (3-0)	3	..
CE 4a-V	Strength of Materials Laboratory (1-3)	..	2
ME 1-V	Kinematics (1-3)	2	..
CE 6-V	Fluid Mechanics (2-3)	..	3
EE 9-V	Electrical Measurements (3-6)	5	..

*Students entering the V-12 Program must add N 1-V, 2-V, Naval Organization, 1 unit each semester.

ELECTRICAL ENGINEERING OPTION, FOURTH YEAR, CIVILIAN AND V-12

(For First, Second, and Third Years see pages 127, 141, 142, and 146)

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 77.

FOURTH YEAR, CIVILIAN AND V-12*

(November, 1944, to June, 1945, only)

		Units per Semester 1st	2nd
Option C			
	†Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
EE 106ab	Electrical Engineering (2-0; 2-0)	2	2
EE 107ab	Electrical Engineering Laboratory (0-3; 0-3)	1	1
EE 70	Engineering Conference (1-0)	1	..
EE 62	Electron Tubes (3-0)	3	..
Ph 7ab	Electricity and Magnetism (2-0; 2-0)	2	2
Ph 9	Electrical Measurements (0-3)	1	..
(either) I	(Meets the Navy requirements for both Power and Communications)		
EE 190ab	Ultra-High Frequency Techniques (2-0; 4-0)	2	4
EE 191ab	Ultra-High Frequency Techniques Lab. (0-3; 0-6)	2	3
ME 21	Heat Engineering (3-0)	..	3
(or) II	(Meets the Navy requirements for Power only)		
ME 4a-V	Thermodynamics (3-0)	3	..
ME 3a-V	Heat Power (2-3)	..	3
EE 165	Electronics Laboratory (0-3)	..	1
CE 4a-V	Strength of Materials Laboratory (1-3)	..	2
EE 148	Specifications and Designs of Electrical Machinery (2-0)	..	2
Option D			
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
EE 106ab	Electrical Engineering (2-0; 2-0)	2	2
EE 107ab	Electrical Engineering Laboratory (0-3; 0-3)	1	1
EE 70	Engineering Conference (1-0)	1	..
Ph 8	Electricity and Magnetism (2-0)	2	..
Ph 9	Electrical Measurements (0-3)	1	..
EE 62	Electron Tubes (3-0)	3	..
Hy 3	Hydraulics (2-3)	..	3
(either) I	(Meets the Navy requirements for both Power and Communications)		
	†Humanities Elective (3-0)	3	..
EE 190ab	Ultra-High Frequency Techniques (2-0; 4-0)	2	4
EE 191ab	Ultra-High Frequency Techniques Lab. (0-3; 0-6)	2	3
ME 21	Heat Engineering (3-0)	..	3
(or) II	(Meets the Navy requirements for Power only)		
	†Humanities Electives (3-0)	3	3
ME 4a-V	Thermodynamics (3-0)	3	..
ME 3a-V	Heat Power (2-3)	..	3
EE 165	Electronics Laboratory (0-3)	..	1
CE 4a-V	Strength of Materials Laboratory (1-3)	..	2
EE 148	Specifications and Design of Electrical Machinery (2-0)	..	2

*Students entering V-12 Program must add N 1-V, 2-V, Naval Organization, 1 unit each semester.

†Students who have not taken N 3-V, Naval History, must elect this subject. For the list of Humanities electives, see footnote, page 129.

ELECTRICAL ENGINEERING OPTION, FOURTH YEAR, CIVILIAN AND V-12

(For First, Second, and Third Years see pages 127, 141, 142, 146, and 147)

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 77.

FOURTH YEAR, CIVILIAN AND V-12

(July, 1945, until V-12 Program is discontinued)

		Units per Semester 1st	2nd
Option C (Communications)			
	Elective	..	3
ME 10C-V	Naval Machinery (1-3)	..	2
EE 13a-V	Alternating-Current Machinery (3-3)	4	..
EE 7C-V, 8C-V	High-Frequency Circuits (4-3)	5	5
EE 14a-V	Electrical Design (1-3)	..	2
EE 15-V	Electrical Engineering Laboratory (2-3)	..	3
PS 1-V	Psychology (3-0)	3	..
GE 3-V	Industrial Organization (3-0)	..	3
ME 7-V	Machine Design (2-3)	3	..
CE 6-V	Fluid Mechanics (2-3)	3	..
Option P (Power)			
	Elective	..	3
EE 5-V, 6-V	Electron Tubes and Circuits (1-3; 3-3)	2	4
EE 13-V	Alternating-Current Machinery (4-3)	5	..
EE 14-V	Electrical Design (1-6)	..	3
EE 15-V	Electrical Engineering Laboratory (2-3)	..	3
ME 10C-V	Naval Machinery (1-3)	..	2
GE 5-V	Contracts and Specifications (2-0)	2	..
PS 1-V	Psychology (3-0)	3	..
GE 3-V	Industrial Organization (3-0)	..	3
ME 9-V	*Mechanical Processes (2-3)	3	..
ME 7-V	Machine Design (2-3)	3	..

*Students who have had ME 3 will take PS 1-V, En 7, or a Senior Humanities elective in place of ME 9-V. For the list of Humanities electives, see footnote, page 129.

ELECTRICAL ENGINEERING OPTION, POST-WAR

Probable Post-War Curriculum

THIRD YEAR

		Units per Semester 1st	2nd
Courses Common to Both Options			
En 7ab	English (3-0)	3	3
AM 1abcd	Applied Mechanics (5-3)	6	6
EE 2ab	Electrical Machinery (2-0; 3-0)	2	3
EE 3ab	Electrical Machinery Laboratory (0-3; 0-3)	1	2
EE 14	Electric Circuits (2-0)	2	..
Option I*			
Ma 11	Differential Equations (2-0)	..	2
ME 21	Heat Engineering (3-0)	3	..
Hy 3	Hydraulics (2-3)	..	3
Option II*			
Ph 5	Mathematical Physics (4-0)	4	4

FOURTH YEAR

Courses Common to Both Options			
	†Humanities Electives (3-0)	3	3
H 5, 10	Current History, Constitution of the U. S. (1-0)	1	1
EE 70ab	Engineering Conference (1-0)	1	1
EE 62	Electron Tubes (3-0)	3	..
Ph 9	Electrical Measurements (0-3)	1	..
Ec 25	Business Law (2-0)	..	2
Option I*			
EE 106ab	Electrical Engineering (2-0; 3-0)	2	3
EE 107ab	Electrical Engineering Laboratory (0-3)	1	1
EE 65	Electronics Laboratory (0-3)	..	2
ME 27	Mechanical Laboratory (0-3)	..	2
ME 5a	Machine Design (2-3)	3	..
Ph 7ab	Electricity and Magnetism (2-0)	2	2
Option II*			
EE 156a	Communication Circuits (2-0)	2	..
EE 157	Communications Laboratory (0-3)	2	..
EE 190	Ultra-High Frequency Techniques (4-0)	..	4
EE 191	Ultra-High Frequency Techniques Lab. (0-6)	..	3
Ph 8	Electricity and Magnetism (2-0)	2	..
ME 21	Heat Engineering (3-0)	3	..
Hy 3	Hydraulics (2-3)	..	3

*A student should consult with a member of the department before selecting his option.
†For the list of Humanities electives, see footnote, page 129.

MECHANICAL ENGINEERING OPTION, THIRD AND FOURTH YEARS, CIVILIAN AND V-12

(For First and Second Years, see pages 127, 141, 142)

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 77.

THIRD YEAR, CIVILIAN AND V-12*

		Units per Semester 1st	2nd
ME 4-V	Thermodynamics (5-0)	5	..
ME 3-V	Heat Power (3-6)	..	5
EE 10-V	Direct Currents (3-3)	4	..
EE 11-V	Alternating Currents (3-3)	..	4
CE 3-V	Strength of Materials (3-0)	3	..
CE 4-V	Strength of Materials Laboratory (1-6)	..	3
ME 7-V	Machine Design (2-3)	3	..
CE 6-V	Fluid Mechanics (2-3)	..	3
ME 9-V	†Mechanical Processes (2-3)	3	..
ME 8-V	Mechanics of Machinery (2-3)	..	3

FOURTH YEAR, CIVILIAN AND V-12*

(November, 1944, to June, 1945, only)

Civilian students who expect to enter the Graduate School of Aeronautics should, in the fourth year, substitute Ma 15ab (3 units) for ME 50ab and Ec 18.

	‡Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
ME 50ab	Engineering Conference (1-0)	1	1
Hy 1ab	Hydraulics (2-0; 3-3)	2	4
Hy 11	Hydraulics Laboratory (0-3)	..	1
ME 25	Mechanical Laboratory (0-3)	2	..
ME 26	Mechanical Laboratory (0-6)	..	2
ME 17	§Heat Engineering (I.C.E.) (2-0)	2	..
AM 3	Testing Materials Laboratory (0-3)	1	..
Ec 18	Industrial Organization (2-0)	2	..
ME 5ab	Machine Design (2-3; 3-3)	3	4

*Students entering the V-12 Program add N 1, 2, Naval Organization, 1 unit each semester.

†Students who have had ME 3 will take PS 1-V or a senior Humanities elective in place of ME 9-V.

‡V-12 students who have not taken N 3, Naval History, must elect this subject. For the list of Humanities electives, see footnote, page 129.

§ME17, Heat Engineering (I.C.E.), will be offered in the second semester for irregular V-12 students.

MECHANICAL ENGINEERING OPTION, FOURTH YEAR, CIVILIAN AND V-12

(For First, Second, and Third Years, see pages 127, 141, 142, and 150)

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 77.

FOURTH YEAR, CIVILIAN AND V-12

(July, 1945, until V-12 Program is discontinued)

Civilian students expecting to enter the Graduate School of Aeronautics should, in the fourth year, substitute Ma 11, Differential Equations (3 units, one semester) and Ma 15ab, Higher Mathematics for Engineers and Physicists (3 units, two semesters) for ME 13-V, Refrigeration (3 units, one semester) and EE 5a-V, 6a-V, Electron Tubes and Circuits (2 units, two semesters).

		Units per Semester	
		1st	2nd
ME 11-V, 12-V	Heat Power (3-6)	5	5
ME 10C-V	Naval Machinery (1-3)	2	..
ME 17-V	Metallurgy (2-3)	3	..
GE 3-V	Industrial Organization (3-0)	3	..
ME 14-V	Aerodynamics (3-0)	..	3
ME 13-V	Refrigeration (2-3)	..	3
ME 15-V, 16-V	Mechanical Design (2-3)	3	3
EE 5a-V, 6a-V	Electron Tubes and Circuits (1-3)	2	2
GE 5-V	Contracts and Specifications (2-0)	..	2

MECHANICAL ENGINEERING OPTION, POST-WAR

Probable Post-War Curriculum

THIRD YEAR

		Units per Semester 1st	2nd
En 7ab	English (3-0)	3	3
AM 1ab	Applied Mechanics (5-3)	6	6
Ma 11	Differential Equations (2-0)	2	..
EE 8	Direct Currents (2-0)	2	..
EE 9	Direct Currents Laboratory (0-3)	1	..
EE 10	Alternating Currents (2-0)	..	2
EE 11	Alternating Currents Laboratory (0-3)	..	1
Ec 25	Business Law (2-0)	2	..
ME 15	Heat Engineering (2-3)	..	3
ME 16	Heat Engineering (3-0)	..	3
ME 10	Metallurgy (2-0)	2	..

FOURTH YEAR

	*Humanities Electives (3-0)	3	3
H 5	Current History (1-0)	1	..
H 10	Constitution of the U. S. (1-0)	..	1
ME 50ab	Engineering Conference (1-0)	1	1
Hy 1ab	Hydraulics (2-0; 3-3)	2	4
Hy 11	Hydraulics Laboratory (0-3)	..	1
ME 25	Mechanical Laboratory (0-3)	1	..
ME 26	Mechanical Laboratory (0-6)	..	2
ME 17	Heat Engineering (2-0)	2	..
AM 3	Testing Materials Laboratory (0-3)	1	..
Ec 18	Industrial Organization (2-0)	2	..
ME 5ab	Machine Design (2-3; 3-3)	3	4

*For the list of Humanities electives, see footnote, page 129.

METEOROLOGY AND AEROLOGY OPTION

Course arranged for special V-12 class beginning July 1, 1944, but open to undergraduate and graduate students.* The next Meteorology (Aerology) course will begin in March, 1945. Admission will be open to properly qualified graduate students and to undergraduates who have completed the first two years of the Institute curriculum, or the equivalent.

		Units per Semester		
		July, 1944 First	Nov., 1944 Second	March, 1945 Third
My 101abc[1]	Weather Forecasting and Practice (6-0) ...	6	6	6
My 102abc	Meteorological Laboratory (0-15)	5	5	5
My 103abc	Meteorological Instruments (1-3)	2	2	2
My 104ab	Structure of Atmosphere (1-0)	1	1	..
My 105bc	Climatology (2-0)	..	2	2
My 150	Public Speaking (1-0)	1	..	..
Ge 178	Oceanography (1-0)	..	..	1
Ma 11	Differential Equations (2-0)	2	..	..
For B.S. degree, the subjects shown above, plus the following:				
	†Humanities Electives (3-0)	..	3	3
H 5	Current History (1-0)	..	1	..
H 10	Constitution of the U. S. (1-0)	..	..	1

[1] a: 2nd semester, Junior year.
b: 1st semester, Senior year.
c: 2nd semester, Senior year.

*Students entering V-12 Program add N 1, N 2, Naval Organization, 1 unit each semester.

†V-12 students who have not taken N 3, Naval History and Elementary Strategy, must elect this subject. For the list of Humanities electives see footnote, page 129.

SCHEDULES OF FIFTH- AND SIXTH-YEAR COURSES

COURSES IN SCIENCE

SUBJECTS COMMON TO ALL COURSES

		Units per Semester 1st	2nd
H 100 En 100 Pl 100	*Seminar in American History and Government or English Literature or Philosophy	3	3
Ec 100ab	or Business Economics	4	4
	Engineering or Research Seminars	1	1
	Professional Subjects	14	14

BIOLOGY

	Subjects common to all courses (see above)	4	4
	Approved elective courses in biology or other subjects, to be arranged with the professor in charge.		

CHEMISTRY

	Subjects common to all courses	4-5	4-5
Ch 280-286	Research	4-6	4-6
	Advanced elective subjects, including thesis, to constitute a program of study approved by a member of the Division.		

CHEMICAL ENGINEERING

Fifth Year

	Subjects common to all courses	4-5	4-5
Ch 166ab	Chemical Engineering	4	4
Ch 167ab	Chemical Engineering Laboratory	5	5
	Advanced elective subjects, mainly in chemistry, physics, mathematics, and mechanical engineering, to constitute a program of study approved by a member of the Division.		

Sixth Year

(Leading to the professional degree of Chemical Engineer)

Ch 186	Research	7-10	7-10
	Advanced elective subjects, including thesis, mainly in chemistry, physics, mathematics, and mechanical engineering, to constitute a program of study approved by a member of the Division.		

FIFTH- AND SIXTH-YEAR COURSES

GEOLOGICAL SCIENCES

		Units per Semester 1st	2nd
H 10 En 100 Pl 100	Seminar in History and Govt., or English Literature, or Philosophy, or	3	3
Ec 100ab	Business Economics	4	4
Ge 100	Geology Club	1	1
Ge 102	Oral Presentation	1	1
	Elected units from group A or B (see below)	13	13
A. Geology and Paleontology			
Ge 105	Optical Mineralogy	3	..
Ge 106	Petrography	..	4
Ge 109	Structural Geology	2	..
Ge 110	Engineering Geology	..	2
Ge 111	Invertebrate Paleontology	..	5
Ge 112	Vertebrate Paleontology	..	5
Ge 115	Micropaleontology	..	2
Ge 121ab	Advanced Field Geology	3-4	3-4
Ge 122	Spring Field Trip	..	1
Ge 123	Summer Field Geology	..	4
Ge 175	Introduction to Applied Geophysics	..	2
Ge 176	Elementary Seismology	2	..
Ge 200	Mineragraphy	1	..
Ge 202	Metalliferous Deposits	..	3
Ge 209	Sedimentary Petrology	..	2
Ge 210	Metamorphic Petrology	..	2
Ge 211	Petrology (Seminar)	..	1
Ge 212	Non-Metalliferous Deposits	..	3
Ge 213	Mineral Deposits (Seminar)	..	1
Ge 214	Mineral Economics (Seminar)	..	1
Ge 215	Mineralogy (Seminar)	1	..
Ge 220	History of Geology	2	..
Ge 225	Geology of Western America	2	..
Ge 226	Geomorphology	2	..
Ge 227	Shoreline Geomorphology	..	2
Ge 228	Geomorphology of Arid Regions	..	2
Ge 230	Geomorphology (Seminar)	..	1
Ge 232ab	Introduction to Petroleum Geology	2	2
Ge 235	Petroleum Geology (Seminar)	..	1
Ge 237	Tectonics	..	2
Ge 238	Structural Geology (Seminar)	1	..
Ge 245	Vertebrate Paleontology (Seminar)	..	2
Ge 248	Fossils of the California Tertiary	..	2
Ge 249	Stratigraphy of the Coast Ranges	1	..
Ge 250	Invertebrate Paleontology (Seminar)	1	..

GEOLOGICAL SCIENCES (Cont.)

B. Geophysics		Units per Semester 1st		2nd
My 104ab	Structure of the Atmosphere	1		1
CE 2	Advanced Surveying	..		5
CE 122	Analysis of Earthquake Effects upon Structures (units by arrangement)	..		..
EE 8/9	Direct Currents	3		..
EE 10/11	Alternating Currents	..		3
EE 62	Electron Tubes	3		..
EE 65	Electronics Laboratory	2	or	2
EE 156ab	Electrical Communications	2		2
Ge 3	Mineralogy	4		4
Ge 109	Structural Geology	2		..
Ge 121ab	Advanced Field Geology	3-4		3-4
Ge 122	Spring Field Trip	..		1
Ge 175	Introduction to Applied Geophysics	..		2
Ge 176	Elementary Seismology	2		..
Ge 225	Geology of Western America	2		..
Ge 226	Geomorphology	2		..
Ge 232ab	Introduction to Petroleum Geology	2		2
Ge 238	Structural Geology (Seminar)	1		..
Ge 261	Theoretical Seismology	2		..
Ge 262/3	Interpretation of Seismograms	1		1
Ge 265	Introduction to General Geophysics	..		2
Ge 270	Seismic Instruments	2		..
Ge 273	Applied Geophysics I	2		..
Ge 274	Applied Geophysics II	2		2
Ge 275	Applied Geophysics III	2		..
Ge 278	Interpretation of Field Seismograms	..		2
Ge 279	Laboratory and Field Work in Electrical Methods	2		..
Ge 280	Laboratory, Gravitational and Magnetic Methods	..		2
Ge 282	Geophysics Seminar	1		..
Ge 283	Geophysical Instruments Seminar	..		1
Ge 285	Geophysics Research Conference	..		1
Ge 297	Advanced Study (297u or 297w, or 297x) (units by arrangement)	..		..
Ge 299	Research (299u, or 299w, or 299x) (units by arrangement)	..		..
Ma 8ab	Advanced Calculus	3		3
Ma 12	Probability and Least Squares	2		..
Ma 118ab	Statistics	3		3
Ph 9ab	Electrical Measurements	1		1
Ph 91ab	Introduction to Mathematical Physics	3		3
Ph 101ab	Electricity and Magnetism	3		3
Ph 221	Potential Theory	..		4

FIFTH- AND SIXTH-YEAR COURSES

MATHEMATICS

		Units per Semester 1st	2nd
	Subjects common to all courses (See page 154)	3	3
Ma 114ab	Math. Anal. (4-0) *(Schedule B, page 149)*		
	or	4	4
Ma 102ab	Higher Geometry (4-0) *(Schedule A, page 149)*		
Ma 101ab	Modern Algebra (3-0) (two semesters)		
	or both of the following one-semester courses:	3	3
Ma 111	Elementary Theory of Tensors (3-0)		
Ph 114	Quantum Mechanics (3-0)		
	Electives and Research	7	7

PHYSICS OR APPLIED PHYSICS

	Subjects common to all courses (page 154)	4	4

ELECTIVES

Ph 101ab	Electricity and Magnetism	3	3
Ph 103ab	Analytical Mechanics	4	4
Ph 105ab	Optics	2	2
Ph 106ab	Optics Laboratory	1	1
Ph 107ab	Atomic Physics	3	3
Ph 108	Spectroscopy Laboratory	..	1
Ph 110ab	Kinetic Theory	3	3
Ph 114	Principles of Quantum Mechanics	..	2
Ph 115	Application of Quantum Mechanics	2	..
Ph 116	Relativistic Quantum Mechanics	..	2
Ph 120	History of Physics Seminar	1-3	1-3
Ma 114ab	Mathematical Analysis	1	1
Ma 118ab	Introduction to Statistics	3	3
EE 190	Ultra High Frequency Techniques	..	4
EE 191	Ultra High Frequency Laboratory	..	3
Ph 142	Research	5	5

FIFTH- AND SIXTH-YEAR COURSES

COURSES IN ENGINEERING

AERONAUTICS

	Fifth Year	Units per Semester 1st	2nd
	Subjects common to all courses (page 154)	3 or 4	3 or 4
AE 251ab	Aerodynamics of the Airplane	3	3
AE 252ab	Airplane Design	4	4
AE 253ab	Design of Aircraft Components	2	2
AE 257ab	Engineering Mathematical Principles	5	5

Sixth Year

(Leading to the professional degree of Aeronautical Engineer)

AE 254ab	Advanced Problems in Airplane Design	2	2
AE 266ab	Theoretical Aerodynamics	4	4
AE 270ab	Elasticity Applied to Aeronautics	2	2
AE 259	Thermodynamical Fundamentals of Fluid Mechanics	1	..
AE 267	Turbulence	2	..
AE 261	Compressibility	..	3
AE 262	Compressibility Laboratory	..	2*
			or
AE 271ab	Vibration and Flutter Problems	2	2*
AE 260ab	Research	5	5

*In the second semester of the sixth year the student has the choice of continuing with AE 271b or taking AE 262. For those students who wish more advanced aerodynamics, AE 265ab, Advanced Problems in Airplane Aerodynamics (2 units, two semesters) may be substituted for AE 267 and AE 262.

CHEMICAL ENGINEERING

(See page 154)

FIFTH- AND SIXTH-YEAR COURSES

CIVIL ENGINEERING

	Fifth Year	Units per Semester 1st	2nd
Ec 100ab	Business Economics	4	4
CE 120a	Statically Indeterminate Structures	3	..
CE 121a	Structural Design	4	..
CE 121b	Civil Engineering Design	..	3
CE 125	Irrigation and Water Supply	..	4
CE 126	Masonry Structures	2	..
CE 127	Sewerage	2	..
Ma 15ab	Higher Mathematics for Engineers	3	3
AM 105	Soil Mechanics	..	3
CE 130	Seminar	1	1
	Research or Thesis as arranged	1	1
	Supplementary Subjects:		
CE 120b	Statically Indeterminate Structures	..	2
CE 122	Earthquake Effects upon Structures	..	2
CE 131ab	Sewage Treatment Plant Design	..	..
CE 132ab	Water Power Plant Design	..	..
CE 134ab	Ground Water Investigations	..	..
CE 135ab	Geodesy and Precise Surveying	..	..
GE 110	Engineering Geology	..	2
AE 270ab	Elasticity	2	2
Hy 100	Fluid Mechanics	..	3
Hy 103	Hydraulic Problems	..	1

ELECTRICAL ENGINEERING

	Subjects common to all courses (See page 154)	4	4
EE 120a	Advanced Alternating Current	3	..
EE 120b	Analysis and Machinery	..	3
EE 121ab	Alternating Current Laboratory	1	2
	Advanced elective subjects in electrical engineering or physics to constitute a program of study approved by a member of the Electrical Engineering Department.		

FIFTH- AND SIXTH-YEAR COURSES

INDUSTRIAL DESIGN

Fifth Year

		Units per Semester 1st		2nd
ID 101ab	Industrial Design I	5		5
ID 111ab	Shop Practice I	3		3
ID 121ab	Design Techniques I	1		2
ID 131a	Design Trends	1		..
ID 141ab	Non-metallic Materials	3		3
ID 151a	Cost Analysis	..		3
ID 161a	History of Art	..		1
Ec 100a	Business Economics	4		..
	For some students:			
ME 3	Materials and Processes	3	or	3

Sixth Year

(Leading to the professional degree of Industrial Designer)

ID 201ab	Industrial Design II (Thesis)	7		8
ID 211ab	Shop Practice II	3		3
ID 221ab	Design Techniques II	2		1
ID 231ab	Technical Trends in Design	2		2
ID 241ab	Social and Buying Psychology	3		3

MECHANICAL ENGINEERING

Fifth Year

Ec 100	Business Economics	4		4
ME 101a	Advanced Machine Design	3		..
ME 101b	Mechanical Vibrations	..		3
ME 110ab	Science of Metals	2		4
ME 111ab	Metallography Laboratory	1		2
ME 120, 121	Heat Engineering	3		2
	Electives	5		3

METEOROLOGY AND AEROLOGY

(See page 153)

SUBJECTS OF INSTRUCTION

SUBJECTS IN SCIENCE

BIOLOGY

PROFESSORS: ALFRED H. STURTEVANT, HENRY BORSOOK, A. J. HAAGEN-SMIT, THOMAS HUNT MORGAN,[1] FRITS WENT.
ASSOCIATE PROFESSORS: ERNEST G. ANDERSON, JAMES BONNER, STERLING EMERSON, ANTHONIE VAN HARREVELD, CORNELIS WIERSMA.
ASSISTANT PROFESSORS: ROBERT EMERSON, HUGH M. HUFFMAN,[2] GEORGE E. MACGINITIE, ALBERT TYLER.

UNDERGRADUATE SUBJECTS

Bi 1. Elementary Biology. 3 units (2-3); first semester.
An introductory subject intended to give the student of general science some information about the fundamental properties of living things.
Instructors: Sturtevant, van Harreveld, Mampell.

Bi 2. Genetics. 2 units (1-3); second semester.
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. 4 units (2-6); first semester.
A general survey of the morphology and life histories of plants.
Instructor: Went.

Bi 4. Invertebrate Zoology. 2 units (1-3); second semester.
A survey of the main groups of invertebrates.
Instructor: MacGinitie.

Bi 5. Plant Physiology. 4 units (2-6); second semester.
A general study of water relations, growth and the chemical processes taking place in the living plant.
Instructors: Went, R. Emerson.

Bi 6. Embryology. 4 units (2-6); second semester.
A subject in descriptive and experimental embryology, covering both vertebrates and invertebrates.
Instructor: Tyler.

Bi 7. Biochemistry. 4 units (2-6); second semester.
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 12. Histology. 3 units (1-6); first semester.
A subject in technique and in the microscopic structure of animals.
Instructor: Tyler.

[1]Emeritus.
[2]On leave of absence.

Bi 13. Mammalian Anatomy. 1 unit (0-3); first semester.
The dissection of a mammal.
Instructor: van Harreveld.

Bi 16ab. Animal Physiology. 3 units (2-3); both semesters.
A survey of comparative and mammalian physiology.
Instructors: Wiersma and van Harreveld.

Bi 17. Vertebrate Anatomy. 3 units (1-6); second semester.
This subject deals with the comparative anatomy of the vertebrates.
Instructor: MacGinitie.

Bi 18. Review. 1 unit (1-0). 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.

Bi 22. Research. Units to be arranged in individual cases.
An opportunity will be given to follow special lines of research under direction. Students may register for this subject with any member of the staff, after consultation.

ADVANCED SUBJECTS

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

Bi 82. Same as Bi 12.

Bi 86. Same as Bi 6.

***Bi 92. Biological Assays.** 2 units (0-2); two semesters.
A course, with lectures and laboratory practice, on certain biological tests for physiologically active substances.
Instructors: Went, Haagen-Smit, Bonner.

Bi 93. Same as Bi 13.

***Bi 94. Immunology.** 4 units (2-6); first or second semester.
A course on the principles and methods of immunology and their application to various biological problems. Some previous knowledge of organic chemistry, bio-chemistry, embryology and genetics is desirable.
Instructor: S. Emerson.

***Bi 96ab. Animal Physiology.** Same as Bi 16.

Bi 97ab. Biochemistry. Same as Bi 7.

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

Bi 101. Biology Seminar. 1 unit.
Meets weekly for reports on current literature of general biological interest.
In charge: Sturtevant.

***Bi 102. Biochemistry Seminar.** 1 unit.
A seminar throughout the academic year on special selected topics and on recent advances.
In charge: Borsook.

***Bi 104. Genetics Seminar.** 1 unit.
Reports and discussion on special topics.
In charge: Anderson.

*May or may not be given during the war emergency.

Bi 105. Experimental Embryology Seminar. 1 unit.
Reports on special topics in the field; meets twice monthly.
In charge: Tyler.

Bi 106. Immunology Seminar. 1 unit.
Reports and discussion.
In charge: Tyler.

Bi 110ab. Advanced Biochemistry. 4 units.
Lectures and laboratory studies of biological oxidations, fermentations, preparation of enzymes and study of their action, chemistry and physiology of vitamins. To be given once every three years.
Instructors: Borsook, Huffman.

***Bi 111. Applications of Thermo-chemistry to biological problems.**
To be given if enough students apply for it.
Instructor: Huffman.

Bi 114ab. Chemistry of Bio-Organic Substances. 2 units (2-0); both semesters.
Prerequisite: Ch 41ab.
A series of lectures on selected topics of organic chemistry which have special interest from a biological viewpoint. The lectures will be accompanied by laboratory exercises and demonstrations dealing with the chemical and physiological behavior of naturally occurring substances.
Instructor: Haagen-Smit.

Bi 115. Chemistry of Bio-Organic Substances. Units based on work done.
Advanced work with opportunity for research is offered to properly qualified graduate students.
Instructor: Haagen-Smit.

Bi 117. Quantitative Organic Microanalysis. Units based on work done (0-20); second semester.
Laboratory practice in the methods of quantitative organic microanalysis required for structure determinations of organic compounds. Students must obtain permission from the instructor before registering for this subject as the enrollment is necessarily limited.
Instructor: Haagen-Smit.

Bi 120. Experimental Embryology. 2 units (2-0).
Lectures and discussion of the problems of embryonic development, including such topics as growth of the ovary, breeding habits of animals, fertilization, cleavage, organ formation, metamorphosis, regeneration, tissue culture, embryonic metabolism, etc.
The subject may be taken for two consecutive years since the subject matter will be duplicated only in alternate years.
Instructor: Tyler.

Bi 121. 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 125ab. Graduate Genetics. 4 units (2-6).
In the first semester a systematic survey of the field will be presented. In the second semester special subjects will be treated in more detail. The material in the second semester will not ordinarily be duplicated in a period of three years, and

*May or may not be given during the war emergency.

students majoring in Genetics will be expected to register for four semesters. The laboratory work will consist of individual problems.

Instructors: Sturtevant, Anderson, S. Emerson.

***Bi 140ab. Plant Physiology.** 2 units (2-1); both semesters.

Reading and discussion of the main problems of plant physiology.

Instructors: Went, Bonner.

***Bi 141. Plant Chemistry.** 2 units (0-3); both semesters.

Laboratory subject in the analysis of plant materials by macro- and micro-chemical methods.

Instructor: Bonner.

Bi 160. Advanced Physiology. 4 units (0-4); both semesters.

A subject in the methods of physiology, with special reference to nerve and muscle, with opportunity for research.

Instructors: Wiersma, van Harreveld.

Bi 170. Research.

In special cases, not included in the preceding announcements, students doing advanced work in the department may register under this heading and receive a stated amount of credit. Students should consult with the instructor in charge of their major work before registering for this subject.

*May or may not be given during the war emergency.

CHEMISTRY AND CHEMICAL ENGINEERING

PROFESSORS: LINUS PAULING, STUART J. BATES, JAMES E. BELL, ROSCOE G. DICKINSON, WILLIAM N. LACEY, HOWARD J. LUCAS, BRUCE H. SAGE, ERNEST H. SWIFT, RICHARD C. TOLMAN,[1] DON M. YOST, LASZLO ZECHMEISTER.
RESEARCH ASSOCIATES: EDWIN R. BUCHMAN, JOSEPH B. KOEPFLI.
ASSOCIATE PROFESSORS: RICHARD M. BADGER, CARL G. NIEMANN.
ASSISTANT PROFESSORS: DAN H. CAMPBELL, JAMES H. STURDIVANT.
SENIOR FELLOWS IN RESEARCH: ROBERT B. COREY, DAVID PRESSMAN, VERNER F. H. SCHOMAKER.
INSTRUCTORS: WILLIAM H. EBERHARDT, JOHN M. O'GORMAN, STANLEY M. SWINGLE, JÜRG WASER.

UNDERGRADUATE SUBJECTS

Ch 1ab. Chemistry. 4 units (3-6); both semesters.

Lectures, recitations, and laboratory exercises dealing with the general principles of chemistry. The two semesters are devoted to the preparation and properties of substances and to the fundamental laws and theories of chemistry, and to the qualitative analysis of the common metals.

Instructors: Pauling, Bell, Swingle, and Teaching Fellows.

Ch 11. Quantitative Chemical Analysis. 3 units (1-6); second semester.

Prerequisite: Ch 1ab.

Laboratory practice in certain typical methods of gravimetric and volumetric analysis, supplemented by lectures and problems emphasizing the principles involved.

Text: *Chemical Analysis*, Swift.

Instructors: Swift, Waser.

Ch 12a. Analytical Chemistry. 4 units (2-6); first semester.

Prerequisite: Ch 1ab.

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.

Instructors: Swift, Waser.

Ch 12b. Analytical Chemistry and Chemistry Review. 4 units (2-6); second semester.

Prerequisite: Ch 12a.

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.

Instructors: Swift, Waser.

***Ch 13ab. Inorganic Chemistry.** 4 units (4-0); both semesters.

Prerequisite: Ch 12b, 21ab.

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.

[1]On leave of absence

*Ch 16. **Instrumental Analysis.** 2 units (0-6); first semester.
Prerequisite: Ch 12b.
Laboratory practice designed to familiarize the student with special analytical apparatus and methods, used both for process control and for research.
Instructors: Eberhardt and Teaching Fellows.

Ch 21ab. Chemical Principles. 4 units (4-0); both semesters.
Prerequisites: Ch 12b; Ph 2ab; Ma 2ab.
Conferences and recitations dealing with the general principles of chemistry from an exact, quantitative standpoint, and including studies on the elements of thermodynamics; the pressure-volume relations of gases; on vapor-pressure, boiling point, freezing point, and osmotic pressure of solutions; on the molecular and ionic theories; on electrical transference and conduction; on chemical and phase equilibria; on thermochemistry, and the elements of thermodynamic chemistry and of electrochemistry. A large number of problems are assigned to be solved by the student.
Text: *Chemical Principles,* Noyes and Sherrill.
Instructor: Bates.

*Ch 22. **Thermodynamic Chemistry.** 2 units (2-0); one semester.
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 23ab. Chemical Principles. 4 units (4-0); both semesters.
Prerequisities: Ch 11 or Ch 12b; Ph 2ab; Ma 2ab.
A selection of topics from Ch 21ab and from Ch 22 adapted to the needs of Science Course students in the Physics and Biology Options.
Text: *Chemical Principles,* Noyes and Sherrill.
Instructor: Bates.

Ch 24ab. Physical Chemistry. 4 units (4-0); both semesters.
Prerequisites: Ch 12ab; Ma 2ab; Ph 2ab.
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: Eberhardt.

*Ch 26ab. **Physical Chemistry Laboratory.** 2 units (0-6); one semester.
Prerequisites: Ch 12ab; Ch 21a.
Laboratory exercises to accompany Ch 21.
Text: *Laboratory Experiments on Physico-Chemical Principles,* Sherrill.
Instructor: Badger.

*Ch 29. **Colloid and Surface Chemistry.** 2 units (3-0); one semester.
Prerequisite: Ch 22.
Class-room exercises with outside reading and problems, devoted to the properties of surfaces and interfaces, and to the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired.
Text: *Colloid Chemistry,* Weiser.
Instructor: Badger.

Ch 41ab. Organic Chemistry. 3 units (3-0); both semesters.
Prerequisite: Ch 12b.
Lectures and recitations treating of the classification of carbon compounds, the development of the fundamental theories, and the characteristic properties of the

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principal classes including hydrocarbons, alkyl halides, alcohols, acids, ethers, esters, amines, carbohydrates, aromatics.

Text: *Organic Chemistry,* Lucas.

Instructor: Lucas.

Ch 46ab. Organic Chemistry Laboratory. 2 units (0-6), first semester; 2 or 3 units (0-6 or 0-9), second semester.

Prerequisite: Ch 12.

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

Text: Mimeographed notes, Lucas and Pressman.

Instructors: Lucas and Teaching Fellows.

Ch 47ab. Organic Chemistry Laboratory. 1 unit (0-3); both semesters.

Prerequisite: Ch 12.

Similar to 46ab. Selected experiments for students of biology.

Instructors: Lucas and Teaching Fellows.

***Ch 48. Qualitative Organic Chemical Analysis.** 4 units (2-6); one semester.

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.** 4 units (1-9); one semester.

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

Instructor: Niemann.

Ch 50. Advanced Organic Laboratory. Units to be arranged; any semester.

Laboratory practice in the synthesis of typical organic compounds.

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

***Ch 61ab. Industrial Chemistry.** 2 units (2-0); both semesters.

Prerequisites: Ch 21ab.

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

Text: *Industrial Chemistry,* Read.

Instructor: Lacey.

Ch 62. Engineering Chemistry. 2 units (2-0); one semester.

Prerequisite: Ch 1ab.

Reading, discussion and problems dealing with the application of chemical principles to engineering problems and the relations of engineering to the chemical industries.

Text: *Chemistry of Engineering Materials,* Leighou.

Instructor: Eberhardt.

***Ch 63ab. Chemical Engineering Thermodynamics.** 2 units (2-0); both semesters.

Prerequisite: Ch 21a.

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.

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Ch 80-86. Chemical Research.

Opportunities for research are afforded to undergraduate students in all the main branches in chemistry; thus, in analytical or inorganic chemistry (Ch 80), in physical chemistry (Ch 82), in organic chemistry (Ch 84), and in applied chemistry (Ch 86). Such research may be taken as electives by students in honor standing in the sophomore and junior years; and every candidate for a degree in the Chemistry Option is required to undertake in his senior year an experimental investigation of a problem in chemistry. A thesis embodying the results and conclusions of this investigation must be submitted to the faculty not later than one week before the degree is to be conferred.

FIFTH-YEAR AND ADVANCED SUBJECTS

***Ch 113ab. Inorganic Chemistry.** 2 units; one semester.

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 122ab. Thermodynamic Chemistry.** 2 units (2-0); both semesters.

This subject is open to students who have had a course in physical chemistry. During the first semester the elements of thermodynamics are reviewed. The second semester is the same as Ch 22.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Bates.

***Ch 129. Colloid and Surface Chemistry.** 2 units; one semester.

This course is the same as Ch 29.

Instructor: Badger.

***Ch 148. Qualitative Organic Chemical Analysis.** 4 units (2-6); one semester.

This course is the same as Ch 48.

Instructor: Lucas.

***Ch 149. Quantitative Organic Chemical Analysis.** 4 units (1-9); one semester.

This course is the same as Ch 49.

Instructor: Niemann.

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

This course is the same as Ch 50.

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

***Ch 166ab. Chemical Engineering.** 3 units (3-0); both semesters.

Prerequisites: Ch 61; Ch 63ab.

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.

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***Ch 167ab. Chemical Engineering Laboratory.** 5 units (0-15); both semesters.

Prerequisites: Ch 21; Ch 61; Ch 63.

A course of laboratory work to give training in the methods and technique fundamental to engineering measurements and to research encountered by the chemical engineer.

Instructor: Sage.

Ch 180-186. Chemical Research.

Opportunities for research in analytic and inorganic chemistry (180), physical chemistry (182), organic chemistry (184), and applied chemistry and chemical engineering (186) are offered to candidates for the degree of Master of Science. The main lines of research in progress are tabulated under Ch 280-286.

Ch 221ab. The Nature of the Chemical Bond (Seminar). 1 unit; both semesters.

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.

Text: *The Nature of the Chemical Bond*, Pauling.

In charge: Pauling.

***Ch 222ab. Seminar on Thermodynamics and Statistical Mechanics, with Chemical Applications.** 2 units; both semesters.

A thorough discussion of the fundamental principles and methods of thermodynamics and statistical mechanics, followed by their application to the practical problems of modern chemistry, including the calculation of thermodynamic properties of substances from spectroscopic and structural data.

Given every third year.

In charge: Dickinson, Yost, Badger.

Ch 223ab. Kinetics of Homogeneous and Heterogeneous Reactions (Seminar). 2 units; one semester.

Lectures and discussions relating to homogeneous and heterogeneous chemical reactions, adsorption, and contact catalysis.

Given every third year.

In charge: Dickinson, Badger.

***Ch 224abc. Statistical Mechanics** (Seminar). 2 units; three semesters.

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 Satistical Mechanics*, Tolman.

In charge: Tolman.

***Ch 226ab. Introduction to Quantum Mechanics, with Chemical Applications.** 3 units; both semesters.

A review of Lagrangian and Hamiltonian mechanics and of the old quantum theory is first given, followed by the discussion of the development and significance of the new quantum mechanics and the thorough treatment of the Schrödinger wave equation, including its solution for many simple systems such as the rotator, the harmonic oscillator, the hydrogen atom, etc. During the second and third terms various approximate methods of solution (perturbation theory, the variation method, etc.) are discussed and applied in the consideration of the resonance phenomenon, the structure of many-electron atoms and of simple molecules, the nature of the

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covalent chemical bond, the structure of aromatic molecules, and other recent chemical applications.

Given every third year.

Text: *Introduction to Quantum Mechanics, with Applications to Chemistry,* Pauling and Wilson.

Instructors: Pauling, Schomaker.

***Ch 227ab. The Structure of Crystals.** 3 units; both semesters.

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.

Given every third year.

Instructors: Sturdivant, Pauling.

***Ch 228ab. Crystal Structure Laboratory.** Units determined by the instructor; any semester.

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.** 2 units.

A discussion of the diffraction of X-rays and electrons by gases, liquids, glasses, and crystals.

Instructors: Sturdivant, Schomaker.

***Ch 230. Photochemistry.** 1 unit; one semester.

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

Instructor: Dickinson.

Ch 232. Radioactivity and Isotopes. 1 unit; one semester.

Lectures and discussions on natural and artificial radioactivity. The fundamental particles and isotopes. The applications of natural and artificial radioactive substances and isotopes to the study of chemical and biochemical reactions are discussed.

Instructors: Dickinson and Yost.

***Ch 234. Introduction to the Spectra of Molecules.** 1 unit; one semester.

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. Units based on work done; any semester by arrangement.

Laboratory practice in the methods of quantitative organic microanalysis required for structure determinations of organic compounds. Students must obtain

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permission from the instructor before registering for this subject as the enrollment is necessarily limited.

Instructor: Haagen-Smit.

***Ch 244. The Reactions of Organic Compounds.** 2 units; one semester.

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.

Given every third year.

Instructor: Niemann.

***Ch 245. The Synthesis of Organic Compounds.** 2 units; one semester.

A systematic treatment of the practical synthesis of organic compounds including historical examples of the various types of synthesis.

Given every third year.

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

***Ch 246. Theoretical Organic Chemistry.** 2 units; one semester.

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.

Given every third year.

Instructor: Lucas.

Ch 250ab. Current Problems of Biochemistry. 1 unit; both semesters.

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

Instructor: Zechmeister.

Ch 251. The Chemistry of Natural Pigments. 1 unit; one semester.

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

Instructor; Zechmeister.

***Ch 252. The Chemistry of Carbohydrates.** 1 unit (1-0); one semester.

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

Given every third year.

Instructor: Niemann.

***Ch 253. The Chemistry of the Lipids.** 1 unit; one semester.

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

Instructor: Niemann.

***Ch 254. The Chemistry of Amino Acids and Proteins.** 1 unit (2-0); one semester.

Lectures on the properties of proteins and related substances.

Instructor: Niemann.

Ch 255ab. Chemistry of Bio-Organic Substances. 2 units; both semesters.

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 41ab; Ch 46ab.

Instructor: Haagen-Smit.

Ch 256. Chemistry of Bio-Organic Substances. Units based on work done.

Advanced work with opportunity for research is offered to properly qualified graduate students.

Instructor: Haagen-Smit.

*May or may not be given during the war emergency.

*Ch 257. **The Chemistry of Vitamins.** 2 units (2-0); one semester.
Lectures on recent advances in knowledge of the chemical nature of vitamins and related substances.
Given every third year.
Instructor: Buchman.

Ch 258. **Immunochemistry.** 2 units (2-0).
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.** 1 unit (2-0); one semester.
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.** 1 unit (1-0); one semester.
Prerequisites: Ch 21, 61.
Problems and discussions relating to industrial applications involving heterogeneous equilibria, primarily in solid-liquid systems.
Instructor: Lacey.

*Ch 262ab. **Thermodynamics of Multi-Component Systems.** 3 units (3-0); one semester.
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.

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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.

GEOLOGICAL SCIENCES

PROFESSORS: JOHN P. BUWALDA, BENO GUTENBERG, CHESTER STOCK
ASSOCIATE PROFESSORS: HUGO BENIOFF,[1] IAN CAMPBELL, GENNADY W. POTAPENKO
ASSISTANT PROFESSORS: HORACE J. FRASER,[1] ROBERT MINSSEN KLEINPELL,[1] JOHN H. MAXSON,[1] CHARLES F. RICHTER
INSTRUCTORS: FRANCIS D. BODE,[1] RAYMOND A. PETERSON
CURATOR: WILLIS P. POPENOE

UNDERGRADUATE SUBJECTS

Ge 1a. Physical Geology. 3 units (2-2); first semester.
Prerequisites: Ch 1ab; Ph 1ab.
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 1b. Elementary Paleontology. 2 units (2-0); second semester.
Prerequisite: Ge 1a.
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 1c. Historical Geology. 2 units (1-3); second semester.
Prerequisite: Ge 1a.
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: Popenoe.

Ge 3ab. Mineralogy. 4 units (2-6); both semesters.
Prerequisites: Ge 1a; Ch 12ab.
A comprehensive course dealing with the materials of the Earth's crust. The first part of the course constitutes an introduction to crystallography; the body of the course is concerned with physical, chemical and determinative mineralogy, and with the genesis, occurrence, association, extraction and use of minerals; the last part of the course deals especially with mineral aggregates (rocks), their classification, field determination, and geologic occurrence. This course is designed to give a working knowledge of the geographic occurrence and the geologic factors controlling the formation of mineral and ore deposits, and in conjunction with Ge 121a, knowledge of lithology sufficient for the needs of the beginning field geologist.
Text: *Manual of Mineralogy,* Dana, Hurlbut.
Instructor: Campbell.

***Ge 14. Geologic Illustration.** 2 units (0-6); first semester.
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.

[1]On leave of absence.
*May or may not be given during the war emergency.

Ge 21ab. Introduction to Field Geology. 2 units (0-6); both semesters.
Prerequisites: Ge 1ab; 3a.
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: Popenoe.

UNDERGRADUATE OR GRADUATE SUBJECTS

***Ge 100. Geology Club.** 1 unit; both semesters.
Presentation of papers on research in geological science by the students and staff of the Division of Geological Sciences, and by guest speakers.
Required of all senior and graduate students in the Division.

***Ge 102. Oral Presentation.** 1 unit; both semesters.
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.** 3 units (2-6); first semester.
Prerequisites: Ge 1, 3.
Study of optical mineralogy and use of the petrographic microscope in the identification of minerals.
Text: *Thin Section Mineralogy,* Rogers and Kerr.
Instructor: Campbell.

Ge 106. Petrography. 4 units (2-6); second semester.
Prerequisites: Ge 3ab; 105; Ch 24ab.
A systematic study of rocks; the identification of their constituents by application of the polarizing microscope; interpretation of textures; problems of genesis; qualitative and quantitative classifications. Occasional field trips will be arranged.
Text: *Petrology for Students,* Harker.
Instructor: Campbell.

***Ge 109. Structural Geology.** 2 units (2-0); first semester.
Prerequisite: Ge 21ab.
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. 2 units (2-3); second semester.
Prerequisite: Ge 1a.
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. Invertebrate Paleontology.** 5 units (2-6); second semester.
Prerequisites: Ge 1ab.
Morphology and geologic history of the common groups of fossil invertebrates, with emphasis on progressive changes in structures and their significance in evolution

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and in adaptive modifications. Laboratory, conferences, lectures, and occasional field trips.

Texts: *Tertiary Faunas,* Davies; *Invertebrate Paleontology,* Twenhofel and Shrock.

Instructor: Popenoe.

Ge 112. Vertebrate Paleontology. 5 units (3-3); second semester.

Prerequisite: Ge 1b.

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.** 2 units (1-3).

Prerequisites: Ge 111ab.

Introduction to the morphology and classification of the foraminifera. Their use in stratigraphic correlation with special reference to the Tertiary of California.

Texts: *The Foraminifera, their Classification and Economic Use,* Cushman; *A Manual of the Foraminifera,* Galloway.

Instructor: Kleinpell.

Ge 121ab. Advanced Field Geology. 3-4 units; both semesters.

Prerequisites: Ge 3ab; 21ab.

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: Popenoe.

***Ge 122. Spring Field Trip.** 1 unit.

Brief studies of various localities in the Southwest representative of important geologic provinces. Trips are conducted in successive years to Owens and Death Valleys where excellent Paleozoic sections are exposed, and Basin Range structure and morphology may be observed; to the Salton Basin and Lower California where the San Andreas fault and the Peninsular Range may be studied; to the San Joaquin Valley and the mountains to the west where important Tertiary formations are exposed and typical Coast Range structure may be seen; and to the Grand Canyon of the Colorado River where a fascinating record of Archean, Algonkian and Paleozoic geologic history may be investigated.

Required of junior, senior, and graduate students in the Division of Geological Sciences.

Instructors: Buwalda, Maxson, Bode.

***Ge 123. Summer Field Geology.** 4 units.

Prerequisites: Ge 3ab; Ge 21ab.

Intensive field mapping of a selected area from a centrally located field camp. Determination of the stratigraphy, fossil content, structure, and geologic history. The area chosen will probably lie in the California Coast Ranges in odd-numbered years and in the Great Basin in even-numbered years. As an occasional alternative an expedition will be conducted to localities important in California geology. The interpretations of classical localities afforded in the literature will be studied in the field. The subject begins immediately after Commencement (about June 12th). Required at the end of both the Junior and the Senior year for the bachelor's degree in the Geology course.

Instructor: Bode.

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Ge 175. Introduction to Applied Geophysics. 2 units (2-0); second semester.

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.** 2 units (2-0); first semester.

A survey of the geology and physics of earthquakes.

Instructor: Richter.

Ge 178. Oceanography. 1 unit (1-0); second semester.

Prerequisites: Ma 2; Ph 2.

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, be postponed.

GEOLOGY

***Ge 200. Mineragraphy.** 3 units (1-6); first semester.

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: Fraser.

***Ge 202. Metalliferous Deposits.** 3 units (1-6); second semester.

Prerequisites: Ge 106, 200.

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

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

Instructor: Fraser.

***Ge 209. Sedimentary Petrology.** 2 units (1-3); given second semester of alternate years.

Prerequisite: Ge 106.

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

Text: *Sedimentary Petrography,* 3rd edition, Milner.

Instructor: Campbell.

***Ge 210. Metamorphic Petrology.** 2 units (1-3); given second semester of alternate years.

Prerequisite: Ge 106.

A study of metamorphic processes.

Text: *Metamorphism,* Harker.

Instructor: Campbell.

Ge 211. Petrology (Seminar). 1 unit; second semester.

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.

*May or may not be given during the war emergency.

Ge 212. Non-Metalliferous Deposits. 3 units (1-3); second semester.
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). 1 unit; second semester.
Prerequisite: Ge 202.
Discussion of problems and current literature concerning ore deposits.
In charge: Fraser.

***Ge 214. Mineral Economics** (Seminar). 1 unit; second semester.
Prerequisite: Ge 202.
Discussion and investigation of factors involved in ore estimation, economics of mining and evaluation of mineral deposits.
In charge: Fraser.

***Ge 215. Mineralogy** (Seminar). 1 unit; first semester.
Prerequisite: Ge 200.
Discussion of current literature and special problems related to mineralogy.
In charge: Fraser.

***Ge 220. History of Geology.** 2 units; first semester.
A study of the development of the geological sciences. The evolution of fundamental theories as influenced by earlier and contemporary geological investigators, and a presentation in a connected sequence of the development of geological ideas.
Lectures, assigned reading, and reports.
Instructor: Maxson.

***Ge 225. Geology of Western America.** 2 units; first semester.
Presents an organized concept of the geologic history of the Rocky Mountains, the Colorado Plateau, Basin and Range, and Coast Range Provinces. Lectures, mainly by staff members personally familiar with the regions discussed, and assigned reading.
Instructors: Buwalda, Campbell, Fraser, Maxson.

***Ge 226. Geomorphology.** 2 units (2-0); first semester.
Prerequisites: Ge 109, 121ab.
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.
Instructor: Buwalda.

***Ge 227. Shoreline Geomorphology.** 2 units (2-0); second semester.
Prerequisite: Ge 226.
Processes of marine erosion and the shoreline cycle.
Field trips along the coast of California.
Text: *Shore Processes and Shoreline Development,* Johnson.
Instructor: Maxson.

***Ge 228. Geomorphology of Arid Regions.** 2 units (2-0); second semester.
Prerequisite: Ge 226.
Processes of erosion in an arid climate. Land forms of arid regions and their modes of origin. The arid cycle of erosion in the Basin Range Province.
Lectures, assigned reading. Field trips to the Mojave Desert and Death Valley.
Instructor: Maxson.

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*Ge 230. **Geomorphology** (Seminar). 1 unit; second semester.
Discussion of research and current literature of geomorphology.
In charge: Maxson.

*Ge 232a. **Introduction to Petroleum Geology.** 2 units (2-0); first semester.
Prerequisites: Ge 109, 121ab.
Theories of origin, principles of movement and accumulation of oil and gas; types of reservoir structures.
Instructor: Maxson.

*Ge 232b. **Introduction to Petroleum Geology.** 2 units (2-0); second semester.
Prerequisite: Ge 232a.
Studies of individual oil fields involving discussion of structural conditions, preliminary estimates of reservoir capacity, practical methods of surface and subsurface mapping, and sub-surface correlation.
Instructor: Bode.

*Ge 235. **Petroleum Geology** (Seminar). 1 unit; second semester.
Problems of petroleum geology. Current literature and discussion of new discoveries.
In charge: Bode, Maxson.

*Ge 237. **Tectonics.** 2 units (2-0); second semester.
Prerequisites: Ge 109, or equivalent, and Ge 121ab, or equivalent.
Advanced structural and tectonic geology. Structure of some of the great mountain ranges; theories of origin of mountains, mechanics of crustal deformation; isostasy; continental drift.
Lectures and seminar.
Instructor: Buwalda.

Ge 238. **Structural Geology** (Seminar). 1 unit; first semester.
Critical review of literature dealing with some part of the field of structural geology.
In charge: Buwalda.

PALEONTOLOGY

Ge 245. **Vertebrate Paleontology** (Seminar). 2 units; second semester.
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.** 2 units (1-3); second semester.
Study of some of the more important invertebrate fossils of the California Tertiary with especial emphasis on their use as horizon markers in field geology.
Instructor: Popenoe.

*Ge 249. **Stratigraphy of the Coast Ranges** (Seminar). 1 unit; first semester.
Review, discussion and criticism of literature of the California Coast Ranges, with especial emphasis on correlation and fauna.
In charge: Popenoe.

*Ge 250a. **Invertebrate Paleontology** (Seminar). 1 unit; first semester.
Critical review of classic and current literature in invertebrate paleontology. Study of paleontologic principles and methods.
In charge: Popenoe.

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*Ge 261. **Theoretical Seismology.** 2 units (2-0); first semester.
Prerequisites: Ma 8ab, or Ma 10ab, or Ph 5ab.
Studies and conferences on the principles of physical seismology.
Instructor: Gutenberg.

*Ge 262. **Interpretation of Seismograms of Teleseisms.** 1 unit (0-3); first semester.
Prerequisite: Ge 261.
Instructor: Gutenberg.

Ge 263. **Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes.** 1 unit (0-3); second semester of alternate academic years.
Prerequisite: Ge 261.
Instructor: Richter.

Ge 265. **Introduction to General Geophysics.** 2 units (2-0); second semester.
Prerequisites: Ma 2ab; Ph 2ab.
Structure of the Earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density.
Instructor: Gutenberg.

*Ge 267. **Propagation of Sound Waves in the Atmosphere.** 1 unit (1-0); first semester.
Prerequisites: Ma 8, or Ma 10, or Ph 5.
Velocity of sound in air; effect of temperature and wind on paths and amplitudes of sound waves.
Instructor: Gutenberg.

*Ge 270. **Seismic Instruments.** 2 units (1-3); first semester.
Prerequisites: Ma 8ab, or Ma 10ab, or Ph 5ab.
Description and theory of seismographs. Laboratory experiments.
Instructor: Benioff.

*Ge 273. **Applied Geophysics I.** 2 units (2-0); first semester.
Prerequisites: Ma 8ab, or Ma 10ab, or Ph 5ab.
Methods of seismology applied to geological problems and prospecting.
Instructor: Gutenberg.

Ge 274ab. **Applied Geophysics II.** 2 units (2-0); first semester of alternate academic years.
Prerequisites: Ma 8ab, or Ma 10 ab, or Ph 5ab.
Theory of methods of electrical prospecting.
Instructor: Potapenko.

Ge 275ab. **Applied Geophysics III.** 2 units (2-0); first semester of alternate academic years.
Prerequisites: Ma 8ab, or Ma 10ab, or Ph 5ab.
Theory of gravitational and magnetic methods of prospecting.
Instructor: Potapenko.

*Ge 278. **Interpretation of Field Seismograms.** 2 units (2-3); second semester.
Prerequisite: Ge 273.
Instructor: Gutenberg.

Ge 279. **Laboratory and Field Work in Electrical Methods of Prospecting.** 2 units (2-4); first semester of alternate academic years.
Prerequisite: Ge 274.
Instructor: Potapenko.

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*Ge 280. **Laboratory and Field Work in Gravitational and Magnetic Methods of Prospecting.** 2 units (0-4); second semester.
Prerequisite: Ge 275.
Instructor: Potapenko.

Ge 282. Geophysics (Seminar). 1 unit; first semester.
Prerequisite: At least two subjects in geophysics.
Discussion of papers in both general and applied geophysics.
In charge: Gutenberg, Bateman, Buwalda, Potapenko.

*Ge 283. **Geophysical Instruments** (Seminar). 1 unit; second semester.
Prerequisite: Ge 270.
Discussion of papers relating to geophysical field and station instruments.
In charge: Benioff.

*Ge 285. **Geophysical Research Conference.** 1 unit; second semester.
Prerequisite: Ge 282 or Ge 283.
Discussion of geophysical problems. For advanced students.
In charge: Gutenberg, Bateman, Buwalda, Potapenko.

GENERAL

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

Ge 297. Advanced Study.
Students may register for 3 units or less of advanced study in fields listed under Ge 299. Occasional conferences; final examination.

Ge 299. Research.
Original investigation, designed to give training in methods of research, to serve as theses for higher degrees, and to yield contributions to scientific knowledge. These may be carried on in the following fields: (e) engineering geology, (f) petroleum geology, (g) ground water geology, (h) metalliferous geology, (i) non-metalliferous geology, (j) geochemistry, (m) mineralogy, (n) areal geology, (o) stratigraphic geology, (p) structural geology, (q) geomorphology, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (w) general geophysics, (x) applied geophysics.

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MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, ARISTOTLE D. MICHAL, HARRY C. VAN BUSKIRK,[1] MORGAN WARD
RESEARCH ASSOCIATE: DINSMORE ALTER,[2] Statistics
ASSOCIATE PROFESSOR: LUTHER E. WEAR
ASSISTANT PROFESSORS: WILLIAM N. BIRCHBY, ROBERT P. DILWORTH
INSTRUCTORS: HARRY LASS, ARTHUR TRABANT

UNDERGRADUATE SUBJECTS

NOTE: Students intending to take the Mathematics Option must indicate their choice at the beginning of their sophomore year.

Ma 1ab. Freshman Mathematics. 4 units (4-0); both semesters.
Includes the fundamentals of plane analytical geometry, and an introduction to the differential and integral calculus.
Text: *Analytic Geometry and Calculus,* Phillips.

Ma 2ab. Sophomore Mathematics. 4 units (4-0); both semesters.
Includes an introduction to solid analytical geometry and vector analysis and completes the usual topics of the differential and integral calculus.
Text: *Analytical Geometry and Calculus,* Phillips.

Ma 2d. Mathematics Review. 1 unit (3-0); one semester.
A comprehensive review of freshman and sophomore mathematics during the last three weeks of the sophomore year.
Subjects Ma 1ab and 2abd form a continuous two-year course in analytical geometry, and the differential and integral calculus.

***Ma 3. Theory of Equations.** 3 units (3-0); one semester.
Includes the elementary theorems in the roots of an equation, solution of numerical equations, determinants, symmetric functions, resultants and discriminants.
Instructor: Wear.

***Ma 4ab. Analytic Geometry.** 3 units (3-0); one semester.
Prerequisites: Ma 1, Ma 2.
Aims to acquaint the student majoring in mathematics with the basic ideas and methods of higher geometry. Subjects treated include: homogeneous coordinates, line coordinates, cross-ratio, projective coordinates, point curves and line curves, projective and metric properties of conics, correlations.
Text: *Higher Geometry,* Graustein.
Instructor: Wear.

Ma 8ab. Advanced Calculus. 3 units (3-0); both semesters.
Prerequisites: Ma 1, Ma 2.
Planned to extend the knowledge gained from the previous studies in calculus and analytic geometry and to lay a better foundation for advanced work in mathematics and science. Intended for students interested primarily in experimental science.
Texts: *Methods of Advanced Calculus,* Franklin; *Fourier Series and Boundary Value Problems,* Churchill.
Instructors: Urner, Trabant.

Ma 10ab. Differential Equations. 2 units (2-0); both semesters.
Prerequisite: Ma 2abd.
An introductory course in differential equations, designed to be helpful both to the student of mathematics and the student of science or engineering.
Text: *Differential Equations,* Ford.
Instructor: Birchby.

[1] Emeritus.
[2] On leave of absence.
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Ma 11. Differential Equations. 2 units (2-0); both semesters.
Prerequisite: Ma 2abd.
An abridged course in differential equations for students in Engineering.
Text: *Differential Equations,* Phillips.
Instructors: Dilworth, Lass, Ward, Wear.

***Ma 12. Probability and Least Squares.** 2 units (2-0).
Prerequisites: Ma 1, Ma 2.
A study of the fundamental principles of probability and their application to statistical data, adjustment of observations, and precision of measurements.
Text: *Theory of Errors and Least Squares,* Bartlett.
Instructor: Alter.

***Ma 14. Vector Analysis.** 2 units (2-0); one semester.
Prerequisite: Ma 2abd.
Elementary vector operations (addition, multiplication) and their application to problems of geometry and physics are treated. This course is intended especially for graduate students in aeronautics, meteorology, and mechanical engineering.
Instructor: Lees.

Ma 15ab. Higher Mathematics for Engineers and Physicists. 3 units; both semesters.
Prerequisites: Ma 1, Ma 2.
An alternative course to Ma 8, Advanced Calculus, covering about the same range of subjects. Intended primarily for Engineers and Applied Physicists who do not expect to use advanced theory.
Text: *Modern Operational Mathematics in Engineering,* Churchill.
Instructor: Rasof.

***Ma 16. Introduction to Higher Algebra.** 3 units; one semester.
Prerequisites: Ma 1, Ma 2.
The more frequently used parts of linear transformations, quadratic forms, matrices, etc.
Instructor: Bell.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ma 81ab. Advanced Calculus. 2 units; both semesters.
Prerequisites: Ma 1, 2.
This subject is the same as Ma 8, but with reduced credit for graduate students. Graduate students in mathematics receive no credit for taking this subject.
Instructors: Urner, Trabant.

Ma 101ab. Modern Algebra. 3 units; both semesters.
Prerequisites: Ma 8, reading knowledge of German.
Abstract algebra as developed since about 1910.
Instructor: Bell.

Ma 102ab. Introduction to Higher Geometry. 4 units; both semesters.
Prerequisites: Ma 1ab, 2 abd, 4 ab.
The course covers selected topics in metrical differential geometry and in algebraic geometry.
Instructor: Wear.

Ma 106ab. Introduction to Theory of Functions of Real Variables. 2 units; both semesters. Required for graduation (B.S.) in mathematics.
Prerequisite: Ma 8ab.
Postulational treatment of real number system, descriptive properties of point

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sets, continuous and discontinuous functions, derivatives and differentials. Riemann integration, functions of several real variables, implicit functions.

Instructors: Michal, Ward.

***Ma 111. Elementary Theory of Tensors.** 3 units.

Prerequisites: Ma 8, 10.

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

Instructor: Michal.

***Ma 113ab. Geometry.** 4 units; both semesters.

Prerequisite: Ma 2abd.

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 114ab. Mathematical Analysis. 4 units; both semesters.

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

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

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

Instructor: Ward.

***Ma 118ab. Introduction to Statistics.** 3 units; both semesters.

Prerequisites: At least a year of calculus, and a laboratory course in some science.

First semester: Curve fitting by moments, correction for lack of high contact and for histogram group, introduction to the Pearson family of frequency curves, including the "normal" curve. Second semester: Continuation of frequency curves, coefficients of relationships, including multiple correlation.

Instructor: Dilworth (Alter, alternate).

***Ma 119ab. Introduction to Theory of Numbers.** 3 units.

Prerequisites: Ma 1ab, 2ab.

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

Instructor: Ward.

***Ma 137ab. Real Variables.** 3 units; both semesters.

Prerequisites: Ma 8ab 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.

Instructor: Ward.

***Ma 138ab. Applied Mathematics.** 4 units; both semesters.

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 func-

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tions 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 139ab. Topology and Modern Geometry.** 3 units; both semesters.

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, except 201a, a reading knowledge of French and German is required.

***Ma 201ab. Modern Analysis.** 5 units; both semesters.

Prerequisites: Ma 8, 10.

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

Instructor: Bateman.

***Ma 202ab. Modern Theory of Differential Equations.** 4 units; both semesters.

Prerequisites: Ma 10, 107.

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

Instructor: Ward.

***Ma 204ab. Geometrical Transformations and Invariants.** 5 units; both semesters.

Prerequisite: Graduate standing.

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

Instructor: Bateman.

***Ma 205ab. Theory of Functions.** 5 units; both semesters.

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

Text: *The Theory of Functions,* Titchmarsh.

Instructor: Michal.

***Ma 209ab. Functionals and Functional Equations.** 5 units; both semesters.

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

Functional operations; permutable functions, functions of composition; integral equations, integro-differential equations; differentials of functionals, functional equations with functional derivatives; infinite matrices; Stieltjes and Lebesgue integrals; abstract spaces.

Instructor: Michal.

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*Ma 218ab. **Advanced Mathematical Statistics.** 9 units; both semesters.
Prerequisite: Ma 118ab.
Characteristic function methods, the moment problem, limit theorems of probability theory, selected topics in sampling theory.
Instructor: Dilworth.

*Ma 251a. **Seminar (I) in Algebra and the Theory of Numbers.** 2 units; first semester.
Prerequisite: Graduate standing.
Topics selected to suit the class.
In charge: Bell.

*Ma 251b. **Mathematical Logic.** 2 units; second semester.
Instructor: Bell.

*Ma 251c. **Theory of Algebraic Numbers.** 2 units; first semester, alternate years.
Prerequisite: Graduate standing.
Instructor: Bell.

*Ma 252ab. **Seminar in Continuous Groups.** 3 units; both semesters.
Prerequisite: Graduate standing in Mathematics.
Lie's theory of r-parameter groups; differential geometry of the group manifold. Groups of functional transformations; invariant functionals; differential geometries of function spaces.
In charge: Michal.

*Ma 253. **Seminar in Foundations of Abstract Algebra.** 2 units; both semesters.
Prerequisite: Graduate standing.
Lattice theory, Boolean rings and algebras. Decomposition theorems in rings and hypercomplex systems.
In charge: Ward.

*Ma 254ab. **Seminar in Modern Theories of Integration.** 2 units; both semesters.
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 255ab. **Methods of Mathematical Physics.** 5 units; both semesters.
Prerequisites: Ma 8, 10.
Integral equations in which the kernel is a Green's function, Fourier series and integrals, Sturm-Liouville functions. Methods of Volterra, Fredholm and Hilbert for dealing with integral equations. Laplace's type of equation and the Heaviside calculus, calculus of variations, matrices and bilinear forms. Partial differential equations and the related simple solutions. Expansions in series of orthogonal functions.
Instructor: Bateman or Ward.

*Ma 256ab. **Modern Differential Geometry.** 3 units; both semesters.
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.

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***Ma 257ab. Seminar in Abstract Spaces.** 2 units; both semesters.

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 258ab. Partial Differential Equations of Mathematical Physics.** 4 units; both semesters.

Prerequisites: Ma 8, 10.

Illustration of general methods by consideration of ordinary linear equations. The simple wave-equation, the potential equation. Applications of the integral theorems of Stokes and Green. Reduction to variation problems and the solution of such problems by direct methods. Use of difference equations to obtain approximate solutions. Use of simple solutions expressed as products. Properties of the special functions introduced in this way. Solution of initial and boundary problems by various methods.

Instructor: Bateman.

Ma 260. Reading.

Occasionally advanced work is given by a reading course under the direction of an instructor. Hours and units by arrangement.

Ma 261. Research.

By arrangement with members of the staff, properly qualified graduate students are directed in research. Hours and units by arrangement.

Ma 270ab. Seminar in Applied Mathematics. 2 units; both semesters.

Prerequisite: Graduate standing.

Subjects selected according to the interest of the members of the seminar.

In charge: Michal.

Ma 271ab. Seminar in Mathematical Analysis. 1 or 2 units; both semesters.

A fortnightly seminar open to anyone who has taken or is taking a course in analysis or function theory.

In charge: Michal.

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PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, CARL D. ANDERSON,[1] HARRY BATEMAN, IRA S. BOWEN,[1] PAUL S. EPSTEIN, WILLIAM V. HOUSTON,[1] CHARLES C. LAURITSEN,[1] J. ROBERT OPPENHEIMER,[1] WILLIAM R. SMYTHE, RICHARD C. TOLMAN,[1] EARNEST C. WATSON,[1] FRITZ ZWICKY

ASSOCIATE PROFESSORS: JESSE W. M. DUMOND,[1] WILLIAM A. FOWLER,[1] ALEXANDER GOETZ, H. VICTOR NEHER,[1] GENNADY W. POTAPENKO

ASSISTANT PROFESSORS: FOSTER STRONG, JOHN D. STRONG[1]

RESEARCH FELLOW: JOSEF J. JOHNSON

INSTRUCTORS: LEON BLITZER, LEVERETT DAVIS, JR., STANLEY C. SNOWDON

UNDERGRADUATE SUBJECTS

Ph 1ab. Mechanics, Molecular Physics, Heat, and Sound. 4 units (3-3); both semesters.

Prerequisite: 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: Foster Strong and Teaching Fellows.

Ph 2ab.† Electricity, Light, and Electron Physics. 4 units (3-3); first semester; 3 units (3-3); second semester.

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

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

Text: *Electricity, Light and Atomic Physics,* Millikan, Roller, Watson, Anderson, and Panofsky.

Instructors: Foster Strong and Teaching Fellows.

***Ph 2d. Physics Review.** 1 unit; last three weeks of sophomore year.

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

Ph 2e.† Light. 2 units (1½-1½). Substituted for Ph 2b, during the war emergency.

Instructors: Foster Strong and Teaching Fellows.

***Ph 3. Modern Physics.** 3 units; one semester.

Prerequisites: Ph 1ab, 2ab; Ma 2ab.

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

Instructor: Anderson.

[1] On leave of absence.

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†Ph 2e substituted for Ph 2b during the war emergency.

Ph 5ab. Introduction to Mathematical Physics. 4 units (4-0); both semesters.

Prerequisites: Ph 1ab, 2abd; Ma 2abd.

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

Instructors: Davis and Snowdon.

Ph 7ab. Electricity and Magnetism. 2 units (2-0); both semesters.

Prerequisites: Ph 1ab, 2abd; Ma 2abd.

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

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

Instructor: Snowdon.

Ph 8. Electricity and Magnetism. 2 units (2-0); first semester.

Prerequisites: Ph 5ab.

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

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

Instructor: Snowdon.

Ph 9. Electrical Measurements. 1 unit (0-3); first semester.

Prerequisites: Ph 1ab, 2abd; Ma 2abd.

A laboratory course in advanced electrical measurements.

Text: *Advanced Electrical Measurements,* Michels.

Instructors: Pickering and Teaching Fellows.

Ay 1. Introduction Course in Astronomy. 2 units (2-†); second semester.

This subject is intended to give the student sufficient familiarity with general astronomy to enable him to read with ease most of the semi-popular books dealing with various phases of the subject.

Text: *Astronomy,* Baker.

Instructor: Johnson.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ph 91ab. Introduction to Mathematical Physics. 3 units (4-0); both semesters.

Prerequisites: Ph 1ab, 2abd; Ma 2abd.

This subject is the same as Ph 5ab but with reduced credit for graduate students.

Instructors: Davis and Snowdon.

***Ph. 101ab. Electricity and Magnetism.** 3 units (3-0); both semesters.

Prerequisites: An average grade of C in Ph 5ab.

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

Text: *Static and Dynamic Electricity,* Smythe.

Instructor: Smythe.

***Ph 103ab. Analytical Mechanics.** 4 units (4-0); both semesters.

Prerequisites: Ph 5ab; Ma 8ab, or 10ab.

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

Text: *Dynamics,* Webster.

Instructor: Zwicky.

*May or may not be given during the war emergency.

†Evening observations by arrangement.

***Ph 105ab. Optics.** 2 units (2-0); both semesters.

Prerequisites: Ph 5ab; Ma 8ab, or 10ab.

A problem subject dealing with the fundamental principles of geometrical optics, of diffraction, interference, the electromagnetic theory of light, etc., and their experimental verification.

Text: *Theory of Optics,* Drude.

Instructor: Bowen.

***Ph 106. Optics Laboratory.** 1 unit (0-3); one semester.

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

Text: *Manual of Advanced Optics,* Taylor.

Instructor: Bowen.

***Ph 107ab. Atomic Physics.** 3 units; both semesters.

Prerequisites: Ph 5ab; Ma 8ab, or 10ab.

An outline of the experimental and theoretical basis of modern atomic physics, which covers electron theory, spectroscopy and nuclear physics.

Instructors: Millikan, Bowen, Lauritsen.

***Ph 108. Spectroscopy Laboratory.** 1 unit; one semester.

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

Instructor: Bowen.

***Ph 110ab. Kinetic Theory of Matter.** 3 units; both semesters.

Prerequisites: Ph 1ab; Ma 2abd.

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

Instructor: Goetz.

***Ph 114. Principles of Quantum Mechanics.** 3 units; one semester.

Prerequisites: Ph 5ab; Ma 8ab, or 10ab.

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 Schrödinger equation, methods of approximate solution, electron spin, and Pauli principle.

Instructor: Houston.

***Ph 115. Applications of Quantum Mechanics.** 2 units; one semester.

Prerequisite: Ph 114.

The application of non-relativistic quantum mechanics to problems in various fields of physics. The subjects treated will be determined partly by the interests of the class.

Instructor: Houston.

***Ph 116. Relativistic Quantum Mechanics.** 2 units; one semester.

Prerequisite: Ph 114.

A study of Dirac's relativistic equation for an electron in an external field together with selected topics from recent developments of relativistic quantum mechanics.

Instructor: Houston.

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*May or may not be given during the war emergency.

*Ph 120. **Seminar on the History of Physics.** 1-3 units; both semesters.

Assigned reading and written and oral reports on selected topics in the history of physics. Students will be expected to make the acquaintance of as many as possible of the original memoirs of the great physicists and to study at least one such memoir very thoroughly. Reports will consist of illustrated lectures, biographies, critical studies, translations, bibliographies, etc. Recommended for all students who expect to teach.

Texts: *History of Science,* Dampier; *Rise of Modern Physics,* Crew.

In charge: Watson.

Ph 142. Research in Physics. Units in accordance with the work accomplished. Approval of the department must be obtained before registering.

GRADUATE SUBJECTS

*Ph 211. **Thermodynamics.** 3 units; one semester.

Prerequisites: Ph 1ab, 2abd: Ma 2abd.

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

Instructor: Epstein.

*Ph 221. **Potential Theory.** 4 units; one semester.

Prerequisites: Ma 8ab, 10ab.

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

Instructor: Bateman.

*Ph 222. **Theory of Electricity and Magnetism.** 3 units; one semester.

Prerequisites: Ph 5ab; Ma 8ab, 10ab.

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

Instructor: Epstein.

*Ph 223. **Theory of Electromagnetic Waves.** 3 units; one semester.

Prerequisite: Ph 222.

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

Instructor: Epstein.

*Ph 224. **Theory of Sound.** 2 units; one semester.

Prerequisites: Ph 2abd; Ma 2abd.

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

Instructor: Bateman.

*Ph 225. **Theory of Electrons.** 3 units; one semester.

Prerequisites: Ph 222 and 223.

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

Instructor: Epstein.

*May or may not be given during the war emergency.

***Ph 226. Heat Radiation and Quantum Theory.** 3 units; one semester.

Prerequisites: Ph 103ab, 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.** 3 units; one semester.

Prerequisites: Ph 103ab, 107ab, 229.

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

Instructor: Epstein.

***Ph 229. Quantum Mechanics.** 4 units; both semesters.

Prerequisites: Ph 103ab, 107ab.

Schrödinger's equation and matrix calculus. Applications to spectroscopy and atomic structure. Transformation theory. Dirac's electron equation. Fundamentals of the theory of the electromagnetic field and second quartization.

Instructor: Epstein.

***Ph 232. Physics of Ultra-Short Electromagnetic Waves.** 2 units (2-0); one semester.

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.** 2 units (2-0); one semester.

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

Instructor: Potapenko.

***Ph 234. Topics in Theoretical Physics.** 2 units (3-0); one semester.

The content of this subject will vary from year to year. Typical topics: Theory of atomic collisions; relativistic quantum theory; theory of radiation; statistical mechanics. The course deals with recent contributions to the theory of atomic nuclei; the problem of nuclear stability; nuclear collisions and transmutations; the interaction of neutrons with nuclei; nuclear radiative processes; and the phenomenological theory of beta-ray decay.

Instructor: Oppenheimer.

***Ph 236ab. Introduction to the Theory of Relativity.** 2 units; both semesters.

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 238. Seminar on Theoretical Physics. 1 unit; both semesters.

Recent developments in theoretical physics for specialists in mathematical physics.

In charge: Epstein.

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*May or may not be given during the war emergency.

*Ph 239. **Seminar on the Solid State.** 1 unit; both semesters.

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

In charge: Goetz, in collaboration with Warner.

*Ph 240. **Seminar on X-Radiation.** 1 unit; both semesters.

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.** 1 unit; both semesters.

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

In charge: Millikan and Houston.

Ph 242. Research in Physics. Units in accordance with the work accomplished. Opportunities for research are offered to graduate students in all the main branches of physics. See "Publications of the Staff" for a survey of researches actually in progress. The student should consult the department and have a definite program of research outlined before registering.

SEMINAR IN ASTROPHYSICS

*Discussions on the large scale distribution of matter in the Universe, statistics of the distribution of nebulae and of clusters of nebulae. Hydrodynamic and statistical mechanical analysis of the morphology of nebulae. Theory and discussion of observational data obtained from observations on stars of special interest, such as supernovae, novae, white dwarfs, variable stars, and emission line stars. Theory and practice of new types of telescopes and other observational devices. Practical work of reduction of data obtained with the Schmidt telescopes on Palomar Mountain.

Meetings throughout the year according to agreement.

Instructor: Zwicky.

*May or may not be given during the war emergency.

SUBJECTS IN ENGINEERING

AERONAUTICS

PROFESSORS: THEODORE VON KÁRMÁN, HARRY BATEMAN, CLARK B. MILLIKAN
ASSOCIATE PROFESSORS: ARTHUR L. KLEIN, ERNEST E. SECHLER
ASSISTANT PROFESSORS: LOUIS G. DUNN, ALBERT E. LOMBARD, JR., FRANK J. MALINA, HOMER J. STEWART, HSUF-SHEN TSIEN
INSTRUCTOR: ANDREW FEJER

UNDERGRADUATE SUBJECTS

ME 14-V. Aerodynamics. (See page 237.)

FIFTH YEAR AND ADVANCED SUBJECTS

AE 251ab. Aerodynamics of the Airplane. 3 units; both semesters.
Prerequisites: Ma 11 and Ma 15ab.
Airfoils, wings, and tail groups, stability and control, drag, performance and spinning.
Texts: *Aerodynamics of the Airplane,* Millikan; *Technical Aerodynamics,* Wood; *Engineering Aerodynamics,* Diehl; *Airplane Design,* Warner.
Instructors: Millikan, Stewart.

AE 252ab. Airplane Design. 4 units; both semesters.
Prerequisites: Applied mechanics, strength of materials, and machine design.
The solution of problems connected with the structural design and analysis of complete airplanes, with special emphasis being placed on the problems dealing with monocoque construction. Ae 252 must be taken concurrently with or subsequently to 251.
Texts: *Airplane Structural Analysis and Design,* Sechler and Dunn; *Airplane Structures,* Niles and Newell.
Instructors: Sechler, Dunn.

AE 253ab. Design of Aircraft Components. 2 units; both semesters.
Factory equipment and methods, control systems, flap systems, landing gears, power plants, electrical and instrument installations, heating and ventilating problems, acoustics, other nonstructural components of the airplane; flight testing.
Instructor: Klein, with the assistance of engineers from neighboring aircraft companies.

AE 254ab. Advanced Problems in Airplane Design. 2 units; both semesters.
Prerequisites: AE 251, 252, 253.
Study of specific problems in airplane design. The design of flying boats and seaplanes.
Instructor: Klein and Assistants.

AE 255. Wind Tunnel Operation and Technique. 2 units; first or second semester.
Prerequisite: AE 251a.
A one-semester course covering pressure and velocity measuring instruments, balances, model suspensions, wind tunnel calibrations and correction factors, data reduction and presentation, extrapolation of model results to full scale. Experiments on various aerodynamic phenomena are carried out by the students in a special wind tunnel constructed for instruction purposes.
Instructor: Fejer.

AE 257ab. Engineering Mathematical Principles. 5 units; both semesters.
Prerequisites: Ma 11; Ma 15ab.

Ordinary differential equation and its boundary value problem, numerical method of integration, dynamics of particles and rigid bodies and its application of engineering problems, vibration of a system of finite degree of freedom, vibration of continued systems, Fourier series and Fourier integrals, expansion of solution in orthogonal functions, operational calculus, functions of complex variables, conformal transformation, vector algebra and integral differential calculi of vector quantities, applications to problems of physics and engineering.

Text: *Mathematical Methods in Engineering*, Kármán and Biot.

Instructor: Tsien.

AE 258. Mathematical Fundamentals of Fluid Mechanics. 2 units; first 10 weeks of first semester, to be followed by AE 259.

Hydrodynamical principles, equation of continuity, equations of motion, velocity potentials and simple fluid flow.

Instructor: Stewart.

AE 259. Thermodynamical Fundamentals of Fluid Mechanics. 1 unit; last 6 weeks of first semester.

Thermodynamical elements of thermodynamic principles. Thermodynamics of perfect gases, conservation of energy, entropy principle, reciprocity relations.

Instructor: Stewart.

AE 260. Research in Aeronautics.

Theoretical and experimental research in one of the following fields: fluid mechanics; elasticity, including photoelasticity, structures and aerodynamics.

AE 261. Aerodynamics of Compressible Fluids. 3 units; second semester.
Prerequisites: AE 251ab; AE 257ab.

One-dimensional flow of a compressible fluid, critical velocity, normal and oblique shock waves, approximate methods for solving 2- and 3-dimensional problems of compressible fluid flow as applied in aeronautical engineering, laminar boundary layer and compressible fluids.

Instructor: Liepmann.

AE 262. Compressibility Laboratory. 2 units; second semester.

Flow in nozzles and curved channels, pressure change through shock waves, effect of boundary layer, wind tunnel problems.

Instructor: Puckett.

AE 265ab. Advanced Problems in Airplane Aerodynamics. 2 units; both semesters.

Prerequisites: AE 251ab; AE 257ab; AE 266ab. (Should be taken concurrently.)

Advanced stability and control problems. Hinge moments, flow in ducts, cooling, and other aerodynamic problems of current importance to designers.

Instructor: Millikan and Assistants.

AE 266ab. Theoretical Aerodynamics of Real and Perfect Fluids. 4 units; both semesters.

Prerequisites: AE 251ab; AE 257ab.

Hydrodynamics of perfect fluids, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, two-dimensional 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.

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

Instructors: Millikan, Stewart.

AE 267a. Turbulence. 2 units; first semester.

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. Theoretical Aerodynamics of Compressible Fluids. 4 units; one semester.

Relation of the equations to the kinetic theory of gases, theory of jets and of the Venturi tube, motion with a velocity exceeding the velocity of sound, shock waves, cavitation.

Instructor: Bateman.

AE 269ab. Advanced Problems in Theoretical Aerodynamics. 3 units; both semesters.

A seminar course in the applications of theoretical aerodynamics to aeronautical problems for students who have had AE 266 and AE 267.

Instructors: Kármán and Millikan.

AE 270ab. Elasticity Applied to Aeronautics. 2 units; both semesters.

Prerequisites: Applied Mechanics; AE 257ab.

Analysis of stress and strain. Hooke's law, theory of bending and torsion, stresses in thin shells, theory of elastic stability, vibrations and flutter.

Texts: *Theory of Elasticity,* Timoshenko; *Elastic Stability,* Timoshenko; *Plates and Shells,* Timoshenko.

Instructor: Sechler.

AE 271ab. Vibrations and Flutter Problems. 2 units; both semesters.

Prerequisites: Applied Mechanics; AE 257ab.

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

***AE 290ab. Aeronautical Seminar.** 1 unit; both semesters.

Study and critical discussion of current contributions to aerodynamics and aeronautical engineering.

*May or may not be given during the war emergency.

APPLIED MECHANICS

Associate Professor: Frederick J. Converse
Instructors: Robert L. Janes, Carl B. Johnson, Mark Serrurier

UNDERGRADUATE SUBJECTS

AM 1ab. Applied Mechanics. 6 units (5-3); first semester.
Prerequisites: Ma 1ab, 2abd; Ph 1ab, 2abd.
Action of forces on rigid bodies; composition and resolution of forces; equilibrium, couples, framed structures; cords and chains; centroids; displacement; velocity and acceleration; translation, rotation, and plane motion; moments of inertia; inertia forces; kinetic and potential energy; work and energy; impulse and momentum; impact; power; efficiency.
Text: *Engineering Mechanics,* Singer.
Instructors: Converse, Janes, Johnson, and Assistants.

AM 1cd. Strength of Materials and Mechanics Problems. 6 units (5-3); second semester.
Prerequisite: AM 1ab.
c. 12 weeks. Elasticity and strength of materials of construction; theory of stresses and strains; elastic limit; yield point; ultimate strength; safe loads; repeated stresses; beams; cylinders; shafts; columns; riveted joints; structural shapes.
Texts: *Elements of Strength of Materials,* Timoshenko and MacCullough; *Steel Construction,* A. I. S. C.
d. 4 weeks. Mechanics problems.
Instructors: Converse, Janes, Johnson, and Assistants.

AM 3. Testing Materials Laboratory. 1 unit (0-3); second semester.
Prerequisite: AM 1c.
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, Janes, and Assistants.

ADVANCED SUBJECTS

AM 105. Soil Mechanics. 3 units (2-4); second semester.
A study of the physical and mechanical properties of soils, and the determination of principles which govern their behavior under load. The application of these principles to problems of foundations and of earthwork engineering.
Instructor: Converse.

CHEMICAL ENGINEERING

(See Chemistry and Chemical Engineering, page 165)

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL
ASSOCIATE PROFESSORS: FREDERICK J. CONVERSE, WILLIAM W. MICHAEL
ASSISTANT PROFESSORS: A. PERRY BANTA,[1] RICHARD POMEROY

UNDERGRADUATE SUBJECTS

CE 1. Surveying. 3 units (1-6); one semester.

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

Text: *Surveying,* Bouchard.

Instructor: Michael.

***CE 2. Advanced Surveying.** 3 units (3-6); one semester.

Prerequisite: CE 1.

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

Text: *Surveying,* Bouchard.

Instructor: Michael.

***CE 3. Plane Table Surveying.** 2 units (1-6); one semester.

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

Text: *Surveying,* Bouchard.

Instructor: Michael.

CE 4. Highway Engineering. 3 units (3-0); one semester.

Prerequisite: CE 1.

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

Text: *Highway Design and Construction,* Bruce.

Instructor: Michael.

***CE 6. Transportation Engineering.** 2 units (2-0); one semester.

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.

[1] On leave of absence.

*May or may not be given during the war emergency.

CE 7. Curves and Earthwork. 3 units (2-3); one semester.
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.** 2 units (0-6); one semester.
Prerequisite: CE 7.
The class devotes one entire day a week to field surveys of a route location, applying the principles as outlined under course CE 7.
Text: *Railway Curves and Earthwork,* Allen.
Instructor: Michael.

***CE 9. Elements of Structures.** 3 units (2-3); one semester.
Prerequisite: AM 1c.
An abridged subject in design of simple structures of timber, steel, masonry, and reinforced concrete. Emphasis is placed upon methods and computations in numerous typical examples.
Text: *Structural Design,* Thomas.
Instructor: Thomas.

CE 10ab. Theory of Structures. 3 units (3-0); both semesters.
Prerequisite: AM 1c.
Methods used in the calculation of stresses in beams, girders, and columns; study of the effects of moving load systems; graphic statics applied to roofs and bridges. A study of arch, cantilever, and continuous bridges; and deflection of trusses.
Text: *Structural Theory,* Sutherland and Bowman.
Instructor: Martel.

***CE 11. Design of Structures.** 3 units (3-0); one semester.
Prerequisite: CE 10a.
The computation of stresses in girders, truss members, and building frames; the design of structural parts and their connections.
Text: *Structural Design in Steel,* Shedd.
Instructor: Martel.

CE 12. Reinforced Concrete. 3 units (2-3); one semester.
Prerequisites: AM 1c; CE 10a.
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 13. Sanitary Engineering. 3 units (3-0); one semester.
Prerequisite: CE 6-V.
A brief study of commonly used methods of developing, collecting, distributing and treating water supplies; and a study of current practices in the collection and disposal of sewage.
Text: *Water Supply and Sewage,* Steele.
Instructor: Pomeroy.

CE 14ab. Engineering Conferences. 1 unit (1-0); both semesters.
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.

*May or may not be given during the war emergency.

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

Instructors: Michael, Eagleson.

FIFTH-YEAR AND ADVANCED SUBJECTS

***CE 120a. Statically Indeterminate Structures.** 3 units; one semester.

Prerequisites: CE 11, 12.

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

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

Instructor: Martel.

***CE 120b. Statically Indeterminate Structures.** 2 units; one semester.

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

Instructor: Martel.

***CE 121a. Structural Design.** 3 units (0-12); one semester.

Prerequisites: CE 10ab; CE 11.

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

Instructor: Thomas.

***CE 121b. Structural Design.** 2 units (0-9); one semester.

Prerequisites: CE 10a, 12.

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

Instructors: Thomas, Martel.

***CE 121c. Civil Engineering Design.** 2 units (0-9); one semester.

Prerequisite: CE 125.

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

Instructor: Thomas.

***CE 122. Analysis of Earthquake Effects Upon Structures.** Units to be based upon work done; any semester.

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.** 4 units (4-0); one semester.

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.** 3 units (2-3); one semester.

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.

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*May or may not be given during the war emergency.

*CE 127. **Sewerage.** 2 units (2-0); one semester.

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: Pomeroy.

*CE 130ab. **Engineering Seminar.** 1 unit (1-0); both semesters.

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 131ab. **Sewage Treatment Plant Design.** Units to be based upon work done; any semester.

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

Instructor: Banta.

*CE 132ab. **Water Power Plant Design.** Units to be based upon work done; any semester.

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 133ab. **Water Treatment Plant Design.** Units to be based upon work done; any semester.

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 134ab. **Ground Water Investigations.** Units to be based upon work done; any semester.

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 135ab. **Geodesy and Precise Surveying.** Units to be based upon work done; any semester.

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 141ab. **Structural Engineering Research.** Units to be based upon work done; any semester.

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

Instructor: Martel.

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*May or may not be given during the war emergency.

***CE 142ab. Sanitation Research.** Units to be based upon work done; any semester.

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

Instructor: Banta.

***CE 143ab. Highway Research.** Units to be based on work done; any semester.

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.

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*May or may not be given during the war emergency.

ELECTRICAL ENGINEERING

PROFESSORS: ROYAL W. SORENSEN,[1] FREDERICK C. LINDVALL,[1] S. STUART MACKEOWN
ASSISTANT PROFESSORS: FRANCIS W. MAXSTADT, WILLIAM H. PICKERING

UNDERGRADUATE SUBJECTS

EE 2a. Electrical Machinery. 2 units (2-0); first semester.
Prerequisites: Ma 2ab; Ph 2ab.
A study of electric and magnetic circuits as applied to direct current machinery. The direct current dynamo, its design, characteristics and applications. Starters, relays and rheostats. Numerous problems are solved.
Text: *Electric Circuits and Machinery*, Vol. I, Hehre and Harness.
Instructor: Maxstadt.

EE 2b. Electrical Machinery. 3 units (3-0); second semester.
Prerequisites: EE 2a.
Three phase circuits and alternating current machinery. The transformer, alternator, synchronous and induction motor; their design characteristics and applications. Numerous problems are solved.
Text: *Electric Circuits and Machinery*, Vol. II, Hehre and Harness.
Instructor: Maxstadt.

EE 3a. Electrical Machinery Laboratory. 1 unit (0-3); first semester.
Prerequisites: Ma 2ab; Ph 2ab.
Use of measuring instruments; operation of direct current motors and generators; determination of their characteristics.
Text: Mimeographed Laboratory Notes.
Instructors: Maxstadt and Assistants.

EE 3b. Electrical Machinery Laboratory. 2 units (0-3); second semester.
Prerequisite: EE 3a.
Alternating current measurements; operation of synchronous alternators and motors; induction motors and transformers.
Text: Mimeographed Laboratory Notes.
Instructors: Maxstadt and Assistants.

EE 8. Direct Currents. 2 units (2-0); first semester.
Prerequisites: Ma 2ab; Ph 2ab.
An abridged course in direct current machinery and circuits designed to acquaint students, not majoring in electrical engineering, with the design, behavior and applications of motors, generators, rheostats, and starters, together with their circuits. Numerous problems are solved.
Text: *Principles and Practice of Electrical Engineering*, Gray and Wallace.
Instructor: Maxstadt.

EE 9. Direct Current Laboratory. 1 unit (0-3); first semester.
Prerequisites: Ma 2ab; Ph 2ab.
An abridged course for students other than those majoring in electrical engineering.
Text: Mimeographed Laboratory Notes.
Instructors: Maxstadt and Assistants.

EE 10. Alternating Currents. 2 units (2-0); second semester.
Prerequisites: EE 8 and 9.
An abridged course in alternating current machinery and circuits; a continuation of EE 8.
Text: *Principles and Practice of Electrical Engineering*, Gray and Wallace.
Instructor: Maxstadt.

[1] On leave of absence.

EE 11. Alternating Current Laboratory. 1 unit (0-3); second semester.

Prerequisites: EE 8 and 9.

A continuation of EE 9 dealing with alternating current apparatus; meters, generators, transformers and motors.

Text: Mimeographed Laboratory Notes.

Instructors: Maxstadt and Assistants.

EE 14. Electric Circuits. 2 units (2-0); second semester.

Prerequisites: EE 2ab; EE 3ab.

Single phase circuits, complex algebra and vectors, magnetic circuits. Supplementary to EE 2b.

Text: *Alternating Current Circuits,* Kerchner and Corcoran.

Instructors: Mackeown and Assistants.

EE 62. Electron Tubes. 3 units (3-0); first semester.

Prerequisites: EE 2ab or Ph 5ab and preceding subjects.

Fundamental theory of electron tubes in radio, communication and control circuits.

Text: *Principles of Electron Tubes,* Reich.

Instructor: Pickering.

EE 65. Electronics Laboratory. 2 units (0-3); first or second semester.

Prerequisite: EE 62, or to be taken concurrently.

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

Instructors: Pickering and Assistants.

EE 70. Engineering Conference. 1 unit (1-0); first semester.

Prerequisites: EE 2ab; EE 3ab.

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

Instructor: Mackeown.

FIFTH-YEAR SUBJECTS

***EE 106ab. Electrical Engineering.** 2 units (2-0), first semester; 3 units (3-0), second semester.

Prerequisites: EE 2ab; EE 3ab.

Windings; graphical methods; commutation; alternator short circuit current; short transmission lines; power system stability.

Instructor: Lindvall.

***EE 107ab. Electrical Engineering Laboratory.** 1 unit (0-3); both semesters.

Prerequisites: EE 2ab; EE 3ab.

A continuation of EE 3. Efficiency tests of alternating current machinery. Graphical solution of alternator regulation; operation of machines in parallel; transformers in parallel; communication circuit test; use of electronic devices; servo mechanisms. Writing of engineering reports.

Text: Mimeographed Laboratory Notes.

Instructors: Maxstadt and Assistants.

***EE 120a. Advanced Alternating Current Analysis and Machinery.** 3 units (3-0); first semester.

Prerequisites: EE 107 and preceding courses.

Advanced study of magnetic and electric circuits. Solution of problems involving the symbolic method and complex notation; symmetrical components; analysis

*May or may not be given during the war emergency.

of electromotive force and current; nonsinusoidal wave forms; analysis of oscillograms.

Text: *Problems in Electrical Engineering,* Lyon; *Applications of the Method of Symmetrical Components,* Lyon.

Instructor: Sorensen.

***EE 120b. Advanced Alternating Current Analysis and Machinery.** 3 units (3-0); second semester.

Prerequisites: EE 120a 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.

Instructor: Sorensen.

***EE 121ab. Alternating Current Laboratory.** 1 unit (0-3), first semester; 2 units (0-3), second semester.

Prerequisites: EE 107 and preceding courses.

Complete tests of the induction motor; operation of transformers in parallel; study of polyphase connections; photometric tests; use of the oscillograph; calibration of relays and watt-hour meters; high voltage tests of insulation. Special emphasis is placed on the report.

Text: Advanced Laboratory Notes.

Instructor: Maxstadt.

***EE 128. Electric Traction.** 2 units (2-0); first semester.

Prerequisites: EE 2ab; EE 106ab.

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. Other references.

Instructors: Lindvall, Maxstadt.

***EE 130. Electric Lighting and Power Distribution.** 2 units (2-0); second semester.

Prerequisites: EE 2ab; EE 106ab.

Requirements of the electric system outside the power station. Economics of power distribution. Power factor, load factor diversity and demand. Commercial rates. Prime movers, power station and substation layouts; protective equipment; reliability of service.

Text: *Electrical Distribution Engineering,* Seelye. Other references.

Instructor: Maxstadt.

***EE 148. Specifications and Design of Electrical Machinery.** 2 units (2-0); second semester.

Prerequisites: EE 107a and preceding courses.

Design calculations for alternating and direct current machinery. Complete design of a rotating machine. Study of commercial specifications.

Text: *Electrical Machine Design,* Gray. Other references.

Instructors: Sorensen, Maxstadt.

***EE 152. Dielectrics.** 2 units (2-0); second semester.

Prerequisites: EE 120ab and preceding courses.

A study of electric fields in insulators; boundary properties of electric fields between air and solids; sparking voltages and distances; effects of atmospheric pres-

*May or may not be given during the war emergency.

sure, frequency, humidity and temperature; commercial insulators and insulations. Corona phenomena. High frequency voltages.

Text: *Theory of Dielectrics,* Schwaiger and Sorensen.

Instructor: Sorensen.

***EE 156ab. Communication Circuits.** 2 units (2-0); both semesters.

Prerequisites: EE 2ab and EE 14.

Theory of communication circuits. Includes a study of four terminal networks, transmission lines and filter theory.

Instructor: Mackeown.

***EE 157. Communications Laboratory.** 2 units (0-3); first semester.

Prerequisite: Must be taking or have taken EE 156a.

Use of measuring instruments and circuits at audio frequencies. Includes four terminal network, filters and transmission line.

Instructor: Pickering and Assistants.

***EE 163. Radio.** 2 units (2-0); first semester.

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 190. Ultra High Frequency Techniques. 4 units (4-0); second semester.

Prerequisites: EE 62; EE 156a; 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. 3 units (0-6); second semester.

Prerequisites: Must be taking or have taken EE 190.

Laboratory measurements and use of ultra high frequency equipment.

Instructor: Pickering and Assistants.

ADVANCED SUBJECTS

EE 200. Research in Electrical Engineering. Units to be arranged.

Research on special problems in electrical engineering problems will be arranged to meet the needs of the student. The Institute is unusually well equipped for this advanced work. Work relating to theory of electrical machine design, electric transients and high voltage is under the direction of R. W. Sorensen and F. C. Lindvall; work relating to distribution and industrial uses of electrical power for lighting and industrial uses is under the direction of F. W. Maxstadt; and work relating to electronics, electron tubes, radio and ultra high frequency is under the direction of S. S. Mackeown and W. H. Pickering.

***EE 220. Research Seminar in Electrical Engineering.** 1 unit; both semesters.

Meets once a week for discussion of work appearing in the literature and in progress at the Institute, or for presentation of technical developments in the industry. All advanced students in electrical engineering and members of the electrical engineering staff are expected to take part.

In charge: Sorensen, Lindvall, Mackeown, Pickering, Maxstadt.

***EE 221. Transmission Line Problems.** 4 units.

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

Instructor: Sorensen.

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*May or may not be given during the war emergency.

***EE 223ab. Electric Strength of Dielectrics.** 4 units.
A study of the effect of high potentials applied to dielectrics.
Text: *Theory of Dielectrics,* Schwaiger and Sorensen.
Instructor: Sorensen.

***EE 224ab. Electron Tubes and Radio Frequency Circuits.** Units to be based on work done; both semesters.
A study of advanced problems in the field of electronics and radio.
Instructors: Mackeown and Pickering.

***EE 225. Principles of Electrical Design.** 4 units; first semester.
A discussion and calculation course in the analysis of the principles and methods used in the design of electrical machinery.
Instructors: Sorensen, Maxstadt.

***EE 226ab. Engineering Mathematical Physics.** 5 units; both semesters.
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 Analyses.** 3 units.
An introduction to the solution of circuit problems by operational methods.
Instructor: Mackeown.

***EE 228. Conductivity of Electricity in Gases.** Units to be arranged; both semesters.
Selected topics in glow, arcs, and spark discharges.
Instructor: Mackeown.

***EE 229. Advanced Circuit Analysis.** Units to be arranged; both semesters.
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 230ab. Microwave Electronics.** 2 units; both semesters.
The behavior of vacuum tubes at ultra high frequencies, electron transit time effects, microwave oscillators.
Instructor: Pickering.

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ENGINEERING DRAFTING

ASSISTANT PROFESSOR: HOWELL N. TYSON
INSTRUCTORS: DAVID F. WELCH, N. W. WILCOX

D 1a. Freehand Drawing. 1 unit (0-3); first semester.

The first ten weeks of the semester are devoted to the study of geometrical forms and their representation by means of freehand perspective. Training in pencil rendering is given and the fundamental principles of perspective are illustrated by simple architectural and engineering studies. Emphasis is placed on careful observation and accurate drawing. Engineering drafting is begun during the latter part of the semester.

Instructors: Wilcox and Assistants.

D 1b. Engineering Drafting. 1 unit (0-3); second semester.

Prerequisite: D 1a.

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, Welch.

D 2. Descriptive Geometry. 2 units (0-6); first or second semester.

Prerequisites: D 1ab.

The course is designed to supplement the study of shape description as given in D 1ab, and to present a graphical means of solving three-dimensional problems. Special emphasis is placed on the ability to analyze structures and on three-dimensional visualization of problems. 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 applications of descriptive geometry in the various fields of engineering.

Text: *Geometry of Engineering Drawing*, Hood.

Instructors: Wilcox, Welch, Tyson.

D 5. Descriptive Geometry. 1 unit (0-3); second semester.

Prerequisites: D 1ab.

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 6. Engineering Drafting. 2 units (0-6); first or second semester.

Prerequisites: D 1ab.

This is a continuation of D 1b. The accepted standards for machine drafting are given, and working drawings are made which illustrate the use of these standards. The student is also given basic training in the layout of elementary machine mechanisms, and in making pictorial drawings, engineering charts and graphs.

Text: *Engineering Drawing*, sixth edition, French.

Instructors: Tyson and Assistants.

D 7. Advanced Engineering Drafting. Maximum of 2 units. Elective; any semester.

Prerequisites: D 1ab; D 2; D 6.

The study and execution of layout drawings involving further applications of machine mechanisms.

Instructor: Tyson.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY
ASSOCIATE PROFESSOR: ROBERT T. KNAPP[1]
ASSISTANT PROFESSOR: VITO A. VANONI[1]
INSTRUCTORS: JAMES W. DAILY, WALTER F. HILTNER, E. HARRISON KING, JR.

UNDERGRADUATE SUBJECTS

Hy 1ab. Hydraulics. 2 units (2-0), first semester; 4 units (4-0), second semester. (For mechanical engineers.)

Prerequisite: AM 1a, or to be taken at the same time.

Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; hydraulic turbines; centrifugal pumps and other hydraulic equipment.

Text: *Hydraulics,* Daugherty.

Instructor: Hiltner.

Hy 2ab. Hydraulics. 3 units (3-0); both semesters. (For civil engineers.)

Similar to Hy 1ab.

Instructor: King.

Hy 3. Hydraulics. 3 units (3-0); second semester. (For electrical engineers.)

Prerequisite: AM 1a, or to be taken at the same time.

An abridgement of Hy 1ab for electrical engineering students.

Instructor: King.

***Hy 4. Hydraulic Machinery.** 3 units (3-0); one semester.

Prerequisites: Hy 1 and 2.

Theory, construction, installation, operation, and characteristics of hydraulic turbines and centrifugal pumps.

Instructor: Knapp.

Hy 11. Hydraulics Laboratory. 1 unit (0-3); first or second semester.

Prerequisite: AM 1ab.

Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs; use of Pitot tube; tests of impulse and reaction turbines, centrifugal pumps, and other hydraulic apparatus.

Instructors: Daily and Assistants.

ADVANCED SUBJECTS

***Hy 100. Fluid Mechanics.** 3 units (3-0); one semester.

Prerequisites: Hy 1 and 11.

Dimensional analysis; principles of energy, continuity, and momentum; potential flow; use of the flow net; cavitation; equations of viscous motion; laminar flow; turbulence; resistance of immersed bodies; flow in closed conduits; flow in open channels; wave motion.

Text: *Fluid Mechanics for Hydraulic Engineers,* Rouse.

Instructor: Daugherty.

***Hy 101. Hydraulic Machinery.** Units to be based on work done; any semester.

A study of such machines as the hydraulic turbine and the centrifugal pump and their design to meet specific conditions.

Instructor: Daugherty.

[1]On leave of absence.
*May or may not be given during the war emergency.

***Hy 102. Hydraulics of Open Channels.** 2 units (0-6); one semester.

Prerequisite: Hy 1.

Computation of surface profiles for gradually varied flow in open channels; characteristics of the hydraulic jump; delivery of canals in hydroelectric and irrigation projects.

Text: *Hydraulics of Open Channels,* Bakhmeteff.

Instructor: Vanoni.

***Hy 103. Hydraulics Problems.** 2 units (0-6); one semester.

Prerequisite: Hy 1.

Selected advanced problems in hydraulics such as penstock design, water hammer and surge chamber calculations, hydraulic jump determinations, etc.

Instructor: Knapp.

***Hy 200. Advanced Work in Hydraulic Engineering.**

Special problems in hydraulics will be arranged to meet the needs of students wishing to do advanced work in this field.

*May or may not be given during the war emergency.

INDUSTRIAL DESIGN

PROFESSORS: ROBERT D. GRAY, JOHN R. MACARTHUR
VISITING PROFESSOR: GILBERT BRIGHOUSE
LECTURERS: ANTONIN HEYTHUM, J. PAUL YOUTZ
INSTRUCTORS: HAROLD M. HUSTON, BEVERLEY W. MORANT, NATHANIEL W. WILCOX

FIFTH-YEAR SUBJECTS

ID 101ab. Industrial Design I. 5 units (2-9); first and second semester.

Basic elements in industrial designing. Analysis of interdependence of function, construction, or manufacturing process, material and appearance. Abstract and practical form problems. Six major problems, and a number of selected minor problems.

Instructor: Heythum.

ID 111ab. Shop Practice I. 3 units (2-2); first and second semesters.

Machine instruction in woodworking, metal and non-metallic work, foundry work, pattern work.

Instructor: Morant.

ID 121ab. Design Techniques I. 1 unit (0-3), first semester; 2 units (0-6), second semester.

Instruction in the various methods of two-dimensional visual presentation, perspective design, freehand drawing, crayon, color rendering. Three dimensional models, and mountages.

Instructors: Heythum, Wilcox.

ID 131a. Design Trends. 1 unit (1-0); first semester.

A survey of how the designer and the artisan in industry, in their recent products, have interpreted and answered the needs of the public.

Instructor: Heythum.

ID 141ab. Non-Metallic Materials and Technical Trends. 3 units (2-4); first and second semesters.

A study of plastics, fibers, and the products of the chemical laboratory as related to modern manufacture and design.

Instructor: Youtz.

ID 151a. Cost Analysis. 3 units (4-2); second semester.

Instruction in specialized account practice of value to the designer in controlling and analyzing production costs and in cooperating with the needs of industry.

Instructor: Huston.

ID 161a. History of Art. 1 unit (1-0); second semester.

A survey of the development of artistic expression and theory, correlating ideas and forms of art with the cycles of social, political and economic change through the ages.

Instructor: Macarthur.

ADVANCED SUBJECTS

ID 201ab. Industrial Design II. 7 units (2-15), first semester; 8 units (0-24), second semester.

Selected advanced problems in industrial design and a major problem assigned individually to the student, giving an opportunity and the encouragement for the exercise of personal initiative in the solution. This class is conducted as a seminar. A number of selected 24-hour problems and two major ones. The second semester is devoted to thesis work.

Instructor: Heythum, in first semester. Second semester, Heythum, members of the faculty, and visiting experts.

ID 211ab. Shop Practice II. 3 units (2-2); first and second semesters.
Tool engineering, tool planning, and tool design. Machine practice.
Instructor: Morant.

ID 221ab. Design Techniques II. 2 units (0-7), first semester; 1 unit (0-4), second semester.
Production illustration, perspective diagrams, cut-away section drawings, illustration of production operations, breakdown-diagrams, photograph-diagrams.
Instructors: Heythum, Wilcox.

ID 231ab. Technical Trends in Design. 2 units (2-0), first semester; 2 units (2-2), second semester.
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 241ab. Social and Buying Psychology. 3 units (2-2); first and second semesters.
A study of the broader implications of the work of the designer in controlling and analyzing production costs and cooperating with the needs of industry.
Instructor: Brighouse.
Additional and supplementary subjects are offered as the need arises.
Lectures are given from time to time by visiting designers and engineers.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP,[1] FREDERICK C. LINDVALL[2]
ASSOCIATE PROFESSOR: ROBERT T. KNAPP[2]
ASSISTANT PROFESSORS: DONALD S. CLARK, DONALD E. HUDSON, ALBERT E. LOMBARD, JR.,[2] HOWELL N. TYSON
LECTURER: ALADAR HOLLANDER
INSTRUCTORS: JAMES W. DAILY, WALTER L. JOHNSON, PETER KYROPOULOS, WILLIAM F. NASH, ANDREW FEJER
ASSISTANT INSTRUCTORS: JOHN H. CARR, ROLF SABERSKY, GEORGE P. SUTTON

UNDERGRADUATE SUBJECTS

ME 1. Mechanism. 3 units (3-3); first or second semester.

Prerequisites: Ma 1abd; Ph 1ab; D 1, 4, 12ab.

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

Text: *Elements of Mechanism,* Schwamb, Merrill and James.

Instructor: Tyson.

ME 3. Materials and Processes. 2 units (2-2); first or second semester.

A study of the materials of engineering and of the processes by which these materials are made and fabricated. The fields of usefulness and the limitations of alloys and other engineering materials are studied, and also the fields of usefulness and limitations of the various methods of fabrication and of processing machines.

The class work is combined with inspection trips to many industrial plants. The student is not only made acquainted with the technique of processes but of their relative importance industrially and with the competition for survival which these materials and processes continually undergo.

Text: *Materials and Processes,* Clapp and Clark.

Instructors: Clark, Nash.

ME 5ab. Machine Design. 4 units (3-3); both semesters.

Prerequisites: ME 1; AM 1ab; ME 10.

Applications of mechanics of machinery and mechanics of materials to practical design and construction. Riveting and welding; boilers and plate vessels; bolts and screws; force and shrink fits; hydraulic cylinders; cylinders and cylinder heads for steam and gas engines; stuffing boxes and packing; pistons and piston rings; leaf springs, coil springs; piston pins; connecting rods and cross heads; cranks and crank-shafts; flywheels; spur gears; helical gears; bevel gears; worm gears; spiral gears; belting; pulleys; rope driving; chains; friction drives; wire rope and hoisting; plain bearings; ball bearings; roller bearings; shafts and couplings; clutches; brakes; high speed disks; piping. Also a study of manufacturing processes with especial reference to the economics of design.

Text: *Design of Machine Elements,* Faires.

Instructors: Hudson, Hollander, Johnson.

[1] Emeritus.
[2] On leave of absence.

ME 10. Metallurgy. 3 units (2-3); first semester.
Prerequisites: ME 3; Ch 6.
A study of the principles underlying the heat treatment, properties, use, and selection of ferrous and non-ferrous alloys as applied to design.
Text: *Physical Metallurgy for Engineers,* Clark.
Instructors: Clark, Nash.

ME 15. Heat Engineering. 4 units (3-3); first or second semester.
Prerequisites: Ma 2abd; ME 1.
Principles of engineering thermodynamics; properties of gases; thermodynamic processes of gases; gas cycles; internal combustion engines; air compressors; and elements of different types of power plants. Inspection of local power plants, laboratory demonstration tests, and computing room exercises.
Text: *Applied Thermodynamics,* Faires.
Instructor: Kyropoulos.

ME 16. Heat Engineering. 3 units (3-0); second semester.
Prerequisite: ME 15.
Additional work in thermodynamics; properties of vapors; thermodynamic processes of vapors; vapor cycles; steam engines; steam turbines.
Text: *Applied Thermodynamics,* Faires.
Instructors: Daugherty, Kyropoulos.

ME 17. Heat Engineering. 3 units (3-0); first semester.
Prerequisite: ME 16.
A study of internal combustion engines, fuels, and lubricants. Analysis of real fuel-air cycles, combustion in both spark-ignition and compression-ignition engines, carburetion, detonation, engine preformance.
Text: *The Internal Combustion Engine,* Taylor and Taylor.
Instructor: Daugherty.

ME 20. Heat Engineering. 3 units (2-3); second semester.
An abridgement of ME 15, 16, and 17 for students in civil engineering.
Instructor: Fejer.

ME 21. Heat Engineering. 3 units (3-0); first semester.
An abridgement of ME 15, 16, and 17 for students in electrical engineering.
Instructor: Fejer.

ME 25. Mechanical Laboratory. 2 units (0-3); second semester.
Prerequisite: ME 15.
Tests of steam engine, steam turbine, blower and gas engine, etc., for efficiency and economy.
Text: *Power Plant Testing,* Moyer.
Instructors: Daily and Assistants.

ME 26. Mechanical Laboratory. 2 units (0-6); second semester.
Prerequisite: ME 15.
Additional work in the laboratory on air compressors, fuel and oil testing, and special work on steam and internal combustion engines.
Text: *Power Plant Testing,* Moyer.
Instructors: Daily, Kyropoulos.

ME 27. Mechanical Laboratory. 2 units (0-3); first semester.
Prerequisites: ME 15 and Hy 1.
An abridgement of ME 25 and Hy 2 for students in electrical engineering.
Instructors: Daily and Assistants.

ME 50ab. Engineering Conferences. 1 unit (1-0); both semesters.
A course in public speaking for engineers, on engineering topics.
Instructor: Daugherty.

***ME 100. Advanced Work in Engineering.**

In addition to the regular fifth-year and other advanced courses which are here outlined, the staff of the mechanical engineering department will arrange special courses or problems to meet the needs of advanced students.

ME 101a. Advanced Machine Design. 3 units; first semester.

Prerequisites: ME 5; ME 10; Ma 11.

A study of topics from advanced Strength of Materials and Theory of Elasticity, with applications to problems of machine design.

Subjects include: Strain energy methods; problems of elastic instability; stress analysis of plates, cylinders, rotating disks, curved bars, etc.; theories of failure of materials; design stresses; properties of materials; methods of experimental stress analysis.

Instructor: Hudson.

ME 101b. Mechanical Vibrations. 3 units; second semester.

Prerequisites: AM 1abc; Ma 11.

A study of the theory of vibrating systems with particular application to problems of machine design. Subjects include: theory of resonant systems; elimination of undesirable vibrations, vibration instrumentation; self excited vibrations and instability in mechanical systems; impact and transient excitations; introduction to non-linear systems.

Instructor: Hudson.

***ME 110ab. Science of Metals.** 2 units, first semester; 4 units, second semester.

Prerequisite: ME 10.

A study of modern engineering metals and alloys; their mechanical and physical properties, and the effects upon these properties brought about by the various processes of manufacture and fabrication. A study of the physical principles governing metallic behavior.

Text: *Principles of Physical Metallurgy*, Doan.

Instructor: Clark.

***ME 111ab. Metallography Laboratory.** 2 units (0-6); both semesters.

Prerequisite: ME 110a, or to be taken at the same time.

Pyrometry, thermal analysis, microscopy, preparation of metallographic specimens, photomicrography, structures of steels and cast irons, heat treatment of steel, structures and treatment of non-ferrous alloys, recrystallization and grain growth, macroscopy, inspection methods, special problems.

Instructor: Nash.

***ME 120. Heat Engineering.** 3 units (3-0); one semester.

Prerequisite: ME 17.

A study of internal combustion engines, fuels, and lubricants. Analysis of real fuel-air cycles, combustion in both spark-ignition and compression-ignition engines, carburetion, detonation, engine performance.

Text: *The Internal Combustion Engine*, Taylor and Taylor.

Instructor: Daugherty.

***ME 121. Heat Engineering.** 2 units (2-0); one semester.

Prerequisite: ME 120.

Advanced work in engineering thermodynamics. Special problems, air conditioning, refrigeration.

Instructor: Daugherty.

*May or may not be given during the war emergency.

*ME 122. **Heat Engineering.** 2 units (2-0); one semester.
Prerequisite: ME 120.
Study of the laws of heat transmission, and their application to selected engineering problems.
Instructor: Daugherty.

*ME 125. **Refrigeration Plants.** Units to be based on work done; any term.
Design of various types of refrigeration plants best adapted to different conditions of service.
Instructor: Daugherty.

*ME 130. **Advanced Mechanical Laboratory.** 5 units (1-9); one semester.
Prerequisites: ME 17, 26.
Advanced work on steam turbines, internal combustion engines, lubrication, and similar subjects. Each problem will be studied in enough detail to secure a thorough analysis. Conference hour for progress discussion.
Instructors: Daily, Kyropoulos.

*ME 132. **Engine Laboratory.** 5 units; both semesters.
Use of the dynamometer. Experimental work in engine performance, carburetion, ignition, fuel consumption, etc.
Instructor: Daily.

*ME 140ab. **Research or Thesis.** 4 units; second semester.
This work is arranged with the department to fit the needs and desires of the individual student.

*ME 150ab. **Mechanical Engineering Seminar.** 1 unit each semester.
Attendance required of graduate students in mechanical engineering. Conference on research work and reviews of new developments in engineering.

*May or may not be given during the war emergency.

METEOROLOGY

PROFESSORS: BENO GUTENBERG, IRVING P. KRICK[1]
ASSOCIATE PROFESSOR: PAUL E. RUCH
ASSISTANT PROFESSORS: ROBERT D. ELLIOTT, WILLIAM H. REMPEL, NEWTON C. STONE, HOMER J. STEWART
INSTRUCTORS: STEPHEN E. BLEWETT, THOMAS A. GAFFNEY, JR.

My 101abc. Weather Forecasting Theory and Practice. 6 units (6-0).

The application of hydrodynamics and thermodynamics to the study of atmospheric phenomena and the application of the principles of meteorological theory to practice forecasting problems. Atmospheric hydrostatics, stability, motion of pressure fields, frontogenesis, circulation vorticity, discontinuity surfaces, energy of air movements, gusts, turbulence, etc. Modern theory on structure of extra-tropical 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 fixed level and isentropic analyses. Forecasting local weather phenomena such as fog, thunderstorms and icing with particular emphasis on their relationship to aircraft operations. Transoceanic forecasting and selected problems pertaining to northern hemisphere and tropical synoptic analysis and forecasting. An introduction to the synoptic weather type of long term forecasting for North America.

Instructors: Ruch, Stewart, and special lecturers.

My 102abc. Meteorological Laboratory. 5 units (0-15).

Decoding of synoptic and radiosonde reports; plotting and analysis of synoptic, fixed level, and isentropic 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, Gaffney, Rempel, Ruch, Stone.

My 103abc. Meteorological Instruments and Observations. 5 units (0-15).

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 semesters students operate the weather station on a regular schedule. Thermometers, psychrometers, barometers, altimeters, anemometers, precipitation gages, nephoscopes, recorders. Theodolites and radiosonde transmitters-recorders.

Instructors: Blewett, Gaffney.

My 104ab. Structure of Atmosphere. 1 unit (1-0).

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. Transmission of sound waves in the atmosphere.

Instructor: Gutenberg.

My 105bc. Climatology. 2 units (2-0).

General circulation of the atmosphere; temperatures, evaporation, condensation forms, precipitation, the hydrologic cycle, Micro-climatology, principles of dynamic climatology, military uses of climatology. Sources of climatic data and methods of analysis of climatic data.

My 150. Public Speaking. 1 unit (1-0).

Fundamentals of public speaking with special emphasis on the function of briefing pilots.

[1]On leave of absence.

Ge 178. Oceanography. 1 unit (1-0).

Configuration of ocean bottoms, heat budget of ocean, physical properties of ocean water, eddy viscosity and instrumental observation. Distribution of temperatures and salinity. Tides, seiches, and ocean currents. Interaction between atmosphere and the oceans.

Instructor: Gutenberg.

My 280abc. Meteorological Research. Units to be determined.

First, second and third semesters selected problems in Meteorology research assigned to meet the needs of advanced students.

In charge: Ruch.

My 291abc. Meteorological Seminar. 2 units.

First, second and third semesters. Reviews and discussions of current meteorological literature and problems.

In charge: Ruch.

SUBJECTS IN THE HUMANITIES

ECONOMICS

PROFESSORS: PHILIP S. FOGG,* ROBERT D. GRAY, GRAHAM A. LAING, RAY E. UNTEREINER*
ASSOCIATE: EDWIN F. GAY
LECTURERS: ARCHIBALD B. YOUNG, ARTHUR H. YOUNG
VISITING PROFESSOR: ALBERT E. WAUGH
VISITING LECTURERS: JOSEPH MCCLINTIC, PHILIP NEFF
ASSOCIATE PROFESSOR: HORACE N. GILBERT*
ASSISTANT PROFESSOR: VICTOR V. VEYSEY
INSTRUCTOR: EDWARD M. WALES

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. 3 units (3-0).

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, Wales, Waugh.

Ec 17. Accounting. 2 units (2-0). Open only to engineering students in their Junior year.

This is a subject in the interpretation of the financial statements with which engineering students who enter business will come in contact. A description of bookkeeping methods is presented, but not in sufficient detail to enable the average student to keep a set of business books. Emphasis is placed upon the study of actual business problems involving the executive interpretation of accounting reports. A liberal amount of descriptive material regarding business activities accompanies the instruction.

Not given 1944-1945.

Instructor: Wales.

Ec 18. Industrial Organization. 2 units (2-0).

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: Wales.

Ec 20. Financial Organization. 2 units (2-0).

A general study of the financial organization of society. The subject includes a study of the following topics: Principles of money; nature and functions of credit; the varieties of credit instruments; the marketing of low and high grade securities;

*On leave of absence.

the functions of the corporation and the stock exchange as capital-raising devices; the development of the banking system and the general principles of banking, including studies of commercial banking, the national banking system, and the Federal Reserve system.

Not given 1944-1945.

Instructor: Laing.

Ec 25. Business Law. 2 units (2-0).

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 34. Corporation Finance. 2 units (2-0).

Corporation promotion; the issue and payment of securities; underwriting; the sale of speculative securities. Discussion of the principles of capitalization, the management of corporate income, and the relation of dividend to income. Financial problems of expansion, combination, and reconstruction of corporations.

Not given 1944-1945.

Instructor: Laing.

Ec 48. Introduction to Industrial Relations. 3 units (3-0).

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.

Ec 50. Industrial Management. 3 units (3-0).

Open to senior engineers.

This subject aims to give students planning to enter the general field of manufacturing (1) information regarding special management techniques and (2) an idea as to the relationship of the production function to industrial sales, industrial finance, and general executive policies. The scope of the subject is further indicated by the following partial list of topics studied: plant location, types of factory buildings, plant layout, simplification and standardization of products, time and motion studies, the production budget, production control, cost control, wage systems, and industrial relations.

Several field trips are made to enable students to see industrial management techniques in operation.

Not given 1944-1945.

Instructor: Gilbert.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ec 100ab. Business Economics. 4 units (4-0); first and second semesters. Open to graduate students.

This subject endeavors to bridge the gap between engineering and business. It is intended for students in applied science and technology who wish to use their technical training as an approach to the administrative side of business and industry.

The subject includes, in brief (a) a description of business and industry, and (b) a consideration of principles of business economics which are relevant to the fields of interest of engineers and applied scientists. The principal subjects treated are (1) business organization, (2) industrial promotion and finance, (3) factory problems, and (4) the marketing of industrial goods. An introduction is given to industrial statistics and accounting. Students are made familiar with the operations

of the Federal Reserve system and with various other significant subjects in business economics. Several industries are studied in detail as to the nature of their particular economic problems and as to the actual companies operating in them. The case method of instruction developed by the Harvard Graduate Business School is employed to a considerable extent throughout the subject.

Not given 1944-1945.

Instructors: Gray, Wales.

Ec 106. Business Economics Seminar. 3 units. Open to graduate students.

Special studies of current economic problems are presented by the instructor, after which an open discussion is held. Emphasis is placed on the materials of economic science, i.e., statistics of production, consumption, prices, banking and finance, etc. These quantitative studies are accompanied, where advisable, by reference to economic doctrine.

Not given 1944-1945.

In charge: Gilbert.

Ec 110. Industrial Relations. 4 units (4-0).

Prerequisite: Ec 100ab.

The course will include the study of labor relations, personnel managements, and labor economics. The seminar method, permitting general participation through individual investigation and special reports will be largely followed. Training in research methods and in the use of pamphlet and other material in the Industrial Relations Library will also be given.

Instructors: Gray, Arthur H. Young.

ENGLISH

PROFESSOR: CLINTON K. JUDY
ASSOCIATE: LOUIS B. WRIGHT
VISITING LECTURER: WILLIAM H. DAVENPORT
ASSOCIATE PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE,* L. WINCHESTER JONES, GEORGE R. MACMINN
ASSISTANT PROFESSOR: ROGER STANTON†
INSTRUCTOR: PAUL BOWERMAN
ASSISTANT: BOYD MARSHALL

English composition is prescribed for all students in the Freshman year, and a survey of English literature is prescribed for all students in the Junior year. In the Senior year the students are offered a number of options in English, American, and European literature.

The instruction in composition is intended to give a thorough training in both written and spoken English. The instruction in literature is intended to provide an appreciative acquaintance with the chief works of those authors, past and present, who are most significant in the development of modern civilization, and to foster the habit of self-cultivation in books.

The regular subjects in English do not exhaust the attention given at the Institute to the student's use of the language; all writing, in whatever department of study, is subject to correction with regard to English composition.

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination is not confined to specific courses, but covers the general attainments of the students in their humanistic work throughout the first two years.

UNDERGRADUATE SUBJECTS

En 1ab. English Composition and Reading. 3 units (3-0); first and second semesters.

This subject is designed to give the student a thorough review of the principles of composition, with much practice in writing and speaking, and a broad introduction to good reading. The student is offered every inducement of self-cultivation, and is allowed ample opportunity for the exercise of special talents or the pursuit of special intellectual interests.

The work of the honor section is directed toward the stimulation of intellectual initiative. The members of the section are held to high standards of excellence in writing and speaking, and are expected to undertake a considerable amount of cultural reading.

Instructors: Bowerman, Eagleson, Huse, Judy, MacMinn, Stanton.

En 7. An Introduction to English Literature. 3 units (3-0).‡

A study of Shakespeare, Swift and Browning as major literary figures.

Instructors: Judy, Stanton.

En 8. Contemporary English and European Literature. 3 units (3-0).‡

Prerequisite: En 7.

A continuation of the survey of English literature to cover the period from 1890 to the present, with some extension into Continental literature.

Instructors: Eagleson, Judy.

En 9. Contemporary American Literature. 3 units (3-0).‡

Prerequisite: En 7.

A survey of the literature of the United States during the past half-century, with emphasis upon the chief writers of the present time. Special attention is

*On leave of absence.
†On leave until November 1, 1944.

given to the reflection of national characteristics in the novel, the short story, drama, and poetry.

Instructor: MacMinn.

En 10. Modern Drama. 3 units (3-0).‡

Prerequisite: En 7.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production.

Instructors: Huse, Stanton.

En 11. Literature of the Bible. 3 units (3-0).‡

Prerequisite: En 7.

A study of the Old and New Testaments, exclusively from the point of view **of literary interest. Special attention is given to the history of the English Bible.** Opportunity is offered for reading modern literature based on Biblical subjects.

Instructor: MacMinn.

En 12ab. Debating. 1 unit (1-0).‡

Elective, with the approval of the Registration Committee. Study of the principles of argumentation; systematic practice in debating; preparation for intercollegiate debates.

Instructor: Marshall.

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 subjects in English and History, or independently of any subject, but under the direction of members of the department.

En 14. Special Composition. 1 unit (1-0).

This subject may be prescribed for any student whose work in composition, general or technical, is unsatisfactory.

En 15abc. Journalism. 1 unit (1-0).

Elective, with the approval of the Registration Committee.

A study of the principles and practice of newspaper writing, editing, and publishing, especially as applied to student publications at the Institute.

Not given 1944-1945.

Instructor: MacMinn.

En 16. Spelling. No credit.

This subject may be prescribed for any student whose spelling is unsatisfactory.

En 17. Technical Report Writing. 3 units (3-0).‡

Preparation of reports in engineering and science.

Instructors: MacMinn, Stanton.

En 20. Summer Reading. Maximum, 16 credits.

Credits are allowed to the maximum number of 16 for vacation reading from a selected list of books in various subjects, and written report thereon.

FIFTH-YEAR AND ADVANCED SUBJECTS

En-H 100ab. Seminar in History and English. 3 units (3-0); first and second semesters.

Studies in the historical, economic and literary movements in the 18th and 19th centuries: a background for understanding the modern period.

Instructors: Davies, Gay, Wright.

‡The subjects in English to be offered in any given semester will be scheduled before the close of the preceding semester.

HISTORY AND GOVERNMENT

PROFESSORS: WILLIAM B. MUNRO, J. E. WALLACE STERLING, RAY E. UNTEREINER*
VISITING LECTURER: VLASTIMIL KYBAL†
ASSOCIATES: GODFREY DAVIES, EDWIN F. GAY
ASSISTANT PROFESSOR: HARDIN CRAIG, JR.
INSTRUCTOR: EDWARD O. GUERRANT*

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 1ab. History of European Civilization. 4 units (4-0).

Lectures on and discussions of the civilization of Greece and Rome, of the institutions of the Middle Ages, and of the foundations and development of the modern European State System and social structure and their spread overseas.

Instructors: Craig, Sterling.

H 4. The British Empire. 3 units (3-0).

A study of the expansion of England and of the development of empire which has led to the existing British Commonwealth. Attention will be paid to such topics as: The beginnings of English overseas commerce; England in the Age of Discovery; the growth of the Royal Navy; England's struggle against Spain, the Netherlands and France for commerce and colonies; colonial policy and the organization of the Old Empire (to 1763); the American Revolution, the effect on the Empire of the revolution in industry, transport and communication; the development of the self-governing dominions; the problem of Home Rule for India; the World War and its effect on the Empire; the Empire as a Commonwealth of Nations.

Instructor: Sterling.

H 5. Current History. 1 unit (1-0).

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. 3 units (3-0).

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 l bor 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. 3 units (3-0).

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

*On leave of absence.
†Until June 30, 1944.

outlets for her land empire. Special emphasis will be placed on a study of Russian 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. 1 unit (1-0).
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 11. Latin American History. 3 units (3-0).
The development of both internal and external affairs in Latin America from colonial times to the present.
Instructor: Guerrant.

H 12. The History of Europe Since 1789. 3 units (3-0).
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 competition 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.
Instructor: Sterling.

H 14. Anglo-American Relations 1783-1941. 3 units (3-0).
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.

FIFTH-YEAR AND ADVANCED SUBJECTS

En-H 100ab. Seminar in History and English. 3 units (3-0); first and second semesters.
Studies in the historical, economic and literary movements in the 18th and 19th centuries: a background for understanding the modern period.
Instructors: Wright, Davies, Gay.

H 101. Reading and Research. Units to be arranged with the instructor.

LANGUAGES

PROFESSOR: JOHN R. MACARTHUR

The subjects in modern languages are arranged primarily to meet the needs of science students who find it necessary to read books, treatises, and articles in French, German, and Italian. In the study of these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English.

UNDERGRADUATE SUBJECTS

L 1. Elementary French. 4 units (4-0); second semester.

A subject that will provide the student with a vocabulary and knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency. Students who have had French in the secondary school should not register for this subject without consulting the Professor of Languages.

Texts: *Minimum Essentials of French,* Shelton; selected readings, including *Aventures par la Lecture,* Bovée.

Instructor: Macarthur.

L 32ab. Elementary Scientific German. 4 units (4-0); first and second semesters.

This subject is presented in the same manner as Elementary French. Students who have had German in the secondary school or junior college should not register for this subject without consulting the Professor of Languages.

Texts: *First German Course for Science Students,* Fiedler and Sandbach; *Technical and Scientific German,* Greenfield.

Instructor: Macarthur.

L 35ab. Advanced Scientific German. 4 units (4-0); first and second semesters.

Prerequisite: L 32ab, one year of college German, or two years of high school German.

This is a continuation of L 32ab with special emphasis on the reading of scientific literature.

Text: *Berühmte Forscher und ihre Beiträge,* Sokol and Nye.

Instructor: Macarthur.

L 39. 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. Primarily intended for students who cannot otherwise secure required language work.

L 40. German Literature. 3 units (3-0).

Prerequisites: L 32ab; L 35a.

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.

Not offered in 1944-1945.

Instructor: Macarthur.

PHILOSOPHY, PSYCHOLOGY, AND SOCIOLOGY

PROFESSORS: THEODORE G. SOARES,* GRAHAM A. LAING
VISITING LECTURERS: GILBERT BRIGHOUSE, DONALD P. WILSON
ASSISTANT: DAVID G. SOASH

UNDERGRADUATE SUBJECTS

Pl 1. Introduction to Philosophy. 3 units (3-0).
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.
Instructor: Soares.

Pl 4. Ethics. 3 units (3-0).
The fundamental ethical concepts and theories that have emerged in the process of human thought. The major social problems of modern life.
Instructor: Soares.

Pl 5. Sociology. 3 units (3-0).
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.
Not given 1944-1945.
Instructor: Laing.

PS 1. General Psychology. 2 units (3-0); either semester.
The objective of this subject is to provide an understanding of the general principles of psychology as applied specifically to normal behavior and to leadership.
Text: *Fundamentals of General Psychology,* Dashiell.
Instructors: Brighouse, Eagleson, Soash, Wilson.

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl 100. A Study of Some Aspects of Philosophical, Ethical or Social Development. 3 units; first and second semesters.
Not given: 1944-1945.
Instructor: Soares.

*Emeritus as of November 1, 1944.

PHYSICAL EDUCATION

PHYSICAL DIRECTOR AND MANAGER OF ATHLETICS: HAROLD Z. MUSSELMAN
INSTRUCTOR: PAUL R. ACKERMAN
CONSULTING PHYSICIAN: DR. E. D. KREMERS
PHYSICIAN TO ATHLETES: DR. FLOYD HANES

PE 1, 2, 3, 4. Physical Education. First and second semesters.

All undergraduates are required to participate daily in some form of physical education. This requirement may be satisfied by engaging in organized sports, which include both intercollegiate and intramural athletics, or by attendance at physical education classes.

Representative intercollegiate teams in baseball, basketball, cross country, golf, swimming, tennis, track and water polo are developed and trained by experienced coaches. A strong intramural program in these same sports offers an opportunity for competition to those with less experience. Fair spirited and clean-cut athletic competition is encouraged for its social and physical values, and as a unity of student interest.

Once a semester, each student is given a physical strength and skill test. These tests are used as a basis for determining the proper exercise for individual students and for measuring the benefits obtained therefrom. Corrective or special exercises are prescribed for physically deficient students.

NAVY V-12 SUBJECTS OF INSTRUCTION

(From Navy V-12 Bulletin No. 101.)

Course numbers listed in the curricula on pages 145 to 153, followed by the letter "V" will be found in this section.

A1-V. Analytical Mechanics—Statics. 2 units (2-0); one semester.

Prerequisite: To be accompanied by or preceded by Calculus M5-V, M6-V.

Concept and definition of force, scalar, and vector quantities; combination and resolution of forces, parallelogram law, and triangle law; principle of moment and couples, including forces in space; graphical and analytical condition for equilibrium, force polygon, and string polygon; equilibrium of forces as applied to simple structures and machines, free body sketches, stress diagrams, method of sections, loaded cables; conditions of equilibrium for various force systems; coplanor and noncoplanor; principles of friction applied to wedges, screws, and bearings; centroids and areas, volumes, and masses; hydrostatic pressure and moment of pressure; area and volume theorems (Pappus and Guldinus).

A2-V. Analytical Mechanics—Dynamics. 3 units (3-0); one semester.

Prerequisite: To be accompanied by or preceded by Calculus (M6-V).

Principles of dynamics, motion of a particle, Newton's laws, general equation of motion, rectilinear motion, displacement, velocity, speed, and acceleration motion of a particle acted upon by a constant force, force proportional to displacement, simple harmonic motion, free and forced vibration, resonance, critical speed; inertia forces, work and energy, and relation between work and energy; momentum and impulse; curvilinear motion, velocity, tangential and normal acceleration, trajectories of projectiles and bombs; moment of inertia of masses; rotation, angular displacement, velocity and acceleration, centripetal acceleration, and centrifugal forces; kinetic energy of rotation, torque, and power; balancing of rotating bodies; relative motion; angular momentum and gyroscopic motion; combined translation and rotation.

BA1-V, 2-V. Principles of Economics. 3 units (3-0); two semesters.

Economic principles and economic institutions—their application to concrete problems. During the two semesters the following topics, among others, will be covered: The laws of production and consumption; value, wages, interests, rent, and profits; principles of money, banking, credit, prices, and international trade; problems of population, industry, labor, unemployment, financing, taxation, and economic planning.

These courses may be condensed slightly to provide a five-period course for one semester, or materially condensed to form a two-period course extending through two semesters.

C1a-V, 2a-V. Chemistry. C1a-V, 4 units (3-3), 16 weeks; C2a-V, 2 units (3-3), 8 weeks.

A condensed course extending over one and one-half semesters. The remaining one-half semester will be devoted to Engineering Materials C6-V.

Within the limits of the time available, the course will cover the usual ground of the freshman year. Atomic structure; the periodic system; gas laws; valence. solutions, colloids, atomic weights; hydrogen, oxygen; chlorine; acids, bases, and salts; bromine, iodine, fluorine; nitrogen and its compounds; phosphorus, arsenic. antimony, bismuth; carbon, carbon and hydrogen compounds; the metallic elements; a brief introduction to qualitative analysis.

C6-V. Engineering Materials. 2 units (3-3), 8 weeks, following C2a-V.

A study of the manufacture and properties of ferrous and non-ferrous alloys, cements, clay products, protective coatings, fuels, and water softening.

Laboratory work will illustrate the effects of mechanical workings, heat treating, and welding on the microstructure and physical properties of carbon and alloy constructional and tool steels, proportioning of concrete, and physical characteristics and properties of wood.

CE1-V. Plane Surveying. 3 units (1-6); one semester.

Prerequisite: Mathematics M1-V or M3-V.

Theory and practice of plane surveying. Use and care of instruments, including level, transit, and plane tables; note keeping; methods of measuring distance by tape and stadia; angles and elevation; traverse surveying; leveling, profiles and cross sections; computing areas and volumes; circular curves and vertical curves; general method of land surveying; legal principles.

CE2-V. Geodetic Surveying. 5 units (2-9); one semester.

Prerequisite: Registration in Calculus M6-V.

Triangulation; base lines; measurement of horizontal lines; astronomical observations, properties of the spheroid; calculation of triangulation and geodetic positions; figure of the earth; precise leveling; least squares adjustment of triangulation. Field work will cover triangulation, astronomical observations, and precise leveling.

CE3-V. Strength of Materials. 3 units (3-0); one semester.

Prerequisites: Analytical Mechanics A1-V and Calculus M6-V.

Stress and strain, modulus of elasticity; tension, compression, and shear; thin cylinders, riveted and welded joints; torsion, shafts and helical springs; flexural stresses, bending moment and shear diagrams; slopes and deflections; restrained and continuous beams; columns and column formulas; direct stress and flexure; principal stresses; repeated loads and fatigue; work, resilience, and toughness.

CE4-V. Strength of Materials Laboratory. 3 units (1-6); one semester.

Prerequisite: To accompany or follow Strength of Materials CE3-V.

Theory and operation of testing machines and auxiliary apparatus; preparation of test specimens; standard tests to determine the significant physical properties of wood, steel, cement, aggregates, and concrete; proportioning of concrete.

CE4a-V. Strength of Materials Laboratory. 2 units (1-3); one semester.

Prerequisite: Registration in Strength of Materials CE3-V.

An abridgment of Strength of Materials Laboratory CE4-V.

CE6-V. Fluid Mechanics. 3 units (2-3); one semester.

Prerequisite: Analytical Mechanics A2-V.

Properties of fluids, gas laws, viscosity; static pressures, center of pressure on plane and curved surface; gages and manometers; buoyant force and equilibrium of floating and immersed bodies; dynamics of fluids, Bernoulli's theorem; impulse and momentum, open jets, vanes; flow in pipes, Reynolds' number, hydraulic gradient, divided flow; orifices, nozzles, weirs, and gates; open-channel flow; hydraulic similitude and dimensional analysis.

CE7-V. Structures—Structural Analysis. 5 units (4-3); one semester.

Prerequisite: Registration in Strength of Materials CE3-V.

Analysis of stresses in trusses and other framed structures; shears and moments in simple and continuous girders, frames, and bents. Fixed and moving loads; algebraic and graphic procedures; influence lines; slopes and deflections; moment distribution; space frameworks; Williot diagram and camber.

The laboratory period will be devoted to the solution of problems.

CE8-V. Structures—Theory of Reinforced Concrete. 3 units (3-0); one semester.

Prerequisite: Structures CE7-V.

Historical background; materials, bar sizes, forms, placing; beam and slab theory, rectangular beams; T-beams, beams with compression reinforcing; shear and diagonal tension; bond and anchorage; column theory, columns with lateral ties, columns with spiral reinforcing; direct stress and bending; continuity; code and specification requirements; design of a slab, beam, and girder structure.

CE9-V. Structures—Elementary Structural Design in Steel and Wood. 3 units (1-6); one semester.

Prerequisite: Structures CE7-V.

Fundamental structural units; framing plans; design of tension, compression and flexural members of steel and wood; design of riveted and welded connections for steel; ring and other connections for wood; design of plate girders and simple trusses; general engineering drawings; shop drawings; specifications and bills of material.

CE10-V. Curves and Earthwork. 3 units (2-3); one semester.

Prerequisite: Plane Surveying CE1-V.

Route surveying for railways, highways, canals, etc. Simple, compound, reverse, and parabolic curves; transition spirals; curves super-elevation; setting stakes for earthwork; methods of computing earthwork; mass diagrams.

Laboratory exercises will give the student practice in the laying out of curves, in setting stakes, and in computing.

CE11-V. Structures—Concrete Structures and Foundations. 5 units (3-6); one semester.

Prerequisite: Structures CE8-V.

Design of beam-and-girder and flat-slab building frames including columns; spread, pile and pier foundations; dams, retaining walls and drydocks; construction methods.

The laboratory periods will be devoted to the design of various types of concrete structures.

CE12-V. Structures—Advanced Structural Steel Design. 5 units (3-6); one semester.

Prerequisite: Structures CE9-V.

Types and proportions of bridge and building structures. Design of steel plate-girder, truss, and rigid-frame bridges; design of steel mill and office building frames; riveted and welded construction; crane girders and columns; fabrication and erection procedures; use of alloy steels and non-ferrous alloys.

CE13-V. Sanitary Engineering. 3 units (2-3); one semester.

Prerequisite: Fluid Mechanics CE6-V.

Municipal and rural sanitation. Sanitation of milk and foods; refuse collection and disposal; mosquito, fly, and rodent control; sanitation of swimming pools. Design, construction, and maintenance of storm and sanitary sewer systems. Characteristics of sewage, sewage treatment, and sewage disposal; industrial wastes.

Laboratory periods will include examination and reports on sewage systems, simple design problems, and cost estimates.

CE14-V. Water Supply. 3 units (2-3); one semester.

Prerequisite: Fluid Mechanics CE6-V.

Sources of water supply, quantity available, uses, and rates of demand. Quality, examination, treatment, and purification. Collection, storage, pumping, and distribution systems.

Laboratory periods will include examination and reports on water supply systems, simple design problems, and cost estimates.

CE15-V. Soil Mechanics. 3 units (2-3); one semester.

Prerequisite: Registration in Structures CE11-V.

Origin, formation, development, classification, identification, and characteristics of soils. Soil surveys and sampling; tests of physical properties of soils and their significance; selection of materials, methods of compaction and field control for fills, dams, and subgrades; soil stabilization; consolidation and settlement; bearing capacity tests; pile tests, pile formulas, and their significance; lateral earth pressures; foundation pressures; stability of slopes; frost heaving; construction in swamps, seepage and ground water.

CE16-V. Airport Design. 3 units (2-3); one semester.

Prerequisites: Highway Engineering CE17-V and Soil Mechanics CE15-V.

The factors influencing the location, design, and construction of airports; passenger and express terminal facilities; hangers and accessory structures; field lighting; selection of type of runway, apron, and taxiway. Subgrades; design of base courses; flexible and rigid type pavements; surface and sub-surface drainage.

Laboratory periods will be devoted to design problems.

CE17-V. Highway Engineering. 4 units (3-3); one semester.

Prerequisite: Plane Surveying CE1-V.

Design, construction, and maintenance of highways and city streets. Location, alignment, drainage, width, and capacity; soils and soil stabilization; earth, gravel, and macadam roads; city and rural pavements; grade separations; minor structures; construction in swamps; construction methods and equipment; traffic control; planning surveys, economics, financing, and administration.

Laboratory periods will be devoted to testing of highway materials.

EE1-V. Electricity and Magnetism. 3 units (2-3); one semester.

Prerequisites: Physics PH2-V and to be accompanied by Calculus M5-V.

The experimental bases of electricity and magnetism; elementary electrostatics and magnetostatics; direct-current circuits—voltage, current, power, energy-induced electromotive forces; capacitance and inductance of parallel-plate condenser and toroid; elementary theory of alternating currents; elementary problems in ferromagnetism.

EE3-V, 4-V. Electric and Magnetic Circuits. 5 units (3-6); two semesters.

Prerequisite: Electricity and Magnetism EE1-V.

Kirchhoff's laws; direct-current networks; transients; sinusoidal currents and voltages; complex-number representation of alternating-current quantities; alternating-current networks; transmission lines and filters; polyphase circuits; electric and magnetic fields; ferromagnetism; eddy currents; hysteresis, Fourier series.

EE5-V, 6-V. Electron Tubes and Circuits. 2 units (1-3), first semester; 4 units (3-3), second semester.

Prerequisites: To be taken with or preceded by electrical courses of Third Year.

Electronic emission, cathodes, diodes, static and dynamic characteristics and rectification; rectifiers, power supplies and smoothing circuits; triodes, tetrodes, pentodes—static and dynamic characteristics; amplifiers; oscillators; typical circuits; phototubes; glow and arc-discharge tubes and thyratrons, characteristics, current, and voltage capacities; grid control action, circuits with direct current and alternating current.

EE5a-V, 6a-V. Electron Tubes and Circuits. 2 units (1-3); two semesters.

Prerequisites: Electrical courses of Third Year.

This course is an abridgment of Electron Tubes and Circuits EE5-V, EE6-V.

EE5b-V, 6b-V. Electron Tubes and Circuits. 2 units (1-3), first semester; 3 units (2-3), second semester.

Prerequisite: Electricity and Magnetism EE1-V.

Electron Tubes and Circuits EE5-V, EE6-V in a condensed form.

EE7-V, 8-V. High-Frequency Circuits. 2 units (2-0); two semesters.

Prerequisites: Electrical courses of third year.

Resonance and four-terminal network theory, power rectification, amplification, oscillators; cathode-ray tubes and circuits; modulation, demodulation; receivers; transmitters; high-frequency generators; transmission lines; radiation and propagation, wave guides.

EE9-V. Electrical Measurements. 1 unit (0-3); one semester.

Prerequisites: To be accompanied by Third Year electrical courses.

Electric and magnetic units and standards; direct-current and low-frequency measurements; theory, calibration, and use of laboratory standards, and of potentiometers, galvanometers, watt meters, watt-hour meters, current transformers, potential transformers, and portable direct-current and alternating-current instruments; magnetic flux density measurements and core loss in iron. Use of oscillographs. Measurements for resistance, reactance, capacitance, impedance, voltage, current, and power factor; audio-frequency measurements.

EE10-V. Electrical Engineering—Direct-Current Apparatus and Circuits. 4 units (3-3); one semester.

Prerequisites: Physics PH2-V and Calculus M6-V.

Direct-current circuit and magnetic circuit theory and calculations; principles of design and construction of direct-current generators and motors; theory concerning torque, flux, speed, voltage, and speed regulation, commutation, and armature reaction of shunt and compound machines; parallel operation, and mechanical coupling of electrical machinery; theory and practice of direct-current control equipment for generators and motors.

EE11-V. Electrical Engineering—Alternating-Current Apparatus and Circuits. 4 units (3-3); one semester.

Prerequisite: Electrical Engineering EE10-V.

Relations of simple harmonic electromotive forces and current, phase differences; active, reactive, and apparent power, power factor and reactive factor, resistance, inductance, and capacitance; series, parallel, series-parallel, and resonant circuits; polyphased circuits, balanced and unbalanced. The construction, characteristics, and operation of alternators, induction motors, transformers, synchronous motors, synchronous converters, mercury-arc rectifiers and their regulating and control devices. Brief review of lighting equipment and illumination design. Principles of the synchronous machine; the induction machine, the synchronous converter, and types of single-phased motors.

EE12-V. Direct-Current Machinery and Storage Batteries. 5 units (3-6); one semester.

Prerequisite: Electricity and Magnetism EE1-V.

A study of direct-current motors, generators, motor-generator sets, and storage batteries, including their construction, operation, characteristics, and applications. Emphasis is placed on the theories of armature reaction, commutation, voltage, regulation, and speed control of shunt and compound-wound machines. The theory and operation of starting, control, and regulating devices are covered.

EE12a-V. Direct-Current Machinery and Storage Batteries. 3 units (2-3); one semester.

Prerequisite: Electricity and Magnetism EE1-V.

A condensed form of Direct-Current Machinery and Storage Batteries EE12-V.

EE13-V. Alternating-Current Machinery. 5 units (4-3); one semester.

Prerequisites: Electrical courses of Third Year.

Principles and advanced theory of alternators, transformers, induction motors (polyphase and single-phase), synchronous motors, synchronous converters and mercury-arc rectifiers, and their starting, control, and regulating auxiliaries.

EE13a-V. Alternating-Current Machinery. 4 units (3-3); one semester.
Prerequisites: Electrical courses of Third Year.
Essentially the same material is covered in this course as in Alternating-Current Machinery EE13-V with the omission of the advanced theory.

EE14-V. Electrical Design. 3 units (1-6); one semester.
Prerequisites: Electrical courses of third year.
Field mapping, simple two-dimensional cases; electro-magnetic devices; tractive magnet; series-lockout magnet; direct-current motors, magnetism curves, armature reaction, commutation, interpoles, design of field coils; direct-current motor redesign, rewinding of field coils, rewinding of field and armature for different voltages and speeds. Principles of design of transformers and armatures of alternators and other synchronous machinery are covered briefly. Design factors influencing losses and heat dissipation are studied. Instruction is given in analysis of faults and in emergency repair work.

EE14a-V. Electrical Design. 2 units (1-3); one semester.
Prerequisites: Electrical courses of third year.
This is a condensation of Electrical Design EE14-V.

EE15-V. Electrical Engineering Laboratory. 3 units (2-3); one semester.
Prerequisites: Electrical courses of third year.
Direct-current motors; characteristics and application, manual and automatic control equipment, electrical and mechanical braking, construction and characteristics of control devices. Induction motors, single-phase motor types, characteristics and control. Power factor control for industrial loads; use of fly wheels, hydraulic motor application, hydraulic pumps; drive for machine tools, electric elevators, ventilating fans.
The laboratory periods will be devoted to further tests on synchronous generators, synchronous motors, synchronous converters, induction motors, and single-phase induction motors.

GE1-V. Economics of Engineering. 2 units (2-0); one semester.
Prerequisite: Fourth Year standing.
The relative economy of engineering alternatives; engineering ethics and practice; compound interest and the calculation of annual cost, present worth, and prospective rates of return; elements of construction costs; estimating quantities.

GE2-V. Economics of Engineering. 2 units (2-0); one semester.
Prerequisite: Economics of Engineering GE1-V.
Engineering valuations and appraisals; valuation and value; mortality studies for physical property; depreciation; methods of estimating depreciation; rate structures; taxation; intangible values, preliminary expense, going value, good will value, fair value.

GE3-V. Industrial Organization. 3 units (3-0); one semester.
Prerequisite: Third Year standing.
The historical background of industry; the Industrial Revolution; inventions and their effect on the social system; development of industrial enterprises in the United States; management and organization; plant lay-out; control of budgets; operations; costs; methods and personnel; time and motion study; purchasing; cost finding; wages, labor relations.

GE4-V. Technical Reports. Two lecture-recitation periods per week. 2 units (2-0); one semester.
Prerequisites: Third Year standing.
The assembling of facts and data; the outline; functions of the introduction; sectional headings; paragraphs; final section; conclusions; recommendations; appendices, supporting data, related material; the abstract or résumé; the rough draft, cor-

rections of statements for exactness, completeness, brevity, English; format, typing details, figures, pictures, drawings, tables; practical exercises will include the writing of one or more complete reports.

GE5-V. Contracts and Specifications. 2 units (2-0); one semester.
Prerequisite: Fourth Year standing.
Contract essentials; the discharge of contracts; torts' agency, real property; negotiable instruments; the engineer as an expert witness; employment compensation and accident insurance; contract documents; advertisement, information for bidders, proposals, contract form, specifications, bonds; engineering ethics and practice. Studies will be made of engineering specifications and practice given in writing such specifications.

H1-2-V. Historical Background of Present World War. 2 units (2-0); two semesters.
The major purposes of this course are to provide an understanding of (1) the complexity of our present-day civilization and of the inter-relationships of various aspects of society, such as agricultural, industrial, political; (2) the way in which the nation developed and the factors that contributed to its development; (3) the extent to which we have our roots in foreign soil; and (4) the more immediate background of the present war.
The sources of colonial American population; the founding of American institutions; the effect of our European background on the formation of these institutions; causes and results of the Revolution; creation of the Federal Republic; American democracy and the frontier; post-Revolutionary conditions, national and international; growth of internationalism; development of American ideas of government as reflected in the national government; expansion toward the West; issues leading to the War Between the States; military and naval aspects of the War Between the States; the growth of the nation, disappearance of the frontier; development of railroads; expanding economy and national markets; growth of industrialism, the effects of industrialism on the farmer and on politics; the Spanish-American War; the U. S. as a world power. The new Navy; the U. S. and power politics in Pan-America and abroad; American participation in World War I; the significance of World War I in American diplomatic and military policy; Peace of Paris; the return to "normalcy"; Bolshevism, Fascism, Nazi-ism; crash of 1929; its effect in America and in the world at large; the growing threat to America in the Atlantic and in the Pacific; European policies of appeasement bring first steps in a defense program for America; the outbreak of war in Europe; war and America's awakening; will victory bring peace? Planning for a post-war world.

M5-V. Calculus. 5 units (5-0); one semester.
Prerequisite: First Year Mathematics.
Functions; limits and limit theorems (without proof); the derivative and its interpretations; derivatives of algebraic functions; maxima and minima; rates; derivatives of transcendental functions; applications, including Newton's methods of approximation and tangents and normals; derivatives of higher order; the differential with applications; definite integral with applications such as length, area, surfaces and volume, moments, centroids, moments of inertia; improper integrals.
An early introduction of the integral calculus into Calculus M5-V is desired for certain curricula so that Analytical Mechanics A1-V may be taught from that background. In such cases, Calculus M5-V will be given five periods per week and some of the material in Calculus M6-V will be advanced to Calculus M5-V.

M6-V. Calculus. 4 units (4-0); one semester. In Curricula 452, 455, 456, and 459, this course will be given in six lecture-recitation periods per week for eight weeks, and will be immediately followed by Calculus—Differential Equations M7-V, meeting a like number of times per week for the last eight weeks of the term.
Prerequisite: Calculus M5-V.
Applications of the definite integral such as work and attraction curvature, curve tracing; indeterminate forms; series of constant terms; power series with

Taylor's and Maclaurin's theorems with remainder term and applications in integration; partial differentiation with applications; multiple integrals with applications.

In cases where the Calculus is divided into five-period and three-period courses, some of the material in Calculus M6-V, 7-V will be advanced to Calculus M5-V.

M7-V. Calculus—Differential Equations. 2 units (2-0); one semester. In Curricula 452, 455, 456, and 459, this course will be given in six lecture-recitation periods per week for eight weeks immediately following Calculus M6-V.

This course will cover ordinary equations of the first order and simple ordinary equations of the second order; singular solutions; linear equations with constant coefficients and applications to the Physical Sciences, with practice in setting up and solving the differential equations; approximate methods; systems of differential equations; an introduction to partial differential equations.

ME1-V. Kinematics. 2 units (1-3); one semester.

Prerequisites: Physics Ph2-V and Analytical Mechanics A2-V.

An analytical and graphical study of the displacements, velocities, and accelerations involved in cams, gears, and the commonly used linkages, presented from the point of view of the function performed by such machine elements.

ME3-V. Heat Power. 5 units (3-6); one semester.

Prerequisites: Physics Ph2-V and Analytical Mechanics A2-V.

The objective of the course is to teach the use of thermodynamic principles by analyzing reciprocating and centrifugal gas compressor cycles, internal-combustion-engine cycles, steam engines, gas and vapor nozzles, steam and gas turbines; steam generators and condensers, refrigeration cycles and air-conditioning problems.

The laboratory work, which includes tests and reports on the characteristics and performance of compressors, engines, nozzles, turbines, etc., is correlated as closely as possible with the classroom work.

ME3a-V. Heat Power. 3 units (2-3); one semester.

Prerequisites: Physics Ph2-V and Analytical Mechanics A2-V.

This course has the same objective at Heat Power ME3-V, to teach the application of thermodynamic principles. The reduction in time available is met by a choice of the subject matter studied and not by resorting to a less rigorous approach.

ME4-V. Thermodynamics. 5 units (5-0); one semester.

Prerequisites: Physics Ph2-V and Analytical Mechanics A2-V.

The fundamental concepts and principles involved in the release, transfer, and conversion of thermal energy. Energy concepts and units; principle of conversion of energy; properties of gases, vapors, and mixtures. Combustion reactions; heat release; principles of heat transfer. Compression and expansion of gases and vapors; second law of thermodynamics; steady flow of fluids; the use of steam and gas tables.

ME4a-V. Thermodynamics. 3 units (3-0); one semester.

Prerequisites: Physics Ph2-V and Analytical Mechanics A2-V.

A condensation of Thermodynamics ME4-V. The objective is the same as that of the longer course, but the number and nature of the assignments and problems are adjusted to the reduced time.

ME7-V. Machine Design. 3 units (2-3); one semester.

Prerequisites: Analytical Mechanics A2-V, and to be accompanied by Strength of Materials CE3-V.

This course introduces the transmission of power by gears, belting, and shafting; the proportioning for strength of fastenings, couplings, shafts, and frames; the design of gears for strength and wear; the specification of fits and tolerances; principles of lubrication and bearing design.

ME8-V. Mechanics of Machinery. 3 units (2-3); one semester.

Prerequisites: Kinematics ME1-V and Analytical Mechanics A2-V.

A study of forces in reciprocating engines and compressors, and methods of

balancing them; the construction of crank-effort diagrams and their analysis for flywheel requirements; principles of governors; gyroscopic forces; prediction of critical speeds; methods of vibration damping; and the effects of shock loading.

ME9-V. Mechanical Processes. 3 units (2-3); one semester.

Prerequisite: Third Year standing.

A study of the methods of casting, forming, welding, machining, and heat-treating metals; factors involved in the selection and use of machine tools, the use of automatic machines; the use of jigs and fixtures; inspection and control methods.

ME10-V. Naval Machinery. (Condensed.) 2 units (1-3); one semester.

This course is intended as a survey type of course to orient the student with naval machinery installations. It is to integrate closely with the course in Heat Power. The course in Naval Machinery should include description of Navy-type boilers, boiler feed systems, thrust bearings, reduction gears, lubricating systems and associated equipment. The course should integrate the student's knowledge of the individual elements of a power plant into a coherent picture of a naval machinery installation.

The laboratory work should stress operation, maintenance, and trouble shooting, and should not include research type testing. NAVAL MACHINERY, U. S. Naval Academy, 1941, Parts I, II, and IV, is suggested for reference material and may be used as a text if desired.

ME11-V. Heat Power—Internal-Combustion Engines. 5 units (3-6); one semester.

Prerequisites: Heat Power ME3-V and Thermodynamics ME4-V.

This course covers the principles of operation of spark and compression ignition, internal-combustion engines and their auxiliaries; the properties of petroleum fuels, combustion processes and combustion control, detonation, and octane rating; engine cooling, rating, and performance. Consideration is given to the supercharging of aircraft and diesel engines and to practical gas-turbine cycles.

The laboratory work, which is concerned with the testing of petroleum fuels and combustion engines, gives especial attention to valve injection, and spark timing; engine operation, lubrication, cooling, and maintenance; and to standard test procedures and methods of instrumentation.

ME12-V. Heat Power—Steam Power. 5 units (3-6); one semester.

Beginning with a review of the thermodynamics of vapors and steam table calculations, this course covers power plant cycles and heat balance, followed by a study of combustion and combustion control equipment, boilers, condensers, evaporators, turbines, feed-water equipment, and economizers, together with refrigerating and air-conditioning machinery.

The laboratory work is designed to develop familiarity with the characteristics and performance of the available power plant equipment and the overall relationships between the various units of a steam plant.

ME13-V. Refrigeration. 3 units (2-3); one semester.

Prerequisites: Heat Power ME3-V and Thermodynamics ME4-V.

This course deals with the theory of mechanical refrigeration; the absorption cycle; the principle of low temperature or deep refrigeration, and the liquefaction of gases; properties of refrigerants; refrigeration and cold storage equipment; air-conditioning applications of refrigeration.

The laboratory time is used for the testing of refrigeration and air-conditioning equipment, and allied heat transfer experiments.

ME14-V. Aerodynamics. 3 units (3-0); one semester.

Prerequisites: Fluid Mechanics CE6-V and Heat Power ME3-V.

Properties of air, air flow, air foils, parasite drags; engine and propeller characteristics; stability and control; model testing.

N1-V. Naval Organization. 1 unit (1-0); one semester.

Navy Customs and Courtesy: saluting, general courtesies; ceremonial courtesies; Navy Law, courts martial; charges and evidence; jurisdiction of Naval courts;

instructions after trial; courts of inquiry and boards of investigation; mock trials. Naval Intelligence: organization and function; intelligence ashore and afloat. Naval Communications; written communications; communication security.

N2-V. Naval Organization. 1 unit (1-0); one semester.

Navy Organization: the Naval Reserve; naval personnel officers; warrant officers; petty officers; ratings; classification procedures; Navy Organization ashore; training stations and schools; the civilian administrators; the officer administrators; the Bureaus; Navy Organization afloat; the fleets: fleet subdivisions; the naval ship, types of ships, armament; functions.

ME15-V. Mechanical Design. 3 units (2-3); one semester.

Prerequisites: Machine Design ME7-V and Strength of Materials CE3-V.

The objective of this course is to present methods of stress analysis for rotating discs and wheels; the solution of stresses and deformations in indeterminant machine parts; the analysis of combined stresses and deformations; concentration; plastic deformation and the use of photoelastic and allied methods of stress prediction.

ME16-V. Mechanical Design. 3 units (2-3); one semester.

Prerequisite: Mechanical Design ME15-V.

The purpose of this course is to focus the previously acquired design experience on the creative problem of developing machine parts to perform specified functions; the checking of all parts for stress, wear, vibration, etc.; the problem of proportioning parts that depend upon design judgment; the choice of materials to be used; and the proper consideration of the manufacturing processes involved.

ME17-V. Metallurgy. 3 units (2-3); one semester.

Prerequisite: Fourth Year Standing.

Brief treatment of the ores of iron, copper, lead, zinc, manganese, molybdenum, chromium, aluminum, magnesium, and of the smelting or reduction of ores to metals; alloys; metallic compounds; binary alloys; freezing-point (and structure), diagrams, eutectics, solid-solutions; brasses; bronzes; dural; physical properties, strength, elastic limit, Young's modulus, hardness, ductility, heat and electric conductivity, magnetic permeability and retentivity; stress-strain, tension, compression, shear, torsion, fatigue, dilation; physical property changes due to mechanical working, heat treatment. Weldability, and changes due to welding; iron and steel, iron carbon diagram; Ac and Ar; ferrite, etc., alloy steels.

N3-V. Naval History and Elementary Strategy. 3 units (3-0); one semester.

Sea power beginning; early Mediterranean sea power, Roman sea power; the Navy in the Revolution; the Napoleonic Wars, the War of 1812; the Navy in the War Between the States, and the following years of peace; War with Spain; naval actions of World War I, naval power since 1919, sea power in modern war; what constitutes sea power; command of the sea; land-sea operations; bases; air power and ships; tactics of fleet action.

PS1-V. Psychology—General. 3 units (3-0); one semester.

The major objective of this course is to provide an understanding of normal behavior and of leadership.

During the year the topics listed below, among others, will be covered: individual differences in behavior areas—general ability, special aptitudes, differential achievement, interest and personality characteristics; bases for individual differences; operational methods in psychology—adjustment factors; measurement and analysis of public opinion and group morale factors; psychological aspects of command, supervision and administration—training and learning, emotion, rewards and incentives, interviewing for purposes of individual morale, leadership skills.

The recitations will aim to give students exercise in applying psychological principles to realistic problems of human relations.

The above course description covers the ground to be included in the two-period course extending over two semesters for pre-medical and pre-dental students. It is expected that the topics noted will be expanded for these students.

DEGREES AND CERTIFICATES CONFERRED, FEBRUARY 18, 1944

Doctor of Philosophy

Richard Byrd Escue, Jr. (*Chemistry*), B.A. and M.A., North Texas Teachers College
David Roy Vincent Golding (*Chemistry*), A.B., Harvard College
Ning Hu (*Physics*), B.S., National Tsing Hua University
Geoffrey Lorrimer Keighley (*Biology*), B.A., University of Toronto; M.A., California Institute
Chia Chiao Lin (*Aeronautics*), B.S., National Tsing Hua University; M.A., University of Toronto
Don Stanley Martin, Jr. (*Chemistry*), B.S., Purdue University
Robert Charles McMaster (*Electrical Engineering*), B.S., Carnegie Institute of Technology; M.S., California Institute
Herbert Sargent (*Chemistry*), B.S., California Institute
A. Mordecai Zarem (*Electrical Engineering*), B.S., Armour Institute of Technology; M.S., California Institute

Master of Science in Science

BIOLOGY

Keith S. Ditman, B.S., Santa Barbara State College

CHEMISTRY

Allan Louis Grossberg, B.S., California Institute

CHEMICAL ENGINEERING

Daniel Funderburg Botkin, B.S., New Mexico College of Agriculture and Mechanics Arts

GEOLOGICAL SCIENCES

Walter Ross Fillippone, B.A., Marietta College
Enrique Silgado-Ferro, Bachiller en Ciencias Matemáticas, Universidad Nacional Mayor de San Marcos (Peru)
Sulhi Yüngül, B.S., Montana School of Mines

PHYSICS

Alan H. Andrew, B.S., University of Nebraska
Eugene Willis Peterson, B.S., Purdue University

Master of Science in Engineering

AERONAUTICS

Halit Sunalp, M.S., University of Michigan

CIVIL ENGINEERING

Thomas Grey Curtis, B.S., California Institute
John Martin French, B.S., California Institute

ELECTRICAL ENGINEERING

Nicholas Anthony Begovich, B.S., California Institute
Paul Julius Labanauskas, Royal Italian Naval Academy; Postgraduate School for Torpedo and Elect. Officers, French Navy

Bachelor of Science in Science

Cran Hardin Barrow
Grant Lee Benson, Jr.
Arthur Naeole Carson
Howard How Chung Chang
Charles Shipley Cox
Clifford Ingebritson Cummings
Stanley Schemmer Day
Willard Almur Dodge, Jr.
Frederick Bertram Ely
Thomas Lewis Gilbert*
Forrest Richard Gilmore*
Leon Green, Jr.
Jay Edwin Hammel
Garman Harbottle
Donald A. Keating
Alfred George Knudson, Jr.*
Robert Wayland Lester
Joseph Stewart Martin
Carl Ogden Mattinson
Francis E. Odell†
William Wilkes Olenbush
Louis Shreve Osborne*
Bruno Harrison Pilorz
James McTague Ploeser
Maurice Rattray, Jr.
John Robert Rempel*
Wesley Robert Sandell
Raymond Alfred Saplis
Alois Wolfgang Schardt*
Willard Richard Scott, Jr.
Cornelius Steelink
Robert G. Thomas
Charles Alexander Trilling
William Malley Trimble
James Tuedio

Bachelor of Science in Engineering

Robert Emerson Allingham
Charles Gilbert Almquist, Jr.
Frank Anthony Alonso
Warren Amster
Tway Walter Andrews*†
William Perkins Bair†
Frank Arthur Barnes*
Barton Brewster Beek
Frederick Albert Behrens, Jr.
Ertugrul Birlik
William Howard Bond
Franklin Otis Booth, Jr.
Jay Rolden Borden*
Joseph Raymond Bruman
Ross Alton Buchanan
Willis Arthur Bussard
Herbert John Cabral
Dean Roden Chapman
Harold Victor Curci
Kenneth Ross DeRemer*
Hale Chapin Field
Alvin Martin Galbreath
Richard Hall Gilman, III
Edward Adolph Goldsmith
Elmer Scott Hall
William Pickering Harland
Winfield Henry Hughes
David Roux Jones
Franklin Henry Knemeyer
Warren Kott
Frank Welborn Lehan*
John Warren Marshall
Ralph Waldo Marshall, Jr.
Robert Kidd Mitchell*
Anthony John Andrew Morgan
Frederick William Morris, Jr.
John Byrd Nelson*
Wheeler James North
Hans Nuetzel
Owen Spencer Olds
Carl Warren Olson
Robert Joseph Parks*
Herman Proctor, Jr.
Rolf W. Protzen†
David Frederick Rutland
LeRoy Sanders, Jr.
Arthur Warren Schnacke
Richard Warren Seed
George Shor, Jr.*
Harrison William Sigworth*
Frank Chesley Smith, Jr.†
Richard Joseph Soike
Albert Tenney Spaulding, Jr.
Süreyya Rafet Tanyildiz
Leon Trilling
John Charles Warren
Doyle Ernest Wilcox*
John Hart Wilson
Paul Hugo Winter
Paul Lewis Wolf
Gregory Odd Young

*Graduated with honor in accordance with a vote of the Faculty.
†Awarded Honor Key by the Associated Student Body for participation in student activities.

Senior Certificates

(In recognition of the satisfactory completion of the minimum requirements of the Navy V-12 Engineering Specialist Program)

SCIENCE

George Meade Holstein, III

ENGINEERING

Milo Sedgwick Gates
Clement Richard Huntsberger
Jeremy Jerome Lamb
Willard Wallace Smith
George Woodbury Stimson
Dean Putnam Stone
Hubert W. Witter
Harry John Witz

DEGREES AND CERTIFICATES CONFERRED, JUNE 3, 1944

Master of Science in Engineering

METEOROLOGY

Ellery Frost Bassler, B.E., Wisconsin Central State Teachers College; M.A., Northwestern University
Elvis Erdley Beauchamp, B.S., Missouri State Teachers College
William Emmett Bell, B.S., Virginia Polytechnic Institute
Donald Grant Benjamin, B.A., William Jewell College
George Griffin Bennett, B.S., Clemson College
Lloyd William Brooks, B.A., Trinity College
Joseph Eugene Burch, B.S., Salem College
William Gibson Burke, B.S., University of Michigan
Charles Moran Cooke, B.A., Central Washington College of Education
Guy Brooks Copeland, B.S., Tennessee Polytechnic Institute
Warren Lloyd Cowden, B.Ae., University of Minnesota
Neil Stuart Estrada, B.S. and M.A., University of California
Clarence Henry Grasso, B.S., St. Mary's University
Martin Luther Hahs, B.S., Southeast Missouri State Teachers College
Arthur Satterly Hall, A.B., Cornell University
Robert Gordon Hallwachs, B.A., North Central College; M.A., University of Illinois; M.A. and Ph.D., Princeton University
Charles Philip Harrison, B.S., Central Michigan College of Education
Robert Allan Hill, Jr., B.S., Texas Technological College
Lawrence Edwin Hughes, B.S., Harvard College
Lewis Benjamin Johnson, Jr., B.S., University of Virginia
William Martin Johnson, B.S., North Dakota Agricultural College; M.S., University of Wisconsin
Jack Charles Kern, Jr., B.S., University of Texas
Lester Orin Leenerts, A.B., Carthage College
Philip F. Low, B.S., Brigham Young University
Kenneth Leon McBreen, B.S., University of Washington
John Truman McQuate, B.S., Heidelberg College
Keith Warren Miller, B.A., University of South Dakota
Warner Everett Mills, Jr., A.B., Dartmouth College
Frank Hathaway Moore, Jr., A.B., University of Denver
Donald Blaine Murphy, B.S., University of Washington
Dean Allen Naldrett, B.S., Central Michigan College of Education
Clifford William Oliver, Jr., B. Bus. Ad., University of Cincinnati
Merrill Edward Onstad, B.S., University of Santa Clara
Robert Preston Phipps, B.S., Northwest Missouri State Teachers College
Jim Mack Ridlehuber, B.S., Texas A. and M. College
Charles Robert Rikel, B.A., Amherst College
Adam Anthony Rula, B.S., Pennsylvania State College
Donald Alden Schei, B.Ae.E., University of Minnesota
Mayo Glenwood Shults, A.B. and M.S., Fort Hays, Kansas, State College
Richard Joseph Sieger, B.E., University of Southern California
Harry Wright Stanford, B.S., North Texas State Teachers College
Roberto Stein-Liebes, Facultad de Ingenieria de Guatemala
Richard Burl Sullivan, Jr., B.S., Centenary College
Wayne Carroll Timm, B.A., Upper Iowa University

Edgar Twellman Wein, B.S., Northeast Missouri State Teachers College
D. Rogor Wight, A.B., Olivet College
John Joseph Writt, B.S. and B.A., Kansas State Teachers College of Emporia
Joseph Milo Wuslich, B.S., Davis and Elkins College
Lewis Wilbur Yoho, B.S., Indiana State Teachers College

CERTIFICATES IN METEOROLOGY

John Robert Abbott
Harry Douglas Almy
George Ross Anderson
John Ernest Anderson
Nathan Lorraine Anderson
Percy Jennings Anderson, Jr.
David Robert Appel
Homer Day Austin
Norman H. Barker
John Lee Bauman, Jr.
Donald James Beck
Herbert Robertson Belcher
John William Bell
Arndt B. Bergh
Robert Allyn Best
Charles Frank Bissett
William Robert Blake
Edward Basil Booth
Edward Daniel Bourdet
Mark Edward Bowen
Charles Cox Boydstun
Ralph Clinton Brown, Jr.
Harry Paul Brueggemann
Frank Edward Buck
Philip Edward Burton
Charles Clinton Cage, Jr.
Jack Darwin Callahan
Salvador Joseph Campagna
Sullivan Graham Campbell
Paul Edward Campion
Ralph Stephen Carrigan
Mateo Rio Casaverde
Henry Roy Chope, Jr.
Roger Whitney Coble
Marvin Stanley Cohen
Russell Cravener Collmer
Ernest Richard Cram
William Donham Crawford
Louis Max Culp
James Owen Curtis
Roy Donald Denney
Herbert Clay Dessauer
Howard Franklin Devaney
Charles Albert Deveny, Jr.
Edgar Harrison Dewell
Robert Adolph Dittmar
Ernest David Dorchester
Frank Todd Edwards, Jr.
Rex Theodore Elliott
Keith Stanton Ellis
John Harry Fagan
Cecil Coleman Fisher
Luther Fitzgerald Fisher
William Roderick Foster
Elmer Joseph Fox
James Baxter Garrison, Jr.
Lewis Octave Grant
Thomas B. Gray, Jr.
James William Green
George Mack Grissom
Mario Alves Guimaraes
Ralph David Halbower
Marvin Eugene Harrison
Riddell Lee Hawk
John Allen Hightower
Charles Otto Jenista, Jr.
Howard Earl Johnson
Lloy Dale Johnson
Malcolm Brice Johnstone
Irwin Isaac Katz
Neil Baker Kendrick
William Charles Kincannon
Richard Leroy Kinney
Alvin Henry Landry
Theodore Eugene Landry, Jr.
Philip Herbert Leiderman, Jr.
Charles Neel Lemon, Jr.
Robert Nelson Lewis
Ralph Fredrick Long
Adrian Carl Lunday
Domenick Anthony Luppino
Norman Scott MacDonald
John Harrison Madden, Jr.
Henry David Magnin
Robert Auten Maier
Robert Paul Martin
Paul Meadows
William Ludwig Meier, Jr.
Anthony Louis Merlo
Fred Edward Moore
William James Moore
William Burt Moreland
Charles Thomas Munger
Lewis William Myers
Edgar Thomas Nagle, Jr
Erwin Ward Nommensen
Fred Earl Norris, Jr.
Donald Emmett Ogden
Edward Dionysius Oliver, Jr.
Horace Curtis Paist
Byron Blake Phillips
Robert Polansky

Vernon Price
Merlin Ariel Purcell
Peter Quon
Joseph Edward Reynolds, Jr.
John Clifford Riley
Evan Elijah Roberts, Jr.
Edward Ray Robertson
Burton White Robinson
Frederic Wayne Rugh
Donald Arthur Sandison
Edward Chase Saunders
Thomas Sterling Schalk
Ceestes Billy Sharp
Frederick Jack Sheller
Thomas Lee Shelly
Willis Edwin Simms
Wilfred Aubrey Skinner
James Emmet Smith
Wayne Averill Smith
John Leon Sorenson
Robert Paul Stemler
Dale Jess Stephens
Lawrence Grant Stevenson
David Samuel Stoller
Donald Marvin Stonebraker
David Alloway Strange
Frank Stearns Tait
John Curtis Thompson
George Gibson Van Slyke
Mathis Theron Waddell
John Charles Fremont Walker, III
William Lowry Wallace
James Knerr Weil
Elton Ray Weygandt, Jr.
Henry Orson Wheeler, Jr.
Bruce Johnson Whitaker
Joe Keith Williams
John Gibson Willis
Wayne Jackson Wills
Winston Harold Wingerd
William Theodore Wolf
Marion Chase Woods
Richard Bane Zacha

DEGREES AND CERTIFICATES CONFERRED, JUNE 30, 1944

Doctor of Philosophy

Charles Thompson Boehnlein (*Aeronautics*), B.S. and M.E., University of Minnesota
Gifford Ewing McCasland (*Chemistry*), B.A., University of California at Los Angeles; M.A., Columbia University

AERONAUTICAL ENGINEER

John Joseph Baranowski, B.S., United States Naval Academy
Lester Smith Chambers, B.S., United States Naval Academy
Frank Greene Denison, Jr., S.B., Massachusetts Institute of Technology; M.S., California Institute
Howard Henry Dixon, B.S., The University of Manitoba
Raymond Englebert Doll, B.S., United States Naval Academy
William Clapper Dunn, Post Graduate School, United States Naval Academy
Albert Braly Furer, B.S., United States Naval Academy
DeWitt Allen Harrell, B.S., United States Naval Academy
William Gauss Jackson, Jr., B.S., United States Naval Academy
Statton Ray Ours, Jr., B.S., United States Naval Academy
Dayton Albert Seiler, B.S., United States Naval Academy

Master of Science in Science

GEOLOGY

Ahmed Cebeci, B. Eng., McGill University

PHYSICS

Robert Benjamin Leighton, B.S., California Institute

Master of Science in Engineering

AERONAUTICS

John Joseph Baranowski, B.S., United States Naval Academy
Howard Pennington Barfield, B.S., Georgia School of Technology
Victor Bravo-Ahuja, Ae.E., Escuela Superior de Ingenieria Mecanica y Electrica (Mexico)
Robert Cornelius Bogers, B.S., University of Michigan
James Eugene Broadwell, B.S., Georgia School of Technology
Joseph Raymond Bruman, B.S., California Institute
Rolf Dietrich Buhler, B.A.E., University of Minnesota
Lester Smith Chambers, B.S., United States Naval Academy
Rean Roden Chapman, B.S., California Institute
John Manley DeBevoise, S.B., Massachusetts Institute of Technology

Master of Science in Engineering

AERONAUTICS (Contd.)

Carlos Alberto Viriato de Medeiros, B.S., New York University
Francisco Diaz-Barriga, Ae.E., Escuela Superior de Ingenieria Mecanica y Electrica (Mexico)
Raymond Engelbert Doll, B.S., United States Naval Academy
William Clapper Dunn, Post Graduate School, United States Naval Academy
Raymond Lloyd Ely, B.S., Carnegie Institute of Technology
Albert Braly Furer, B.S., United States Naval Academy
DeWitt Allen Harrell, B.S., United States Naval Academy

Chester Nuhn Hasert, S.B., Massachusetts Institute of Technology
William Gauss Jackson, Jr., B.S., United States Naval Academy
Mark Powers Maier, B.S., University of Michigan
Statton Ray Ours, Jr., B.S., United States Naval Academy
Theodore Browning Parker, B.S., Purdue University
Rufus Burleson Pearce, Jr., B.S., Agricultural and Mechanical College of Texas
Bernard Rasof, B.S., Illinois Institute of Technology
Richard Schamberg, B.S., California Institute
Dayton, Albert Seiler, B.S., United States Naval Academy
Henry Nicholas Titzler, S.B., Massachusetts Institute of Technology
Joseph Franklin Wadsworth, Jr., B.S., Purdue University
Teddy Francis Walkowicz, S.B., Massachusetts Institute of Technology
Jay C. Wayne, B.S., Purdue University
Robert Sydney Williams, S.B., Massachusetts Institute of Technology

CIVIL ENGINEERING

Martin Roger Gayer, B.S., California Institute

Bachelor of Science

SCIENCE

Leonard Sidney Abrams
Bert Henry Golding
Robert Clarke Jopson
Robert Theodore Nahas
Stanley Fox Newman
Max L. Panzer
Floyd Wayne Preston
Irving Stoy Reed
Warren Gleason Schlinger
George Foster Smith

ENGINEERING

W. O. Ballard, Jr.
William Tatem Collings
James Doyle Gray
John Raymond Kettler
John Bruce McNaughton
Joseph Solomon
Floyd Edward Weaver
Eric Weiss
Allen Edward Wolfe
Donald Mackenzie Wyckoff
John Andrew Zivic

Certificate in Ordnance

"In recognition of the satisfactory completion of three semesters of engineering subjects as prescribed by the United States Naval Academy Post Graduate School"

Fred George Archbold, A.B., University of California
Walter Earl Draper, B.A., Dartmouth College
Edmund Joseph Goehring, B.S., University of Pittsburgh
Jack Victor Kinsey, B.S., Purdue University
Richard Davis Miller, B.S., University of Arizona
Ernest Anthony Ryavec, B.S., John Carroll University; M.S., Western Reserve University
George Sumner Steele, B.S., University of Southern California

Senior Certificates

(In recognition of the satisfactory completion of the minimum requirements of the Navy V-12 Engineering Specialist Program)

Robert John Arthur
Robert Pearce Holmes
Wilton Emile Vannier
Roy Lee Walford

Junior Certificate

(In recognition of the satisfactory completion of two semesters of the Navy V-12 Engineering Specialist Program)

UNDERGRADUATE SCHOLARSHIPS, 1943-1944*

JUNIOR SCHOLARS:

KUHN, HAROLD W. METZLER, DAVID E. OGIER, WALTER T. WOODBURY, ERIC J.

DABNEY JUNIOR SCHOLARS:

GOLDING, BERT H. JENSON, PHILIP E. JOPSON, ROBERT C. KAPLAN, ARNOLD M. KNOPOFF, LEON SCHLINGER, WARREN G. SMITH, GEORGE F. STONE, CHESTER R.

SOPHOMORE SCHOLAR: RASMUSSEN, JOHN O., JR.

DABNEY SOPHOMORE SCHOLARS:

BOWEN, GEORGE H. DIXON, WILLIAM J. FERRELL, RICHARD A. GREEN, JOSEPH M. GRYDER, JOHN W. HAMMERLE, WILLIAM G. HENGISON, ROBERT HOGNESS, DAVIS S. KOCK, ARTHUR L. LINCOLN, DAVID C. METZLER, DAVID E. OGIER, WALTER T. RAUSH, HARRY E. TALMADGE, RICHARD B. WEBBER, CARROLL A., JR. WESTEVELT, DONALD R. WOODBURY, ERIC J. WOODS, WILLIAM C. A. YOUTZ, BYRON L.

DRAKE SOPHOMORE SCHOLARS: KAPLAN, ARNOLD M. KUHN, HAROLD W.

FRESHMAN SCHOLAR: HOGNESS, DAVID S.

BLACKER FRESHMAN SCHOLARS:

BARR, JOHN G. CRUMLY, CHARLES B. DIXON, WILLIAM J. FERRELL, RICHARD A. HAMMERLE, WILLIAM G. HUFFORD, GEORGE A. MAILLARD, WILLIAM C. MCCARTHY, JOHN WEBBER, CARROLL A., JR.

DRAKE FRESHMAN SCHOLARS:

STEIN, SHERMAN K. SWEET, RICHARD G. ZABLOW, LEONARD

AMERICAN CHEMICAL SOCIETY SCHOLAR: SEAGRAVE, JOHN D.

*Since two academic years occurred during this period, some names are listed under two scholarships.

GRADUATE STUDENTS

Abbreviations: Eng, Engineering; Sci, Science; ACh, Applied Chemistry; AE, Aeronautics; APh, Applied Physics; Ay, Astronomy; Bi, Biology; CE, Civil Engineering; Ch, Chemistry; ChE, Chemical Engineering; EE, Electrical Engineering; Ge, Geology; ID, Industrial Design; Ma, Mathematics; ME, Mechanical Engineering; My, Meteorology; Ord, Ordnance; Ph, Physics.

Asterisk indicates Teaching Fellow or Graduate Assistant.

(†) following a student's name indicates admission to candidacy for the degree of Doctor of Philosophy.

Name	Major Subject	Home Address
Andrew, Alan H.* B.S., University of Nebraska, 1942	Ph	St. Joseph, Missouri
Archbold, Fred George, Lt., U.S.N.R. A.B., University of California, 1935	Ord	Oakland
Arreguin-Lozano, Barbarin National University of Mexico	Bi	Silao, Gto., Mexico
Ballard, William O. Bradley, Jr., Lt. U.S.N.R. B.S., Purdue University, 1941	Ord	Detroit, Michigan
Baller, Howard* B.S., California Institute, 1940; M.S., 1941	EE	Newark, New Jersery
Baranowski, John Joseph, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1935; M.S., California Institute, 1944; A.E., 1944	AE	Oshkosh, Wisconsin
Barfield, Howard Pennington, Lt., A.C. B.S., Georgia School of Technology, 1943; M.S., California Institute, 1944	AE	Columbia, South Carolina
Baum, William Alvin, Ens, U.S.N.R. A.B., University of Rochester, 1943	Ph	Toledo, Ohio
Begovich, Nicholas Anthony* B.S., California Institute, 1943	EE	San Francisco
Benton, Robert Francis* B.S., California Institute, 1943	Ma	Santa Barbara
Berkant, Nuri B.S., Robert College, 1943; M.S., California Institute, 1944	ME	Istanbul, Turkey
Birlik, Ertugrul B.S., California Institute, 1944; M.S., 1944	ME	Ankara, Turkey
Bogert, Robert Cornelius B.S., University of Michigan, 1941; M.S., California Institute, 1944	AE	Patterson Field, Ohio
Bonner, Walter Daniel, Jr.* B.A., University of Utah, 1940	Bi	Salt Lake City, Utah
Boyd, John Robert* B.S., University of Illinois, 1942; M.S., California Institute, 1944	AE	Urbana, Illinois
Bravo-Ahuja, Victor, Lt., Mexican Army AeE, Escuela Superior de Ingenieria Mecanico y Electrica, 1940	AE	Tuxtepec, Oax., Mexico
Broadwell, James Eugene, Lt., A.C. B.S., Georgia School of Technology, 1942; M.S., California Institute, 1944	AE	Atlanta, Georgia
Brown, James Roy* B.S., Allegheny College, 1944	Ph	Shavon, Pennsylvania
Bruman, Joseph Raymond B.S., California Institute, 1944; M.S., 1944	AE	Pasadena
Bryden, John H.* B.S., College of Idaho, 1942	Ch	San Fernando
Buhler, Rolf Dietrich* B.A.E., University of Minnesota, 1943; M.S., California Institute, 1944	AE	St. Paul, Minnesota
Carter, William Walton* B.S., Carnegie Institute of Technology, 1943	Ph	Fort Worth, Texas

Name	Major Subject	Home Address
Cebeci, Ahmed B.Eng., McGill University, 1943; M.S., California Institute, 1944	Ge	Forest Hills, New York
Chambers, Lester Smith, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1934; M.S., California Institute, 1944; A.E., 1944.	AE	South Pasadena
Chang, Leonard Ivan B.S., Holy Cross College, 1944	CE	Kingston, Jamaica
Charyk, Joseph Vincent* B.S., University of Alberta, 1942; M.S., California Institute, 1943	AE	Lethbridge, Alberta, Canada
Chase, Patrick Stanley* B.S., California Institute, 1943	AE	Altadena
Clough, Ray William, Lt., A.C. B.S., California Institute, 1943	CE	Seattle, Washington
Coensgen, Frederic Harley* B.S., Montana State College, 1941	Ph	Belt, Montana
Cohen, Emanuel Richard B.A., University of Pennsylvania, 1943	Ph	Philadelphia, Pennsylvania
Conti, Mario William B.S., California Institute, 1944	AE	Brooklyn, New York
Corrsin, Stanley* B.S., University of Pennsylvania, 1940; M.S., California Institute, 1942; A.E., 1942	AE	Melrose Park, Pennsylvania
Curtis, Thomas Grey* B.S., California Institute, 1942	CE	Los Angeles
Dana, Stephen Winchester* A.B., Oberlin College, 1940; M.S., University of Southern California, 1942; Ph.D., California Institute, 1944	Ge	Claremont
Dandliker, Walter Beach* B.S., Rollins College, 1940	Bi	Gotha, Florida
Darling, Donald Allan* B.A., University of California at Los Angeles, 1939	Ma	Pasadena
David, Jennings Roy* B.S., University of Colorado, 1940; M.S., California Institute, 1942	EE	Borger, Texas
Davis, Thomas V. B.S., California Institute, 1938	CE	Los Angeles
De Bevoise, John Manley, Lt., A.C. S.B., Massachusetts Institute of Technology, 1942; M.S., California Institute, 1944	AE	Little Neck, New York
de Medeiros, Carlos A. Viriato Civil Eng., Polytechnic School (Brazil), 1941; B.S., New York University, 1943; M.S., California Institute, 1944	AE	Rio de Janeiro, Brazil
Denison, Frank Greene, Jr. S.B., Massachusetts Institute of Technology, 1940; M.S., California Institute, 1941; A.E., 1944	AE	Los Angeles
Diaz-Barriga, Francisco, Lt., Mexican Army AeE., Escuela Superior de Ingenieria Mecanica y Electrica, 1940	AE	Mexico, D.F.
Dishington, Roland Hanley B.E., University of Southern California, 1942	Ph	Hollywood
Dixon, Howard Henry, Flight Lt., R.C.A.F. B.S., University of Manitoba, 1939; M.S., California Institute, 1944; A.E., 1944	AE	Montreal Province, Quebec, Canada
Doll, Raymond Englebert, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1935; M.S., California Institute, 1944; A.E., 1944	AE	Altadena
Donohue, Jerry* (†) A.B., Dartmouth College, 1941; M.A., 1943	Ch	Hanover, New Hampshire
Draper, Walter Earl, Lt., U.S.N.R. A.B., Dartmouth College, 1934	Ord	Natick, Massachusetts

Name	Major Subject	Home Address
Dubbs, Clyde Andrew* B.S., California Institute, 1943	Bi	Pasadena
Dubnoff, Jacob William A.B., University of California at Los Angeles, 1931; M.A., University of California at Berkeley, 1933; Ph.D., California Institute, 1944	Bi	Pasadena
Dunn, William Clapper, Lt. Comdr., U.S.N. Post Graduate School, U. S. Naval Academy, 1942-43; M.S., California Institute, 1944; A.E., 1944	AE	Los Angeles
Eberhardt, William Henry* (†) B.A., Johns Hopkins University, 1941	Ch	Upper Montclair, New Jersey
Edelman, Leonard Benjamin B.S., Louisiana State University, 1942; M.S., California Institute, 1943	AE	Baton Rouge, Louisiana
Elmer, David Arthur B.S., California Institute, 1944	ME	South Pasadena
Ely, Raymond Lloyd, Lt., A.C. B.S., Carnegie Institute of Technology, 1940; M.S., California Institute, 1944	AE	Cleveland Heights, Ohio
Emre, Orhan M.* (†) B.S., Robert College, 1934; M.S., University of Illinois, 1936	CE	Istanbul, Turkey
Estabrook, Frank Behle* A.B., Miami University, 1943	Ph	Nampa, Idaho
Farquhar, John Percival (†) B.S., Harvard College, 1935; M.S., California Institute, 1941	Bi	Pasadena
Felberg, Fred B.S., California Institute, 1942	AE	Monrovia
Finston, Morton B.S., Northwestern University, 1941	AE	Chicago, Illinois
Fong, Conrad Tuck Onn* B.S., University of Hawaii, 1939	Bi	Honolulu, T. H.
Franzini, Joseph Bernard, Jr.* B.S., California Institute, 1942; M.S., 1943; C.E., 1944	CE	Pasadena
Fu, Cheng-Yi* B.Sc., National Tsing Hua University, 1933; M.Sc., McGill University, 1941; Ph.D., California Institute, 1944	Ge	Kunming, China
Furer, Albert Braly, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1936; M.S., California Institute, 1944; A.E., 1944	AE	Honolulu, T. H.
Gayer, Martin Roger* B.S., California Institute, 1942; M.S., 1944	CE	Santa Monica
Geisberg, Ralph Lewis B.M.E., Clemson College, 1937; M.S., California Institute, 1944	AE	Anderson, South Carolina
Goehring, Edmund Joseph, Lt., U.S.N.R. B.S., University of Pittsburgh, 1941	Ord	Pittsburgh, Pennsylvania
Golding, Bert Henry* B.S., California Institute, 1944	Ch	Long Beach
Gray, James Doyle, Lt., U.S.N.R. B.S., Northwestern University, 1941	Ord	Chicago, Illinois
Hagelbarger, David William* A.B., Hiram College, 1942	Ph	Mansfield, Ohio
Harrell, DeWitt Allen, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1935; M.S., California Institute, 1944; A.E., 1944	AE	Scotland Neck, North Carolina
Hasert, Chester Nuhn, Lt., A.C. S.B., Massachusetts Institute of Technology, 1941; M.S., California Institute, 1944	AE	Rockville Centre, New York
Heimer, Harry James, Lt., A.C. S.B., Massachusetts Institute of Technology, 1941; M.S., California Institute, 1944; A.E., 1944	AE	Clayton, Missouri
Henke, Burton Lehman* B.A., Miami University, 1944	Ph	Madeira, Ohio
Hensel, Rudolph William, Lt., A.C. S.B., Massachusetts Institute of Technology, 1942; S.M., 1942; A.E., California Institute, 1944	AE	Brooklyn, New York

Name	Major Subject	Home Address
Hiltner, Walter Frederick B.S., University of Washington, 1934; M.S., Massachusetts Institute of Technology, 1935	ME	Seattle, Washington
Ho, Chung Pen B.S., National Tsing Hua University, 1932	My	Kunming, Yunnan, China
Hornyak, William Frank* B. of E.E., College of the City of New York, 1944	Ph	New York, New York
Howard, Robert Charles A.B., Whitman College, 1944	EE	Walla Walla, Washington
Howton, David R. (†) B.S., California Institute, 1942	Ch	Glendale
Humphrey, George Louis* B.A., Marietta College, 1943	Ch	Belleville, West Virginia
Inn, Edward Chang Yul* B.S., University of Hawaii, 1939; M.S., 1944	Ph	Honolulu, Hawaii
Jackson, William Gauss, Jr., Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1935; M.S., California Institute, 1944; A.E., 1944	AE	Altadena
Janes, Robert Lee B.S., California Institute, 1936; M.S., 1944	CE	St. Paul, Minnesota
Johnson, Carl Burdett B.S., California Institute, 1937; M.S., 1944	CE	Hollywood
Johnson, Philip Ord* B.S., California Institute, 1942; M.S., 1943; A.E., 1944	AE	Pasadena
Johnson, Weller Edward B.S., University of California, 1935; M.S., 1941	ME	Altadena
Judd, David Lockhart* A.B., Whitman College, 1943	Ph	Chehalis, Washington
Keilin, Bertram* B.A., New York University, 1942	Ch	Bronx, New York
Kinsey, Jack Victor, Lt., U.S.N.R. B.S., Purdue University, 1941	Ord	Gary, Indiana
Kuo, Yung-huai* (†) B.A., National University of Peking, 1935; M.A., University of Toronto, 1941	AE	Shanghai, China
Laufer, John* B.S., Louisiana State University, 1942; M.S., California Institute, 1943; A.E., 1944	AE	Szekesfehervar, Hungary
Lees, Lester S.B., Massachusetts Institute of Technology, 1940; S.M., 1941	AE	Riverside, New York
Levy, Charles Nathaniel* S.B., Massachusetts Institute of Technology, 1939	AE	Dayton, Ohio
Lewis, Frank Harlan A.B., University of California at Los Angeles, 1941; M.A., 1942	Bi	Redlands
Ling, Shih-Sang B.C.E., Hangchaw Christian University, 1935; M.A., California Institute, 1943	EE	Hongkong, China
Lipscomb, William Nunn (†) B.S., University of Kentucky, 1941	Ch	Lexington, Kentucky
Loo, Shih-Wei* B.S., National Sun-Yat University, 1931	Bi	Hunan, China
Lym, Robert, Jr. B.A., University of California, 1942	ID	Berkeley
Maier, Mark Powers, Lt., A.C. B.S., University of Michigan, 1940; M.S., California Institute, 1944	AE	Detroit, Michigan
Manildi, Joseph F.* B.S., California Institute, 1940; M.S., 1942; Ph.D., 1944	EE	Saquel
Martin, Harold Clifford B.S., New York University, 1934; M.S., 1937	AE	South Ozone Park, New York
Masterson, Robert Bernard, Jr. B.S., Holy Cross College, 1943; M.S., 1944	AE	West Roxbury, Massachusetts

Name	Major Subject	Home Address
McCasland, Gifford Ewing (†) A.B., University of California at Los Angeles, 1935; M.S., Columbia University, 1938	Ch	Pasadena
McNaughton, John Bruce, Lt., U.S.N. B.S., U. S. Naval Academy, 1934	Ord	Charlerio, Pennsylvania
Mendenhall, Alfred Lewis B.S., Miami University, 1937	Ph	Dayton, Ohio
Miles, John Wilder B.S., California Institute, 1942; M.S., 1943; A.E., 1944; Ph.D., 1944	EE	Oakland
Miller, Herman* B.S., California Institute, 1943	AE	Long Beach
Miller, Richard Davis, Lt., U.S.N.R. B.S., University of Arizona, 1941	Ord	Clifton, Arizona
Millsaps, Knox* B.S., Alabama Polytechnic Institute, 1940; Ph.D., California Institute, 1944	Ma	Birmingham, Alabama
Minasian, John Kachig B.S., California Institute, 1938; M.S., 1944	CE	Los Angeles
Mislow, Kurt Martin* B.S., Tulare University, 1944	Ch	New York, New York
Morgan, Samuel Pope, Jr.* B.S., California Institute, 1943; M.S., 1944	Ph	Casa Grande, Arizona
Muratzade, Enver M. B.S., Massachusetts Institute of Technology, 1939; M.S., University of Iowa, 1940; C.E., California Institute, 1942	CE	Istanbul, Turkey
Myers, Terrell Clay A.B., Whittier College, 1942	Ch	Pico
Nieri-Castagnino, Fernando Civil Eng., Catholic University of Peru, 1943; M.S., California Institute, 1944	Ge	Lima, Peru
O'Reilly, James Donald B.S., National University of Ireland, 1938; Bachelor of Theology, 1940	Ph	Pasadena
Ours, Statton Ray, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1934; M.S., California Institute, 1944; A.E., 1944	AE	Altadena
Ozkaragoz, Ethem B.S., Robert College, 1943; M.S., California Institute, 1944	ME	Burdur, Turkey
Panzer, Max Ludwig B.S., California Institute, 1944	Bi	Beverly Hills
Parker, Theodore Browning B.S., Purdue University, 1942; M.S., California Institute, 1944	AE	West Lafayette, Indiana
Pearce, Rufus Burleson, Jr., Lt., A.C. B.S., Agriculture and Mechanical College of Texas, 1942; M.S., California Institute, 1944	AE	Dallas, Texas
Pfeiffer, Heinz Gerhard* B.A., Drew University, 1941; M.A., Syracuse University, 1943	Ch	Newark, New Jersey
Pi, Te Hsien* B.S., Yenching University, 1932; M.S., 1934; Ph.D., California Institute, 1944	Ph	Tsinan, China
Platou, Anders Stroud, Pfc., A.S.N. B.S., Purdue University, 1943	AE	Toledo, Ohio
Potts, Donald Harry* (†) B.S., California Institute, 1943	Ma	Glendale
Rapport, Maurice M. (†) B.S., College of the City of New York, 1940	Ch	Los Angeles
Rasof, Bernard* B.S., Illinois Institute of Technology, 1941; M.S., California Institute, 1944	AE	Chicago, Illinois
Redemann, Carl Temple A.B., University of California at Los Angeles, 1942	Ch	Los Angeles
Reed, Irving Story B.S., California Institute, 1944	Ma	Fairbanks, Alaska
Richardson, Audre Harold* B.S., California Institute, 1943	AE	Hollywood

Name	Major Subject	Home Address
Rosenthall, Edward B.S., McGill University, 1937; M.S., 1937; Ph.D., California Institute, 1944	Ma	Montreal, Quebec
Rostron, James T. B.S., University of California, 1941	CE	Pasadena
Ryavec, Ernest Anthony, Lt., U.S.N.R. B.S., John Carroll University, 1938; M.S., Western Reserve University, 1939	Ord	Cleveland, Ohio
Sabersky, Rolf Heinrich B.S., California Institute, 1942; M.S., 1943	ME	Los Angeles
Savit, Carl Hertz* (†) B.S., California Institute, 1942	Ma	Pasadena
Schamberg, Richard* B.S., California Institute, 1943; M.S., 1944	AE	Los Angeles
Schardt, Alois Wolfgang* B.S., California Institute, 1944	Ph	Hollywood
Schocken, Victor* B.A., New York University, 1942; M.A., Oregon State College, 1943	Bi	Yonkers, New York
Sease, John William (†) B.A., Princeton University, 1941	Ch	Wilmington, Delaware
Seiler, Dayton Albert, Lt. Comdr., U.S.N. B.S., U. S. Naval Academy, 1936; M.S., California Institute, 1944; A.E., 1944	AE	Elizabethton, Tennessee
Senear, Allen Eugene (†) B.A., Williams College, 1941	Ch	Winnetha, Illinois
Seneker, James Albert A.B., Greenville College, 1943	Ch	Marionville, Missouri
Silgado-Ferro, Enrique B.S., University Mayor de San Marcos, 1939	Ge	Lima, Peru
Sill, Richard Clements B.S., University of Nebraska, 1944	Ph	Lincoln, Nebraska
Smith, Josiah Edward B.S., California Institute, 1940	AE	Corona
Soldate, Albert Mills A.B., Stanford University, 1941; A.M., 1942	Ch	Alturas
Steele, George Sumner, Lt., U.S.N.R. B.S., University of Southern California, 1940	Ord	Long Beach
Sternberg, Joseph* B.S., California Institute, 1942; M.S., 1943	AE	Brooklyn, New York
Stone, David Garabrant, Cpl., U.S.A. A.B., Wheaton College, 1937; M.Sc., Brown University, 1942	AE	Washington, D. C.
Tanyildiz, Sureyya Rafet B.S., California Institute, 1944; M.S., 1944	ME	Istanbul, Turkey
Tejada-Flores, Luis Hernan* B.S., California Institute, 1938; M.S., 1943	EE	La Paz, Bolivia
Titzler, Henry Nicholas, Lt., A.C. B.S., Massachusetts Institute of Technology, 1942; M.S., California Institute, 1944	AE	South Euclid, Ohio
Trabant, E. Arthur* A.B., Occidental College, 1940	Ma	Huntington Park
Trueblood, Kenneth N. (†) A.B., Harvard College, 1941	Ch	Dobbs Ferry, New York
Tuddenham, William John* B.A., University of Utah, 1943	Bi	Salt Lake City, Utah
Turkbas, Necat B.S., Robert College, 1943	ME	Izmir, Turkey
Vey, Ebenezer* (†) B.S., California Institute, 1941; M.S., 1942; C.E., 1943	CE	Grate's Cove, Newfoundland
Wade, Ernest* B.S., California Institute, 1943	EE	Lawndale

Name	Major Subject	Home Address
Wadsworth, Joseph Franklin, Jr., Capt., A.C.	AE	Barberton, Ohio
B.S., Purdue University, 1941; M.S., California Institute, 1944		
Walkowicz, Teddy Francis, Capt., A.C.	AE	Webster, Massachusetts
B.S., Massachusetts Institute of Technology, 1941; M.S., California Institute, 1944		
Waser, Jurg H. E.	Ch	Zurich, Switzerland
Certificate of Maturity, University of Zurich, 1935; Ph.D., California Institute, 1944		
Waterman, Alan Tower, Jr.	My	Cambridge, Massachusetts
A.B., Princeton University, 1939; B.S. in My, California Institute, 1940		
Wayne, Jay Charles, Capt., A.C.	AE	West Lafayette, Indiana
B.S., Purdue University, 1941; M.S., California Institute, 1944		
Wheeler, Donald Bingham, Jr.* (†)	Ph	Buffalo, New York
B.S., Lehigh University, 1938		
Williams, Robert Sydney, Capt., A.C.	AE	Rochester, New York
B.S., Massachusetts Institute of Technology, 1941; M.S., 1944		
Wilson, Albert George* (†)	Ma	Houston, Texas
B.S., Rice Institute, 1941; M.S., California Institute, 1942		
Yungul, Sulhi	Ge	Ankara, Turkey
B.S., Montana School of Mines, 1943		
Zieman, Clayton Melvin	Ph	Honolulu, Hawaii
B.A., University of Wisconsin, 1927; M.S., University of Hawaii, 1939		
Zivic, John Andrew, Lt., U.S.N.R.	Ord	Euclid, Ohio
B.S., Case School of Applied Science, 1941		

UNDERGRADUATE STUDENTS

(For the academic year of March 1 to October 20, 1944)

SENIOR CLASS

Name	Option	Home Address
Abrams, Leonard Sidney	Ma	Los Angeles
Adams, Phillip L.*	EE	Huntington Park
Alpan, Rasit Hilmi	ME	Pasadena
Arthur, Robert John*	ME	San Jose
Atchison, Edward McKean*	ME	Martinez
Baxter, Albert Nathaniel*	ME	Bellflower
Bennett, Dudley Earl*	CE	Arlington
Berbower, Raymond Finley*	CE	Long Beach
Blocker, Robert Francis*	CE	Los Angeles
Bongardt, William George*	CE	Montebello
Brodie, Robert Pearson*	CE	Susanville
Brown, Kenneth Grant, Jr.*	ME	Pasadena
Brydolf, Robert*	ME	Pasadena
Buller, Joseph Stanley*	ME	Los Angeles
Campbell, Andrew Berrien*	ME	San Marino
Carlat, Gerald Elmo*	CE	Sayle, Montana
Carter, Thomas Arthur, Jr.*	ME	Los Angeles
Chadwick, Joseph Howard, Jr.*	EE	Rolling Hills
Clendenen, Frank Byron*	CE	Pasadena
Coda, Leo Robert*	ME	Buena Park
Collings, William Tatem*	CE	Pasadena
Coulson, Carl Charles*	EE	Tule Lake
Dameson, Louis George*	EE	San Diego
Dana, Ilif Ross*	CE	Glendora
Davis, William Richard*	EE	Glendale
Dethlefsen, Douglas George*	EE	Watsonville
Donsbach, Weldon Roger*	EE	San Antonio, Texas
Dykstra, John Dale*	ME	Long Beach
Earl, Joseph Benjamin, II*	CE	Altadena
Elliott, William James*	ME	San Mateo
Field, Almeron Johnston*	CE	Palos Verdes Estates
Fisher, Earle Kenneth*	ME	Pomona
Ford, Maurice Earl, Jr.*	ME	Fullerton
Freeman, James Robert, Jr.*	EE	Los Angeles
Gardner, John Howard*	ME	Santa Paula
Garland, John Jepson, Jr.*	ME	Menlo Park
Golding, Bert Henry	Ch	Long Beach
Greenwood, Donald Theodore*	ME	Glendale
Gulley, William Franklin*	ME	Santa Ana
Hall, Wilbur Lee*	ME	Long Beach
Hamilton, William Robert*	ME	Los Angeles
Hauser, Jack Raymond*	ME	San Francisco
Higgins, Horace Morton*	ME	Pomona
Hinton, Warren David, Jr.*	CE	Pasadena
Hodges, Merwyn E.*	EE	Eagle Rock
Holmgren, John Dwight*	EE	Pasadena
Horine, Graham Allison*	ME	Whittier
Howe, Robert Milton	EE	Oberlin, Ohio

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Hudson, Lawrence Urguhart*	ME	Oakland
Hudson, Richard Albert*	EE	Pasadena
Hudson, Thomas Allan*	CE	Bakersfield
Hudson, Thomas Ernest*	ME	Monterey Park
Huggins, John Charles*	ME	Fullerton
Hurst, Stephen Dalrymple*	ME	Hinsdale, Illinois
Johnson, Ronald Stafford*	ME	Cambridge, Massachusetts
Jopson, Robert Clarke	Ph	San Jose
Judd, Henry Clay*	CE	Menlo Park
Karstedt, Ferdinand Herman*	CE	San Jose
Kerr, James Gilchrist*	ME	Washington, D. C.
Kettler, Jack Raymond	ME	Huntington Beach
Klein, Daniel Sigel*	EE	La Habra
Knopoff, Leon	EE	Los Angeles
Krause, George Bainbridge*	CE	Riverton, Wyoming
Kruse, Frederick William, Jr.*	EE	Palo Alto
Kuhns, Richard Eli*	CE	Lomita
Laabs, Robert Frank*	ME	San Diego
Langford, John Arthur*	EE	Fullerton
Lauterbach, Robert Enos*	EE	Denver, Colorado
Lockett, Dick Henry	EE	Santa Ana
Lockhead, Raymond Ralph*	ME	Univerity City, Missouri
Lockwood, Glynn Husted*	ME	Mentone
Lockwood, William Ellison, Jr.*	ME	Mentone
Long, Neville Stuart*	CE	Los Angeles
Lowe, Edward Kenneth*	ME	Fresno
Lund, Leval, Jr.*	CE	Los Angeles
MacAlister, Robert Stuart	ME	Los Angeles
MacDonald, Francis Edward*	CE	San Gabriel
Mann, Joe Karl	EE	Emmett, Idaho
Mapel, Robert Wallace*	ME	Los Angeles
McAnlis, Robert Guthrie*	ME	Pasadena
McDonald, George DeWald*	ME	Los Angeles
McGarrity, Richard Vincent*	ME	Los Angeles
Mettler, Ruben Fred*	EE	Shafter
Miller, Charles Bradford*	ME	Long Beach
Mitchell, John Alexander*	EE	Glendale
Moore, Return Francis*	CE	Long Beach
Nahas, Robert Theodore	Ge	Pasadena
Newman, Stan Fox	ACh	Kansas City, Missouri
Nicholas, John Robert	Ch	Berkeley
Norsworthy, Thomas Wiley*	ME	Dallas, Texas
Osgood, George Mierow*	EE	Tacoma, Washington
Palmer, Raymond Jefferson*	CE	Long Beach
Panzer, Max Ludwig	Bi	Beverly Hills
Pastoriza, Ralph Babcock*	EE	Bronxville, New York
Pendery, Donald Worthen*	EE	Palm Springs
Phelps, Joseph Mansfield*	CE	Long Beach
Pischel, Eugene Fisher*	EE	Glendale
Poolman, Robert Charles	ME	Glendale
Popp, Leonard Ernest*	ME	Pasadena
Preston, Floyd Wayne	Ch	Los Angeles
Price, Longueville Howe*	CE	Stanford University
Randall, Robert Oram*	ME	Pasadena
Reed, Irving Story	Ma	Fairbanks, Alaska
Riddell, Richard Bradshaw*	ME	Denver, Colorado

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Roberts, William Frederick*	ME	Los Angeles
Robinson, Alfred D.	EE	Fallbrook
Rosencrance, Robert Bruce*	CE	Rockford, Illinois
Sadler, Kirk Hulme*	ME	Alhambra
Saunders, George Reamer*	CE	San Diego
Schaar, Harold William*	ME	Pasadena
Schlinger, Warren Gleason	ACh	Glendale
Shefchik, David Rice*	ME	Duluth, Minnesota
Smith, George Foster	Ph	Roswell, New Mexico
Smith, Philip Bartlett	Ph	New York, New York
Smith Philip Herbert*	ME	Riverside
Sogorka, John Jonathan, Jr.*	ME	San Francisco
Solomon, Joe	ME	Los Angeles
Spencer, William Clarence	CE	Fullerton
Sullivan, Francis Duane*	ME	Pomona
Swanson, Wilbur Milton*	ME	Palo Alto
Taylor, Garland Stavely*	ME	Pasadena
Tookey, William Anderson*	ME	La Canada
Turner, Clemons Corum*	ME	Long Beach
Ukropina, John Robert*	ME	San Marino
Unayral, Asim Menstafra	ME	Ankara, Turkey
Walker, David Fenton*	ME	Altadena
Weaver, Floyd Edward*	CE	Los Angeles
Weidman, Robert McMaster	CE	Placerville
Weiss, Eric	ME	Los Angeles
Welliver, Clarence Leon	EE	Alhambra
Wessels, Philip Summeral*	EE	Bellflower
Whitmore, John Francis*	ME	Los Angeles
Wirta, Roy William*	ME	Mt. Vernon, Washington
Wolfe, Allen Edward	EE	Portland, Oregon
Wood, George Mason*	ME	Phoenix, Arizona
Woodard, Clarence J.*	ME	Fairfield
Wyckhoff, Donald Mackenzie	ME	Pasadena
Yik, George Ke Wu	ME	Peking, China
Young, William Brewster*	ME	Piedmont

JUNIOR CLASS

Name	Option	Home Address
Acosta, Allan James*	ME	Long Beach
Allsup, Wendell Wayne*	ME	Burlington, Iowa
Anderson, Adrian Campbell*	ME	South Pasadena
Anderson, Kenneth Gale	ME	Pasadena
Asher, Rolland Sanford*	AE	Los Angeles
Austin, Dale Havlan*	ME	San Jose
Aydelott, Max Merton*	ME	Long Beach
Backus, Robert Allen*	EE	Pasadena
Bade, William George*	EE	San Diego
Ball, Halcyon*	ME	Long Beach
Banks, David Collins*	EE	Altadena
Barna, Richard Stephen*	ME	South Pasadena
Barnes, Wesley Fuller*	ME	Downey
Bates, Donald Howbert*	ME	Forest Hills, Oswego, Oregon
Bennett, Robert Royce*	EE	Pomeroy, Washington
Bergman, Charles Andrew*	CE	San Marino
Black, Roy Edward*	ME	Long Beach

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Bohjanen, Edward Alfred*	AE	Hancock, Michigan
Bolster, Eugene Wright*	ME	St. Augustine, Florida
Booth, Howard Alfred, Jr.*	EE	Peoria, Illinois
Bowers, Robert Alwyn	ACh	La Jolla
Bozarth, Charles Walter*	EE	Escondido
Briggs, Fred Melvelle*	CE	Kirley, South Dakota
Brough, Harry Ward*	EE	Glendale
Brown, George Edward*	EE	Pasadena
Bryner, Dean Lloyd*	EE	Salt Lake City, Utah
Budd, Otho Mansfield*	EE	Laguna Beach
Budney, George Stanley*	ME	Thomaston, Connecticut
Burke, Billy Frank*	AE	Crescent, Oklahoma
Burke, James Donahue*	ME	Pasadena
Burns, William Robert*	AE	Des Moines, Iowa
Burrell, Kenneth Ray*	CE	Merced
Burt, Frederick Bedell*	EE	Pasadena
Burzell, Linden Robert*	CE	West Los Angeles
Campbell, Donald Delevan*	EE	Paso Robles
Cappadona, Robert Paul*	CE	Los Angeles
Caprio, Joseph Michael*	AE	New Brunswick, New Jersey
Cardall, John Dewey*	ME	Los Angeles
Cato, Glenn Allan*	AE	Portland, Oregon
Chinn, Elroy Kui Chon	ME	Honolulu, Hawaii
Clark, Bert Hyland*	ME	Los Angeles
Clark, Stanley Dimock*	ME	Pasadena
Cole, Richard Carroll*	ME	San Marino
Collins, William Larry*	AE	Beloit, Wisconsin
Cook, Gordon Allen*	CE	South Pasadena
Cook, William Herbert*	CE	Menlo Park
Coughenour, Charles Franklin*	EE	Long Beach
Crawford, Paul Robert*	ME	Long Beach
Cullen, James Albert	Ph	Los Angeles
Cutler, Charles Russell*	EE	Macomb, Illinois
Davis, Charles Melville	EE	Pasadena
Davis, Frederick Henry*	EE	Eugene, Oregon
Davis, John Stephen*	ME	San Diego
Davy, Louis Henry*	EE	San Francisco
Dawkins, Stanley Alan*	ME	San Gabriel
Day, Frank Miles*	ME	Philadelphia, Pennsylvania
Dean, Richard Albert*	AE	Granville, Ohio
Dodder, Donald Charles*	Ph	Los Angeles
Dore, Frank John	ME	Balboa Island
Drake, James Hughes*	EE	West Los Angeles
Duncan, Donal Baker*	Ph	San Marino
Dunkel, Carl Peter	ME	Chicago
Dunne, Brian Boru*	Ph	Pasadena
Durst, Lincoln Kearney	Ma	Santa Monica
Eimer, Manfred	ME	Los Angeles
Elicks, Sidney Lewis*	ME	Sacramento
Elko, Edward Robert*	ME	Glendale
Ellis, Douglas Smith	ME	Altadena
Engel, Harold Leon	Bi	Los Angeles
Erkel, Albert A.*	CE	Los Angeles
Essig, Frederick Charles*	EE	Memphis, Tennessee
Fahy, Thomas Robert	EE	San Diego
Fanz, Martin Carl*	AE	Brookfield, Illinois

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Filmer, Michael Mackenzie*	EE	San Francisco
Fjeldsted, Norman Benge*	EE	Beverly Hills
Flam, Bernard*	ME	Sherman Oaks
Ford, Harold Harrison, Jr.*	EE	Alhambra
Frady, William Ensign, Jr.*	EE	Long Beach
Francis, Donald Lowell*	ME	Auburn
Francis, John Prescott*	EE	Los Angeles
Freedman, Eugene*	AE	Milwaukee, Wisconsin
Freeman, Burton Edgar*	Ph	San Dimas
Fuller, Lawrence Eugene*	ME	Santa Paula
Fulton, Albert Stewart*	EE	Brawley
Furst, Raymond Bruce*	ME	Los Nietos
Gardner, Paul Revere, Jr.*	EE	Ontario
Gerber, Raymond Clyde*	ME	East Highlands
Gerty, John Mitchell*	ME	Hinsdale, Illinois
Gibson, Paul N.*	AE	Taft
Grossberg, Theodore*	ME	Los Angeles
Hadley, James Warren*	Ph	South Pasadena
Hall, Lawrence Gordon*	EE	Pasadena
Harrington, Jerome*	EE	Pasadena
Harvey, Clifford Olin, Jr.*	ME	South Pasadena
Hass, Donald James*	EE	Pasadena
Heinz, John Arnold*	ME	Anaheim
Heller, William Edwin*	CE	Cashion, Oklahoma
Hemmes, Robert Alexander*	Ph	Los Angeles
Henry, Richard Val*	EE	Pasadena
Herndon, Richard James	ACh	Los Angeles
Hibbs, Albert Roach*	Ph	Chillicothe, Ohio
Holmes, Robert Pearce*	Bi	Sacramento
Honey, Richard Churchill*	Ph	Portland, Oregon
Hook, Joseph Frederick*	Ph	Culver City
Horrer, Paul Luther*	AE	Jacksonville, Illinois
Houston, Willard Samuel, Jr.*	AE	Los Angeles
Howe, George Marvel*	AE	Hampden-Sydney, Virginia
Howe, Robert Milton*	Ph	Oberlin, Ohio
Hunt, Charles Warren	Ge	Santa Barbara
Hyman, Alvin*	AE	Chicago, Illinois
Ibbetson, Edwin Thornton*	ME	Long Beach
Jackson, Clive*	CE	Long Beach
Jackson, John Sterling	APh	Pasadena
Jackson, John Waddell*	AE	Washington, D. C.
Jasper, Richard Nathaniel*	CE	Fortuna
Jenkins, Robert Power*	EE	San Diego
Jenson, Philip Everett	ME	Crockett
Johnson, Clarence Dean, III*	ME	Portland, Oregon
Johnson, Donald DePree*	ME	Silver City, New Mexico
Johnson, Gordon Lloyd*	EE	Arcadia
Kaplan, Arnold Marks	Ph	San Mateo
Kaplun, Saul	ME	Pasadena
Keith, Ivan Whitefield*	EE	Beaumont
Kieckhefer, Robert John, Jr.*	ME	Brookfield, Wisconsin
Killian, Roy Garfield*	AE	Blacksburg, South Carolina
King, Edward Joseph*	AE	Mt. Vernon, New York
King, William Robert	Ch	Los Angeles
Kling, Harry Pearce	ME	Woodside, New York
Knox, Robert Vernon*	EE	San Diego

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Knudsen, Richard Albert Berndt*	ME	Pasadena
Knutson, Harry*	ME	Bronx, New York
Kohlhass, Paul William*	ME	Piedmont
Krause, Jack Dewey*	ME	Long Beach
Kuck, Wallace Walter*	AE	St. Mary's, Ohio
Kuhn, Harold William	Ph	Pasadena
Lamar, Charles Eugene*	ME	South Pasadena
Lawson, Bradford Clair*	ME	Pasadena
Leech, John Lyman*	AE	Zion, Illinois
Leinweber, Donald McCloud*	AE	Lee's Summit, Missouri
Levy, Robert Carl	ME	Los Angeles
Levin, Leslie Howard*	ME	Chicago, Illinois
Lewis, James Gordon*	Ph	Altadena
Lyon, John Ballachey, Jr.*	Ph	Long Beach
MacDougall, Donald Duncan*	EE	Montebello
Macomber, Mark Morris*	ME	Caruthers
Magneson, Norman James*	CE	Santa Ana
Maloney, John Ward*	ME	Detroit, Michigan
Marshall, Warren Monroe III*	AE	LaGrange, Georgia
McDonnell, William Carl*	EE	North Sacramento
McElhannon, Marshall Edward*	ME	Monterey Park
McKenney, John Dill*	ME	El Paso, Texas
McLeod, Edward Blake*	EE	Los Angeles
McMurray, Wayne Taylor*	ME	Pasadena
McRuer, Duane Torrance*	ME	Los Angeles
Meinel, Aden Baker	Ph	Pasadena
Mendenson, Burt Gershon*	AE	Chicago, Illinois
Metzler, David Everett	Ch	Fresno
Moore, Boude Clisby*	EE	Arlington, Virginia
Moore, Max Henry*	EE	Los Angeles
Moran, James Herbert*	EE	Great Falls, Montana
Morgan, John Austin*	ME	Sierra Madre
Morison, Bradley Garsed*	CE	Minneapolis, Minnesota
Mounts, Robert Dean*	ME	Wailuku, Hawaii
Muller, David Eugene	Ph	Pasadena
Murphy, Walter Lee*	ME	Point Reyes Station
Myers, Rollie John	Ch	South Pasadena
Myers, William Alexander*	EE	Long Beach
Nason, James Keith*	CE	Jackson, Mississippi
Neerken, Richard Fulcher	ME	West Los Angeles
Nichols, John Frederick*	ME	Glendale
Nichols, John Henry, Jr.*	ME	Anaheim
Nielsen, Roland Holgate*	AE	Mesa, Arizona
Noon, William Lawrence	ACh	Bellingham, Washington
Norton, Lewis Calvin*	AE	Chino
Ogier, Walter Tom	Ph	South Pasadena
Olsen, Raymond Lloyd*	AE	Portland, Oregon
Opperman, David Russell*	AE	Piper City, Illinois
Ott, Lloyd Edward*	EE	Baldwin Park
Owens, Timon Evans, Jr.*	CE	Los Angeles
Parker, Warren Harvey, Jr.*	EE	Phoenix, Arizona
Parks, Jerome Wesley*	ME	Balboa Island
Parode, Lowell Carr*	EE	Los Angeles
Pascoe, Lucien Arthur*	EE	Oceanside
Pecchenino, Paul Leonard*	ME	Oakdale
Perkins, William Reese*	EE	Santa Barbara

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Pettit, John Tanner*	Ph	South Pasadena
Phillips, Robert Edward*	EE	Glendale
Platt, Arthur Elroy*	CE	San Diego
Prichard, Samuel*	ME	Pasadena
Prudden, Terry Macbeth*	ME	Glendale
Pryor, John Andrew*	AE	Wheeling, West Virginia
Rasmussen, Paul Glen*	EE	Salt Lake City, Utah
Razor, Darrell Owen*	ME	Burbank
Reed, Richard John*	AE	Braintree, Massachusetts
Remillard, Wilfred Joseph	AE	Fairhaven, Massachusetts
Rhoads, David Hansell, Jr.*	EE	Philadelphia, Pennsylvania
Richeson, Will, Jr.	ME	Glendale
Rickard, Charles Arthur*	ME	Washoogal, Washington
Riedel, John Cumming*	EE	Altadena
Roberts, Wayne Arthur*	EE	Los Angeles
Robins, Fred Phillip	ME	Anaheim
Romney, Carl Fredrick	AE	Salt Lake City, Utah
Rueda, Marcelino*	CE	Los Angeles
Sanders, Jerrell Lloyd*	AE	Petersburg, Virginia
Scapple, Robert Young*	EE	Riverside
Scarbrough, Alfred Dale*	EE	Yucaipa
Schmoker, Robert Fredrick*	CE	Fullerton
Schnitger, Arthur Wallace*	Ph	Garden Grove
Schroeder, Henry William	ACh	South Pasadena
Schurmeier, Harris MacIntosh*	ME	Winnetka, Illinois
Scott, Eugene Llewellyn*	EE	Taft
Shanahan, Stephen Timothy*	ME	LaHabra
Shauer, Kenneth Melville*	EE	Los Angeles
Shenfil, Leon	APh	San Francisco
Short, William Frederick*	CE	Long Beach
Simmons, Robert Wilson	ME	Pasadena
Sinclair, Donald Wesley*	EE	Vista
Slye, John Marshall*	Ph	Santa Fe, New Mexico
Smith, Alan Wayne*	AE	Alameda
Smith, Dudley Burcham*	CE	Portland
Smith, Raymond James*	CE	Glendora
Smith, William Henry*	AE	Springfield, New Jersey
Snyder, Donald Clinton*	CE	Azusa
Spencer, William Clarence*	CE	Fullerton
Springer, Richard Earl*	Ph	Santa Paula
Stefanoff, John Junior*	ME	Montague, Montana
Stern, John Louis*	CE	Los Angeles
Strite, Robert Eugene*	ME	Minneapolis, Minnesota
Stück, Roger Dean*	EE	Santa Paula
Swanson, Don Richard*	Ph	Santa Monica
Sweet, Donald Hanly*	EE	Bandon, Oregon
Tange, Carl, Jr.*	ME	Outlook, Montana
Tatlock, William Stacy*	AE	Terre Haute, Indiana
Taylor, Edward Clark*	ME	San Diego
Taylor, Theodore Brewster*	Ph	Mexico, D. F., Mexico
Teets, Charles Arthur*	EE	Santa Monica
Teitsworth, Richard Clark*	ME	Plainfield, New Jersery
Tiffany, Charles Edwin*	EE	Hollister
Tillman, Donald C.*	CE	Los Angeles
Tookey, Robert Clarence*	ME	La Canada
Torgerson, Warren Stanley*	AE	Hawley, Minnesota

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Tracy, Tom William	APh	Berkeley
Trout, Robert Glenwood*	ME	Burbank
Van Akin, Harry*	EE	Phoenix, Arizona
Vannier, Wilton Emile*	Bi	Sierra Madre
Vernier, Bruce Rolff*	ME	San Diego
von Esch, Bill Champion*	ME	Monterey Park
Wakefield, Robert Russell*	AE	San Diego
Walford, Roy Lee*	Bi	San Diego
Waugh, Merle Gordon*	ME	Santa Barbara
Werme, John Vernon*	AE	Norwalk, Connecticut
West, Hugh Sloan*	ME	San Francisco
Wheeler, Raymond Croasdale*	EE	Glendale
Wilbur, Arthur Curtner*	EE	San Jose
Wilferth, Lawrence Edwin*	ME	Alhambra
Wilhelm, George*	ME	Portland, Oregon
Wilkinson, Robert Edwin*	ME	Pasadena
Williams, Robert William*	EE	Huntington Park
Wilson, Melvin Noble	ME	San Diego
Winter, Ralph Dana*	CE	South Pasadena
Wood, Edward Philip, Jr.*	EE	Longview, Washington
Woodbury, Eric John	Ph	Altadena
Woodson, William Logan	EE	Pasadena
Yates, Harold Wheeler*	CE	Brea
Young, Thayne Harwood, Jr.*	CE	Hollywood

SOPHOMORE CLASS

Name	Course	Home Address
Adamson, Phil Allen	Eng	San Marino
Ahern, Dennis Joseph*	Eng	Baltimore, Maryland
Allen, John Kenneth*	Eng	Watertown, Massachusetts
Allison, Charles William, Jr.*	Eng	Seattle, Washington
Anderson, John Arthur*	Eng	Long Beach
Anderson, Melvin Keith*	Sci	Pine Bluff, Wyoming
Arms, Willis Harlan*	Eng	Pasadena
Auslender, Leland Irwin*	Eng	Hollywood
Austin, Benjamin Lewis*	Eng	Santa Barbara
Babcock, Stephen Wilson*	Eng	Los Angeles
Barker, Wayne LeMar*	Eng	Los Angeles
Barnes, Stanley Manton	Sci	Palo Alto
Barnett, John Edward*	Eng	Pasadena
Barr, John George	Eng	Pato, Antioquia, Colombia
Barton, George Wendell, Jr.*	Eng	La Canada
Bates, Stuart R.*	Eng	Pasadena
Beek, Joseph Allan, Jr.	Sci	Balboa Island
Beilstein, Howard Francis*	Eng	San Diego
Belyea, Robert Combs*	Eng	Palm Springs
Bement, Dale Edward*	Eng	Salida, Colorado
Benton, Philip Henking*	Eng	Claremont
Bissiri, Paul George*	Eng	Los Angeles
Bormann, Ralph Battin*	Eng	Long Beach
Bosch, Jorge Jose	Sci	Habana, Cuba
Bowen, George Hamilton	Sci	Tulsa, Oklahoma
Brayford, Elton Robert	Eng	Salt Lake City, Utah
Brinkhaus, Harvey Hugh*	Eng	Los Angeles
Brolin, Elmore Gustav*	Eng	Tacoma, Washington

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Buelow, Vern Robert*	Sci	North Hollywood
Burdg, Charles Edward	Eng	Clarksburg
Camp, Herbert Fulton*	Eng	San Diego
Carr, Edward Elmer*	Eng	Denair
Carter, Truland Harold*	Eng	Los Angeles
Chaffee, Glenn Albert	Eng	Alhambra
Chamberlain, Lloyd William*	Eng	Media, Pennsylvania
Chapin, Seymour Leon	Eng	Long Beach
Chavez, Jose Carlos*	Eng	Los Angeles
Cherryman, Rexford Raymond*	Eng	Coronado
Clack, Roderick Whittier*	Eng	Alma, Michigan
Clapp, Roger William*	Eng	San Diego
Clark, Ernest Hubert*	Eng	Burbank
Clark, Paul Torkelson	Sci	Los Angeles
Clark, William Coles*	Eng	Los Angeles
Collier, Richard Lester*	Eng	Altadena
Comlossy, Harold, Jr.*	Eng	Los Angeles
Conradt, Robert Hugh*	Eng	Pasadena
Costello, Joseph Daniel*	Eng	San Marino
Cozens, Edward Hammond	Sci	Encinitas
Cuthbert, Thomas Crosbie	Sci	Salt Lake City, Utah
Darling, Rodney Oswald	Eng	Victoria, B. C.
Davis, Russell Lathrop	Eng	Pasadena
Davis, Wayne Kenneth	Eng	Burbank
Davis, William Angus*	Eng	San Diego
Davy, Louis Henry*	Eng	San Francisco
Dehnke, Theodore Herman*	Eng	Harrisville, Michigan
Demuth, Orin Jack	Eng	Portland, Oregon
Densmore, James Edward*	Eng	Inglewood
Deppe, Harold Frederick*	Eng	San Luis Obispo
Dethier, Bernard Emile*	Eng	Norwood, Massachusetts
Dick, Charles William*	Eng	Santa Monica
Dixon, William Joseph	Eng	Milwaukee, Wisconsin
Doig, Keith*	Eng	Glendale
Dotson, Billy Ray*	Eng	San Diego
Downes, Bertram Wilson*	Eng	Beverly Hills
Driver, James Ogden*	Eng	Los Angeles
Dunkel, Carl Peter*	Eng	Chicago, Illinois
Dunn, Donald Allen*	Eng	South Pasadena
Dyson, Jerome Packard*	Eng	Pasadena
Elliott, Robert Edward*	Eng	Riverside
Ellis, Marston Bishop*	Eng	Pasadena
Ely, Silas James*	Eng	Altadena
Esner, David Robert	Sci	Pasadena
Evans, James Carter*	Eng	Los Angeles
Fagan, Peter James	Eng	Bakersfield
Farmer, Stanley Eugene*	Eng	Corona
Fein, George Samuel	Sci	East Chicago, Indiana
Ferrell, Richard Allan	Sci	Pasadena
Fisher, Floyd Clair*	Eng	Diamond Springs
Fleming, John Eaton*	Eng	Pasadena
Fleming, Wallis Taylor*	Eng	Cashion, Arizona
Foote, Robert Warren*	Eng	Santa Paula
Frohman, Robert*	Eng	Culver City
Fuller, Thomas Lester*	Eng	Austin, Texas
Fulton, David Holmes*	Eng	Redlands

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Furst, Donald Guy*	Eng	Los Nietos
Garbe, Carl John*	Eng	Pittsburgh, Pennsylvania
Gardner, Robert Munroe	Eng	Santa Paula
Gerpheide, John Henry*	Eng	Pasadena
Gibbins, Sidney Gove	Sci	North Hollywood
Gift, Myrven Frank	Sci	Glendale
Gill, George Sanderson*	Eng	Los Angeles
Golding, Robert Alexander	Sci	Long Beach
Gottlieb, Norman Arnold*	Eng	Los Angeles
Gould, Edwin Sheldon	Sci	Los Angeles
Green, Joseph Matthew	Sci	Los Angeles
Greenfield, Howard Lee*	Eng	Alhambra
Gryder, John William	Sci	Los Angeles
Hall, Stephen*	Eng	Spring Valley
Hammerle, William Gordon	Sci	Athens, Ohio
Handsfield, Robert William*	Eng	Anaheim
Hargrove, Phillip Eugene*	Eng	Anaheim
Haynes, William Paul*	Eng	San Jacinto
Henigson, Robert	Sci	Los Angeles
Herzog, Leonard Frederick, II	Sci	Los Angeles
Hicks, Donald Beery*	Eng	Tacoma, Washington
Hill, George Kenneth*	Eng	Alhambra
Hogness, David Swenson	Sci	Chicago, Illinois
Hopkins, Donn Emery*	Eng	Lake Grove, Oregon
Horton, William Franklin	Sci	Carpinteria
Howard, Paul Lamar*	Eng	Atlanta, Georgia
Hufford, George Allen	Eng	Seattle, Washington
Huggins, John William*	Eng	Redwood City
Ingram, Wilbur Atwood*	Eng	Chicago, Illinois
Ireland, Jerold Robert*	Eng	Santa Barbara
Jensen, Jack Leonard*	Eng	Los Angeles
Jensen, Louis Koehler*	Eng	San Marino
Jessen, Howard Ellsworth*	Eng	La Canada
Jones, Jack Ngum	Eng	Willows
Jordan, Robert Bernard*	Sci	Phoenix, Arizona
Jorgensen, Frank C.*	Eng	Los Angeles
Jurach, Paul John*	Eng	Sacramento
Keese, Oliver John	Eng	Los Angeles
Kelly, Thomas Woodward*	Eng	Baltimore, Maryland
Kempton, Calvin Ernest*	Eng	Arcadia
Kendall, Robert Murray*	Eng	San Gabriel
Khazoyan, Ben Baron*	Eng	Pasadena
King, Richard Galpin	Eng	Orange
Kirkendall, Richard Stanley	Eng	Compton
Klein, Albert Odgers*	Eng	Sacramento
Koch, Arthur Louis	Sci	Pasadena
Lagerstrom, Richard Perry*	Eng	South Pasadena
Lamson-Scribner, Frank Hamilton*	Eng	Coronado
Lang, Serge Robert	Sci	Beverly Hills
Lehmer, Donald Eugene*	Eng	Anaheim
Leighton, Thomas Carver	Sci	Santa Monica
Lent, Charles Stephen*	Eng	Long Beach
Leo, Robert Emmet*	Eng	San Mateo
Levin, Richard Grant*	Eng	San Francisco
Levinson, Norman Jay	Eng	Chicago, Illinois
Lewis, David Richard*	Eng	Petersburg, Virginia

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Lewis, James Adams*	Eng	Redding
Libbey, William Hoogs*	Eng	Honolulu, Hawaii
Liekhus, Eugene Adolph*	Eng	Anaheim
Linam, Paul Audrey	Sci	Los Angeles
Lincoln, David Colvill	Eng	Scottsdale, Arizona
Lindsay, Donald Ransom*	Eng	Los Angeles
Long, Walter Alfred*	Eng	Valhalla, New York
Macdonald, Norman Joseph*	Eng	Bethesda, Maryland
Maillard, William Charles	Eng	Rochester, New York
Markham, Richard Glover*	Eng	Altadena
Mason, Robert Doelter*	Eng	San Jose
McCann, Hal Dane*	Eng	Long Beach
McCarthy, James, Lee*	Eng	Great Falls, Montana
McCarthy, John	Sci	Los Angeles
McEwen, Cassius Richard*	Eng	Missoula, Montana
McCready, Colin*	Eng	East Orange, New Jersey
Meixner, George Donald, Jr.*	Eng	Long Beach
Mendes, Stanley Harold*	Eng	Los Angeles
Miller, Edward Wilson*	Eng	Los Angeles
Miller, Emanuel Jacques*	Eng	Roanoke, Virginia
Mills, Walter William*	Eng	Santa Ana
Mitchel, Glen Henry, Jr.	Eng	Los Angeles
Moje, William	Sci	Los Angeles
Montemezzi, Marco Antonio	Sci	Beverly Hills
Moody, Charles Colburn Bills	Eng	Santa Monica
Moorehead, Basil Elmo Atkins	Sci	Los Angeles
Morgan, Howard Wall, Jr.*	Eng	Scarsdale, New York
Morford, Anderson LeRoy	Eng	Martinez
Murdock, Fred Cunningham*	Eng	Kansas City, Missouri
Muzychenko, Paul Joseph*	Eng	Lawrence, Massachusetts
Neale, Edward George	Sci	Reseda
Newbrough, Robert Lee*	Eng	Barstow
Nielsen, David Beers*	Eng	Santa Ana
Nieto, Paul George*	Eng	Oakland
Nixon, Stanley Reid*	Eng	Los Angeles
Norman, Jack Trevor*	Eng	Glendive, Montana
Ouglea, Gerald John*	Eng	San Jose
Peavy, Bradley A.*	Eng	Long Beach
Peeler, Robert Lee, Jr.*	Eng	Santa Monica
Picella, Modesto Vincent*	Eng	Los Angeles
Piemme, Francis Martin*	Eng	Taft
Pierpoint, Robert Charles*	Eng	Pomona
Pond, Murray Douglas*	Eng	Lancaster
Pool, George Robert, Jr.*	Eng	Phoenix, Arizona
Pothe, George Raymond*	Eng	Fullerton
Quintero, Donald Baldwin*	Eng	Brawley
Rand, Murdock MacDonald*	Eng	St. Johns, Michigan
Rasmussen, John Oscar, Jr.	Sci	Pasadena
Rauch, Harry Ernest	Sci	Pasadena
Rechtin, Eberhardt*	Eng	Palos Verdes
Reeder, William Spence*	Eng	Pasadena
Reichwein, Fremont Easton*	Eng	South Pasadena
Rice, Jerry H.*	Eng	Wenatchee, Washington
Robinson, Kenneth Walter*	Eng	Los Angeles
Rodgers, Bertram Joseph*	Eng	Los Angeles
Roese, Robert	Eng	Pacific Palisades

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Name	Option	Home Address
Rogers, William Bliss*	Eng	Berkeley
Root, Donald Everett*	Eng	Long Beach
Ross, Willard Allen*	Eng	Arcadia
Royden, Herbert Nathan*	Eng	Los Angeles
Rumer, William Isaac	Eng	Van Nuys
Rutishauser, Rudolf Walter*	Eng	Pasadena
Sarmento, Harold Leland*	Eng	Soledad
Schmidt, Louis Vincent	Eng	San Rafael
Schneider, Jerome William*	Eng	Jasper, Indiana
Schuster, Richard Philip*	Eng	Beverly Hills
Seegrave, John Dorrington*	Eng	Pasadena
Seifert, Charles Jacob*	Eng	New Orleans, Louisiana
Selby, William Arnold*	Eng	Petrolia
Sensibaugh, Robert Ford*	Eng	Los Angeles
Shaw, Charles Bergman, Jr.	Sci	Dallas, Texas
Shepard, Elmer Ralph*	Eng	Wenatchee, Washington
Shiells, James Francis, Jr.	Eng	Fillmore
Shipway, George Don*	Eng	Sierra Madre
Showell, John Sheldon	Sci	Pasadena
Siegel, Robert Charles*	Eng	Los Angeles
Simmons, Harold Clive*	Sci	Santa Monica
Singleton, Walter Hobbs*	Eng	Mammoth, Arizona
Six, Gene David	Sci	Pasadena
Smith, Richard Allen	Eng	Laguna Beach
Solum, Clayton Lawrence*	Eng	Huntington Park
Stearns, Alan Riley*	Eng	Glendale
Stensgaard, Conrad Peter, Jr.	Sci	Pasadena
Stewart, Dale Fredrick	Sci	Fallbrook
Stewart, Fletcher James*	Eng	Anaheim
Stewart, Robert Malcolm*	Eng	Arlington, Virginia
Stiles, Stanford Grant*	Eng	Whittier
Stites, James Franklin*	Eng	Pomona
Stookey, William Chapman*	Eng	Tacoma, Washington
Strauss, Milton Arthur*	Eng	Lake Mills, Wisconsin
Strong, Herbert William	Sci	Cleveland Heights, Ohio
Stunkard, Norman Wilbur*	Eng	Hillsboro, Oregon
Sullivan, Grant Dexter*	Eng	Whittier
Taber, John Everett*	Eng	Burbank
Tackaberry, Dewey Albert*	Eng	Beverly Hills
Tang, Kenneth Kai-nan	Eng	Berkeley
Taylor, Robert Wilson*	Eng	Los Altos
Taylor, William Clifford*	Eng	Riverside
Tietz, Joseph Elliot	Sci	Arcadia
Todd, Tim Monroe*	Eng	Bellflower
Trainer, Charles Franklin*	Eng	East Liverpool, Ohio
Traverse, Donald Kenneth*	Sci	South Gate
Tucker, Robert Ernest*	Eng	Pittsburg
Updyke, Robert Frank*	Eng	Fullerton
Van Boemel, Edward Gerard*	Eng	Glendale
Van Heusden, Aristide	Eng	Altadena
Vetter, James Edward*	Eng	Fullerton
Voyles, Leo Russell*	Eng	Phoenix, Arizona
Wade, Orison	Eng	Lawndale
Wagner, Carl Bernard*	Eng	San Francisco
Walker, Robert Lawrence*	Eng	San Pedro
Warner, Richard Calvin*	Eng	Wasilla, Alaska

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Option	Home Address
Watson, Fred Simcoe*	Eng	Valley Station, Kentucky
Watt, George Raymond*	Eng	Pomona
Webb, Milton Gene*	Eng	Santa Ana
Webber, Carroll Aubrey, Jr.	Sci	Westfield, New Jersey
Westervelt, Donald Ramsey	Eng	Darien, Connecticut
White, Ralph Simpson*	Eng	Coalinga
Wilford, David Brice	Sci	La Jolla
Williams, Ray Leland*	Eng	Spokane, Washington
Williams, Thomas Blair*	Eng	Altoona, Pennsylvania
Williams, Wayne Clark*	Eng	Los Angeles
Wilson, Teck Albert*	Eng	Seattle, Washington
Wise, Robert Campbell*	Eng	Williamsport, Pennsylvania
Wolbers, Harry Lawrence*	Eng	Los Angeles
Wood, David Edmund*	Eng	San Jose
Woods, Howard Russell*	Eng	Baldwin Park
Woods, William Charles Alva	Sci	San Bernardino
Wozniak, Jacob Francis*	Eng	Pasadena
Wright, Kenneth King, Jr.*	Eng	South Pasadena
Youtz, Byron Leroy	Sci	Santa Maria

FRESHMAN CLASS

Name	Home Address
Alexander, Richard Clarke	Los Angeles
Andres, John Milton	Anaheim
Aron, William Henry	Manhattan Beach
Armstrong, David Ligon	Ontario
Ashe, William Bolado*	San Francisco
Badgley, Max Elwood*	Jackson, Michigan
Barker, Arthur Lyle*	Ajo, Arizona
Bergstrom, George Willard	North Hollywood
Bittner, William Edward	Sacramento
Blackman, Wayne Sturge*	Altadena
Bone, Kenneth Vaughn	Pasadena
Boulter, Kenneth Murray	Los Angeles
Brooks, Robert Craighead, Jr.	Cornelia, Georgia
Brown, Anthony Preble	Burlingame
Buford, Phillip Nolen*	Mansfield, Arkansas
Burke, John Junior*	Los Angeles
Calligeros, John Peter*	Bronx, New York
Carlisle, David Kay	Los Angeles
Carus, Milton Blouke	La Salle, Illinois
Chinn, Newton Kui Shin	Honolulu, T. H.
Coates, James Stansberry*	Monrovia
Colley, Joseph Page*	San Bernardino
Coons, Thomas Paul	South Pasadena
Cowan, Edwin Jack*	Hollywood
Crowhurst, Herbert Edward, Jr.*	Yuba City
Crumly, Charles Burton*	Los Angeles
Cunningham, Robert Emmet*	Wilmette, Illinois
Curray, Joseph Ross	Cedar Rapids, Iowa
Darms, Fred John, Jr.	Arcadia
Davis, Herbert Isaac*	Arcadia
Dayman, Bain, Jr.	Sunland
Decker, Robert Willard	Oakland
Donelson, Andrew Jackson*	Tucson, Arizona

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Home Address
DuFort, Edward Charles	Los Angeles
Elia, Lewis George	Pasadena
Ellis, James Stephen	Santa Monica
Evenson, William Frederick*	San Diego
Everett, Aubrey Cortez*	Magee, Mississippi
Fasola, Henry, Jr.	Glendale
Felberg, Richard LeRoy*	Monrovia
Finnegan, Bernard Joseph	Burbank
Flahive, Thomas Joseph*	Kansas City, Missouri
Flam, Frederick Herbert	Los Angeles
Forrester, Amasa	Pasadena
Fowler, Albert Baird	Denver, Colorado
Gates, Frank Sumner*	Anaheim
Goldwater, Marc Lawrence	Los Angeles
Gould, Roy Walter	Colton
Grube, Robert Harry*	Los Angeles
Hamilton, Gordon Wayne	Wenatchee, Washington
Harder, James Albert	Long Beach
Hardy, George Fisk	Pass-a-Grille, Florida
Harmon, Francis Michael*	New York, New York
Hayne, Benjamin Stiles*	Pasadena
Heiman, Jarvin	Los Angeles
Hildebrandt, Frank Mahlon	Arcadia
Honer, Richard Charles	Santa Ana
Hood, John Acland	Los Angeles
Housman, Howard Burton	San Antonio, Texas
Hughes, Ralph Oliver*	Camino
Ida, Edward Stanley*	Chicago, Illinois
Jennings, Edwin Berg*	Patterson
Johnson, Gaylen Morris	Salt Lake City, Utah
Jung, Moe You	Los Angeles
Kam, Merle Thayne Keliikopu	Honolulu, T. H.
Karzas, William James	Chicago, Illinois
Kim, James William*	Los Angeles
King, Daniel Warner	Burlingame
Knowles, Eugene Daniel*	San Francisco
Knudsen, Chresten Mills*	Redlands
Lee, Norman Ray*	Cotton Valley, Louisiana
Longley, Ted Conner	Monterey Park
Luebbert, William F.	Los Angeles
Lyon, George Wilson*	Kosse, Texas
Lyon, John Adams	Los Angeles
Machetanz, Frederick Allen	Exeter
Madden, David William	San Pedro
Martel, Hardy Cross	Pasadena
Maxstadt, Donald Francis	Pasadena
McCandless, Harrison Charles	Redondo Beach
McClintic, Stanley Arthur	Monrovia
McKay, Richard Alan	Altadena
McLain, Joseph Prosser	Pasadena
Miller, Owen Lee	Long Beach
Mudgett, Walter LeRoy	Los Angeles
Mueller, Albert Herbert*	Van Nuys
Mullen, John Kingsley	Los Angeles
Nicolai, Fred Henry*	Redwood City
Nobles, Laurence Hewit	Spokane, Washington

*Apprentice Seaman, Navy V-12 College Training Program.

Name	Home Address
Otto, Donald Waldo	Fresno
Parker, James Henry, Jr.	Bakersfield
Pavlovich, Sam Marko*	Fresno
Perry, Wearn Ivey, Jr.*	Santa Paula
Pierce, Richard Scott	Mar Vista
Powell, Flavius Morton, Jr.*	Madison, Tennessee
Prestridge, Robert Paul*	San Antonio, Texas
Price, Carl Arthur	Long Beach
Price, John Francis	Pasadena
Richter, John Edward*	Los Angeles
Riesenfeld, Werner Boris	Los Angeles
Ricks, Paul Cardon*	Marin City
Roehm, Richard Monroe	Long Beach
Ross, Martin Neal	Los Angeles
Rudin, Marvin Bernard	Los Angeles
Rutkin, Burton	Los Angeles
Schoen, Richard Isaac	New Rochelle, New York
Schroeder, Donald Albert	Orange
Scull, John Raymond*	Los Angeles
Shaffer, Perry*	Claremont
Shewmaker, Charles Arthur	San Diego
Simmons, George Finlay	Chicago, Illinois
Sinker, Robert Allen	Los Angeles
Smith, Charles Edwin*	Fontana
Smith, Ralph Christie	Arcadia
Stark, Richard Ira	Wilmington
Stein, Sherman Kopalo	Hollywood
Stoddart, Hugh Franklin	Portland, Oregon
Stone, Ralph Jay	Pasadena
Sulmeyer, Irving Ira	Los Angeles
Sutyak, John*	Pittsburgh, Pennsylvania
Sweet, Richard Gordon*	Los Angeles
Utschig, Robert Harold*	Glendale
Vieweg, Arthur Francis	Wilmington
Vrebalovich, Thomas	Los Angeles
Washburn, Curtis Goss	Los Angeles
Wax, Philip F.	Honolulu, T. H.
Westlake, Howard Roy*	Lihue, Kauai, T. H.
Whitehead, William Robert*	San Francisco
Willis, Jack Kester	San Francisco
Wood, Philip Densmore	Knightstown, Indiana
Yarger, Robert Wilbur	Los Angeles
Zablow, Leonard	New York, New York

*Apprentice Seaman, Navy V-12 College Training Program.

SPECIAL STUDENTS

(1943-1944)

Name	Major Subject	Home Address
Abbott, John Robert	My	Oneida, South Dakota
Almy, Harry Douglas	My	Denver, Colorado
Anderson, George Ross	My	Pelham Manor, New York
Anderson, John Ernest	My	Messila Park, New Mexico
Anderson, Nathan Lorraine	My	Miami, Florida
Anderson, Percy Jennings, Jr.	My	San Antonio, Texas
Appel, David Robert	My	Denver, Colorado
Archer, Cass Louis	My	Lubbock, Texas
Austin, Homer Day	My	Wirt, Oklahoma
Babcock, Washington Clay	My	Alexandria, Indiana
Barker, Norman H.	My	Pratt, Kansas
Bassler, Ellery Frost	My	Waupaca, Wisconsin
Bauman, John Lee, Jr.	My	Omaha, Nebraska
Beauchamp, Elvis Erdley	My	Manning, Iowa
Beck, Donald James	My	Newport, Kentucky
Belcher, Herbert Robertson	My	Lubbock, Texas
Bell, John William	My	San Antonio, Texas
Bell, William Emmett	My	Culver City
Benjamin, Donald Grant	My	Friend, Nebraska
Bennett, George Griffin	My	Springvale, Georgia
Bergh, Arndt Bergh	My	Staples, Minnesota
Best, Robert Allyn	My	Omaha, Nebraska
Bissett, Charles Frank	My	Junction, Texas
Blake, William Robert	My	Baxter Springs, Kansas
Booth, Edward Basil	My	Indianapolis, Indiana
Botts, Robert Elgin	My	Meadville, Missouri
Bourdet, Edward Daniel	My	New Orleans, Louisiana
Bowen, Mark Edward	My	Franklin, Indiana
Boydstun, Charles Cox	My	Galesburg, Illinois
Brown, Ralph Clinton, Jr.	My	Buckhannon, West Virginia
Brueggemann, Harry Paul	My	St. Louis, Missouri
Buck, Frank Edward	My	Duluth, Minnesota
Burch, Joseph Eugene	My	West Milford, West Virginia
Burke, William Gibson	My	Billings, Montana
Burton, Philip Edward	My	Lansing, Michigan
Cage, Charles Clinton, Jr.	My	Fisher, Arkansas
Callahan, Jack Darwin	My	Tulsa, Oklahoma
Campagna, Salvador Joseph	My	Chalmette, Louisiana
Campbell, Sullivan Graham	My	Merriam, Kansas
Campion, Paul Edward	My	Moorhead, Minnesota
Carrigan, Ralph Stephen	My	Jackson, Mississippi
Casaverde, Mateo Rio	My	Lima, Peru
Chope, Henry Roy, Jr.	My	Louisville, Kentucky
Coble, Roger Whitney	My	Urbana, Illinois
Cohen, Marvin Stanley	My	Brooklyn, New York
Collmer, Russell Cravener	My	North Hills, Pennsylvania
Copeland, Guy Brooks	My	Alpine, Tennessee
Cowden, Warren Lloyd	My	Evansville, Minnesota
Cram, Ernest Richard	My	St. Francis, Kansas
Crawford, William Donham	My	Little Rock, Arkansas
Culp, Louis Max	My	Troy, Kansas

Name	Major Subject	Home Address
Curtis, James Owen	My	Berryville, Arkansas
Darling, Donald Allan	My	Pasadena
Denney, Roy Donald	My	Oilton, Oklahoma
Dessauer, Herbert Clay	My	New Orleans, Louisiana
Devaney, Howard Franklin	My	Waco, Texas
Deveny, Charles Albert, Jr.	My	Corsicana, Texas
Dewell, Edgar Harrison	My	Omaha, Nebraska
Dittmar, Robert Adolph	My	Geronimo, Texas
Dorchester, Ernest David	My	Denison, Texas
Edwards, Frank Todd, Jr.	My	Stillwater, Oklahoma
Elliott, Rex Theodore	My	Oklahoma City, Oklahoma
Ellis, Keith Stanton	My	Claremont
Estrada, Neil Stuart	My	San Francisco
Fagan, John Harry	My	Shawnee, Oklahoma
Fisher, Cecil Coleman	My	Omaha, Nebraska
Fisher, Luther Fitzgerald	My	Dallas, Texas
Foster, William Roderick	My	Springfield, Missouri
Fox, Elmer Joseph	My	Pasadena
Fulton, Robert Verne	My	Keosauqua, Iowa
Garrison, James Baxter	My	Fort Smith, Arkansas
Grant, Lewis O.	My	Henryetta, Oklahoma
Grasso, Clarence Henry	My	San Antonio, Texas
Gray, Thomas B., Jr.	My	Newcastle, Wyoming
Green, James William	My	Stephens, Arkansas
Grissom, George Mack	My	Port Arthur, Texas
Guimaraes, Mario Alves	My	Sao Paulo, Brazil
Hahs, Martin Luther	My	Friedheim, Missouri
Halbower, Ralph David	My	Fort Worth, Texas
Hall, Arthur Satterly	My	Middletown, New York
Hallwachs, Robert Gordon	My	Naperville, Illinois
Harrison, Charles Philip	My	Mount Pleasant, Michigan
Harrison, Marvin Eugene	My	Stratford, Texas
Hawk, Riddell Lee	My	Dallas, Texas
Hightower, John Allen	My	Ancho, New Mexico
Hill, Robert Allan, Jr.	My	Amarillo, Texas
Holton, Dexter Stone	My	Keene, New Hampshire
Holton, Lloyd Sumner	My	Toledo, Ohio
Hughes, Lawrence Edwin	My	Birmingham, Alabama
Jenista, Charles Otto, Jr.	My	Oak Park, Illinois
Johnson, Howard Earl	My	Denver, Colorado
Johnson, Lewis Benjamin, Jr.	My	Charlottesville, Virginia
Johnson, Lloy Dale	My	Viola, Kansas
Johnson, William Martin	My	Tacoma, Washington
Johnstone, Malcolm Brice	My	Beaumont, Texas
Katz, Irwin Isaac	My	Bayonne, New Jersey
Kendrick, Neil Baker	My	San Benito, Texas
Kern, Jack Charles, Jr.	My	Dallas, Texas
Kincannon, William Charles	My	Hastings, Oklahoma
Kinney, Richard Leroy	My	Wichita, Kansas
Landry, Alvin H.	My	Lafayette, Louisiana
Landry, Theodore Eugene, Jr.	My	Port Allen, Louisiana
Leenerts, Lester Orin	My	LaPrairie, Illinois
Leiderman, Philip Herbert	My	Chicago, Illinois
Lemon, Charles Neel	My	Little Rock, Arkansas
Lewis, Robert Nelson	My	Fort Wayne, Indiana
Liddicoat, Richard Thomas, Jr.	My	Ann Arbor, Michigan
Long, Ralph Fredrick	My	Redondo Beach

Name	Major Subject	Home Address
Low, Philip F.	My	Salt Lake City, Utah
Lunday, Adrian Carl	My	Waco, Texas
Luppino, Domenick Anthony	My	Brooklyn, New York
MacDonald, Norman Scott	My	Cleveland, Ohio
Madden, John Harrison	My	Springfield, Massachusetts
Magnin, Henry David	My	Beverly Hills
Maier, Robert Auten	My	Santa Monica
Martin, Robert Paul	My	Hettinger, North Dakota
McBreen, Kenneth Leon	My	Seattle, Washington
McQuate, John Truman	My	Tiffin, Ohio
Meadows, Paul	My	Crosbyton, Texas
Meier, William Ludwig, Jr.	My	Big Spring, Texas
Merlo, Anthony Louis	My	Pine Bluff, Arkansas
Miller, Keith Warren	My	Lake Norden, South Dakota
Mills, Warner Everett, Jr.	My	Kirksville, Missouri
Moore, Frank Hathaway, Jr.	My	Denver, Colorado
Moore, Fred Edward	My	Lafayette, Colorado
Moore, William James	My	Pine Bluff, Arkansas
Moreland, William Burt	My	Glendale
Munger, Charles Thomas	My	Omaha, Nebraska
Murphy, Donald Blaine	My	Tacoma, Washington
Myers, Lewis William	My	Santa Monica
Nagle, Edgar Thomas, Jr.	My	Fort Worth, Texas
Naldret, Dean Allen	My	Ithaca, Michigan
Nommensen, Erwin Ward	My	Joplin, Missouri
Norris, Fred Earl, Jr.	My	San Diego
Ogden, Donald Emmett	My	Los Angeles
Oliver, Clifford William, Jr.	My	Cincinnati, Ohio
Oliver, Edward Dionysius, Jr.	My	El Paso, Texas
Olson, Clifford A.	My	Culver City
Paist, Horace Curtis	My	Wayne, Pennsylvania
Phillips, Byron Blake	My	Manhattan, Kansas
Phipps, Robert Preston	My	Alhambra
Polansky, Robert	My	El Monte
Price, Vernon	My	McKinney, Texas
Purcell, Merlin Ariel	My	Idaho Falls, Idaho
Quon, Peter	My	San Diego
Reynolds, Joseph Edward, Jr.	My	Salina, Oklahoma
Rikel, Charles Robert	My	Ozone Park, New York
Riley, John Clifford	My	San Francisco
Roberts, Evan Elijah, Jr.	My	Memphis, Texas
Robertson, Edward Ray	My	New Orleans, Louisiana
Robinson, Burton White	My	Logan, Utah
Rugh, Frederic Wayne	My	Eugene, Oregon
Rula, Adam Anthony	My	DuBois, Pennsylvania
Sandison, Donald Arthur	My	Glendale
Saunders, Edward Chase	My	Whittier
Schalk, Thomas Sterling	My	Casper, Wyoming
Schei, Donald Alden	My	Minneapolis, Minnesota
Schreiner, Charles Ronald	My	Larned, Kansas
Sharp, Ceestes Billy	My	Waxahachie, Texas
Sheller, Frederick Jack	My	Bartlesville, Oklahoma
Shelly, Thomas Lee	My	Bishop
Shults, Mayo Glenwood	My	Garden City, Kansas
Sieger, Richard Joseph	My	Los Angeles
Simms, Willis Edwin	My	Ceres
Skinner, Wilfred Aubrey	My	Fort Smith, Arkansas

Name	Major Subject	Home Address
Smith, James Emmet	My	Denver, Colorado
Smith, Wayne Averill	My	San Diego
Sorenson, John Leon	My	Smithfield, Utah
Stanford, Harry Wright	My	Palestine, Texas
Stein, Roberto Liebes	My	Guatemala, Central America
Stemler, Robert Paul	My	Cincinnati, Ohio
Stephens, Dale Jess	My	Norwich, Kansas
Stevenson, Lawrence Grant	My	Princeton, Kansas
Stoller, David Samuel	My	Los Angeles
Stonebraker, Donald Marvin	My	Monterey Park
Strange, David Alloway	My	Antioch
Sullivan, Hubert Cornelius	My	Manchester, New Hampshire
Sullivan, Richard Burl, Jr.	My	Shreveport, Louisiana
Tait, Frank Stearns	My	Milbank, South Dakota
Thompson, John Curtis	My	North Little Rock, Arkansas
Timm, Wayne Carroll	My	Fayette, Iowa
Van Slyke, George Gibson	My	Dallas, Texas
Waddell, Mathis Theron	My	Goose Creek, Texas
Walker, John Charles Fremont, III	My	Bartlesville, Oklahoma
Wallace, William Lowry	My	Lubbock, Texas
Weil, James Knerr	My	North Hills, Pennsylvania
Wein, Edgar Twellman	My	New Melle, Missouri
Weygandt, Elton Ray, Jr.	My	Manhattan, Kansas
Wheeler, Henry Orson, Jr.	My	Los Angeles
Whitaker, Bruce Johnson	My	San Gabriel
Williams, Joe Keith	My	Lubbock, Texas
Willis, John Gibson	My	Durant, Oklahoma
Wills, Wayne Jackson	My	Topeka, Kansas
Wingerd, Winston Harold	My	Navarre, Kansas
Wolf, William Theodore	My	St. Louis, Missouri
Woods, Marion Chase	My	Dove Creek, Colorado
Writt, John Joseph	My	Topeka, Kansas
Wuslich, Joseph Milo	My	Export, Pennsylvania
Yoho, Lewis Wilbur	My	Terre Haute, Indiana
Zacha, Richard Bane	My	Dallas, Texas

SUMMARY

GRADUATE SCHOOL

Research Fellows	20	
Research Assistants of the Institute	20	
Graduate Students		
Aeronautics	56	
Biology	12	
Chemistry	20	
Civil Engineering	13	
Geology	6	
Electrical Engineering	9	
Industrial Design	1	
Mathematics	9	
Mechanical Engineering	9	
Meteorology	2	
Ordnance	9	
Physics	21	
		167

UNDERGRADUATE SCHOOL

Seniors	139	
Juniors	265	
Sophomores	271	
Freshmen	132	
		807
Special Students	200	
		1174

COURSES AND OPTIONS OF UNDERGRADUATE STUDENTS

Science Course	Seniors	Juniors
Biology	1	4
Chemistry	3	3
Applied Chemistry	2	4
Geology	1	1
Mathematics	2	1
Physics	3	25
Applied Physics	0	3
Total	12	41

Engineering Course		
Aeronautics	0	38
Civil	29	28
Electrical	29	67
Mechanical	69	91
Total	127	224

GENERAL INDEX

INDEX OF NAMES

Names in the lists specified below are not included in this index, as they are already arranged alphabetically in the indicated sections of this Catalogue.

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