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DECEMBER 10, 1927

Colleges of Engineering and Architecture

Annual Announcement

1928-1929



PUBLISHED BY THE UNIVERSITY, ANN ARBOR, MICHIGAN

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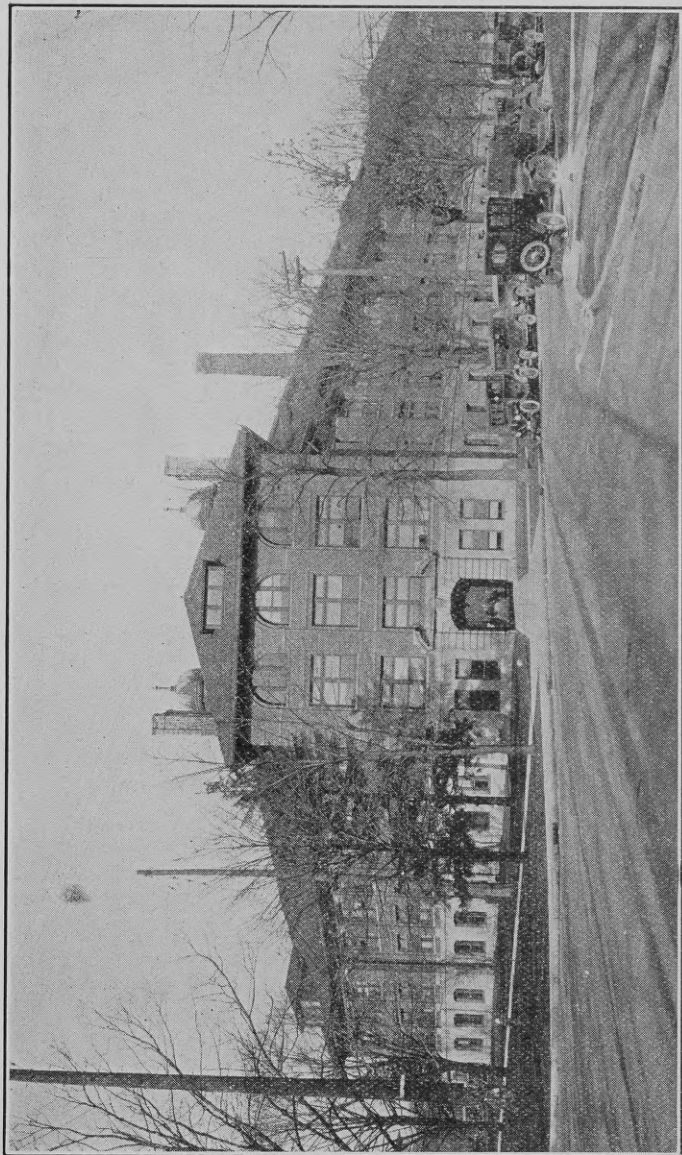
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(Continued on inside page of back cover.)



WEST ENGINEERING BUILDING

Colleges of Engineering and Architecture

Annual Announcement
1928-1929



Ann Arbor
Published by the University
1928

Calendar

1928

June	2	Semester Examinations Begin
June	18	COMMENCEMENT
June 25-August 17		Summer Session
September	10-16	Freshman Week
September	10-14	<i>Examinations for Admission</i>
September 15 and 17		Classification of All Students
September	18	FIRST SEMESTER BEGINS
November	29	Thanksgiving Day
December	21	(Evening) Holiday Vacation Begins

1929

January	7	(Morning) Classes Resumed
January	21	Semester Examinations Begin
Jan. 31—Feb.	2	<i>Examinations for Admission</i>
February	1	(Evening) First Semester Closes
February 2 and 4		Classification for Second Semester
February	5	SECOND SEMESTER BEGINS
February	22	Holiday, Washington's Birthday
April	5	(Evening) Spring Vacation Begins
April	15	Classes resumed
May	30	Holiday, Memorial Day
June	1	Semester Examinations Begin
June	17	COMMENCEMENT
June 24-August 16		Summer Session
September	16-21	Freshman Week
September	16-20	<i>Examinations for Admission</i>
Sept. 21 and 23		Classification of All Students
September	24	FIRST SEMESTER BEGINS

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1928											1929																
JANUARY					JULY						JANUARY					JULY											
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
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8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14	8	9	10	11	12	13	14
15	16	17	18	19	20	21	15	16	17	18	19	20	21	15	16	17	18	19	20	21	15	16	17	18	19	20	21
22	23	24	25	26	27	28	22	23	24	25	26	27	28	22	23	24	25	26	27	28	22	23	24	25	26	27	28
29	30	31	29	30	31	29	30	31	29	30	31
FEBRUARY					AUGUST						FEBRUARY					AUGUST											
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5	6	7	8	9	10	11	5	6	7	8	9	10	11	5	6	7	8	9	10	11	5	6	7	8	9	10	11
12	13	14	15	16	17	18	12	13	14	15	16	17	18	12	13	14	15	16	17	18	12	13	14	15	16	17	18
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26	27	28	29	30	31	...	26	27	28	29	30	31	...	26	27	28	29	30	31	...	26	27	28	29	30	31	...
APRIL					OCTOBER						APRIL					OCTOBER											
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
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22	23	24	25	26	27	28	22	23	24	25	26	27	28	22	23	24	25	26	27	28	22	23	24	25	26	27	28
29	30	29	30	31	29	30	29	30
MAY					NOVEMBER						MAY					NOVEMBER											
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
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13	14	15	16	17	18	19	13	14	15	16	17	18	19	13	14	15	16	17	18	19	13	14	15	16	17	18	19
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27	28	29	30	31	27	28	29	30	31	27	28	29	30	31	27	28	29	30	31
JUNE					DECEMBER						JUNE					DECEMBER											
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
...	1	2	1	1	1	...
3	4	5	6	7	8	9	3	4	5	6	7	8	9	3	4	5	6	7	8	9	3	4	5	6	7	8	9
10	11	12	13	14	15	16	10	11	12	13	14	15	16	10	11	12	13	14	15	16	10	11	12	13	14	15	16
17	18	19	20	21	22	23	17	18	19	20	21	22	23	17	18	19	20	21	22	23	17	18	19	20	21	22	23
24	25	26	27	28	29	30	24	25	26	27	28	29	30	24	25	26	27	28	29	30	24	25	26	27	28	29	30
...	30	31	30	30

The days that the University is in session are printed in Light face type; Sundays, holidays, and vacations in Dark face.

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- WILLIAM H. EGLY, A.M., *Assistant Professor of English*
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- MAURICE BARKLEY EICHELBERGER, B.S., *Assistant Professor of Mechanism and Engineering Drawing* 906 Rose Avenue
- ALFRED LYNN FERGUSON, B.Pd., Ph.D., *Assistant Professor of General and Physical Chemistry*
Packard Road
-

*Absent on leave.

**Absent on leave, 1927-1928.

- FLOYD FIRESTONE, B.S., *Assistant Professor of Physics and Assistant Investigator, Department of Engineering Research*
408 East Kingsley Street
- CHARLES WINFRED GOOD, B.S., *Assistant Professor of Mechanical Engineering and Assistant to the Director of Engineering Research*
622 South Seventh Street
- CHARLES BURTON GORDY, A.M., *Assistant Professor of Mechanical Engineering and Lecturer on Production Management*
1929 Lorraine Place
- HOLGAR MAD S HANSEN, B.C.E., *Assistant Professor of Mechanism and Engineering Drawing*
1210 Wells Street
- JAMES HALLETT HODGES, Ph.D., *Assistant Professor of General and Physical Chemistry*
722 Whaley Court
- OLIVER NELSON HOLLIS, A.B., *Assistant Professor of Mechanical Engineering*
1411 East Jefferson Avenue, Detroit
- RUSSELL C. HUSSEY, Ph.D., *Assistant Professor of Geology*
1420 Geddes Avenue
- ANTHONY JOSEPH JOBIN, A.M., *Assistant Professor of Modern Languages*
1110 White Street
- HUGH EDWARD KEELER, M.S.E., *Assistant Professor of Mechanical Engineering*
508 Elm Street
- CLARENCE FRANK KESSLER, M.S.E., *Assistant Professor of Mechanical Engineering*
Broadway Road
- RICHARD THOMAS LIDDICOAT, B.S.E., *Assistant Professor of Engineering Mechanics*
605 Mary Court
- ANDERS FREDRIK LINDBLAD, Sc.D., *Assistant Professor of Naval Architecture*
1408 Wells Street
- HAROLD RHYS LLOYD, M.A., *Assistant Professor of Mechanical Engineering*
1321 Forest Court
- WILLIAM CHARLES LOUISELL, A.B., Captain U.S.A., *Assistant Professor of Military Science and Tactics*
613 Oakland Avenue
- ROY KENNETH MCALPINE, Ph.D., *Assistant Professor of Analytical Chemistry*
926 Sylvan Street
- HAROLD JAMES MCFARLAN, B.S.E., *Assistant Professor of Geodesy and Surveying*
Long Shore Drive

-
- DEAN B. McLAUGHLIN, Ph.D., *Assistant Professor of Astronomy*
540 Packard Street
- JOHN H. MADISON, 1st Lieutenant C.A.C., *Assistant Professor of Military Science and Tactics*
632 Oakland Avenue
- ALEX MARIN, B.S.E., *Assistant Professor of Mechanical Engineering*
Whitmore Lake Road
- WALTER VAN CLEVE MARSHALL, B.A.E., *Assistant Professor of Architecture*
1330 White Street
- CLIFFORD CYRILLE MELOCHE, Ph.D., *Assistant Professor of Analytical Chemistry*
525 Linden Street
- CHARLES FERDINAND MEYER, Ph.D., *Assistant Professor of Physics*
1137 Fair Oaks Parkway
- FRANK ALEXANDER MICKLE, M.E., *Assistant Professor of Mechanical Engineering*
1053 Olivia Avenue
- THOMAS JOSEPH MITCHELL, B.C.E., *Assistant Professor of Geodesy and Surveying*
1129 Granger Avenue
- ARTHUR DEARTH MOORE, M.S., *Assistant Professor of Electrical Engineering*
718 Onondaga Street
- GEORGE ALEXANDER MORLEY, B.S.(M.E.), *Assistant Professor of Mechanism and Engineering Drawing*
1321 Forest Court
- *JAMES BLAINE NEWMAN, B.A.E., A.M., *Assistant Professor of Architecture*
- JOHN MINERT NICKELSEN, B.S., *Assistant Professor of Mechanical Engineering*
511 Linden Street
- CHARLES THOMAS OLMSTED, B.S.(C.E.), *Assistant Professor of Engineering Mechanics*
2007 Washtenaw Avenue
- JULIUS CLARK PALMER, B.S., *Assistant Professor of Mechanism and Engineering Drawing*
412 East Huron Street
- DONALD LEE PERKINS, M.S.E., *Assistant Professor of Shop Practice*
1602 Packard Street
- LAWRENCE A. PHILIPP, Ph.D., *Assistant Investigator, Department of Engineering Research*
305 Washtenaw Apartments
-

*Absent on leave.

-
- PHILIP ORLAND POTTS, B.M.E., *Assistant Professor of Mechanism and Engineering Drawing* 824 Granger Avenue
- LEWIS STEPHEN RAMSDELL, Ph.D., *Assistant Professor of Mineralogy* Packard Road
- LOUIS JOSEPH ROUSE, Ph.D., *Assistant Professor of Mathematics* 1137 Michigan Avenue
- WILL CARL RUFUS, Ph.D., *Assistant Professor of Astronomy* 216 Pine Ridge
- WALTER CLIFFORD SADLER, M.S., *Assistant Professor of Civil Engineering* 1230 Woodlawn Avenue
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- *FRANCIS LEE SCHNEIDER, A.M., *Assistant Professor of English* 509 Benjamin Street
- RICHARD SCHNEIDEWIND, B.S., *Assistant Investigator, Department of Engineering Research* 210 Miller Avenue
- JAMES ALEXANDER SHOAT, Magister of Pure Mathematics, *Assistant Professor of Mathematics* 508 Thompson Street
- **WILLIAM WARNER SLEATOR, Ph.D., *Assistant Professor of Physics* 2503 Geddes Avenue
- JEAN PAUL SLUSSER, A.M., *Assistant Professor of Drawing and Painting* 1324 Pontiac Street
- ROY STANLEY SWINTON, M.S.E., *Assistant Professor of Engineering Mechanics* 1114 Woodlawn Avenue
- CHARLES H. THOMAS, A.M., *Assistant Investigator, Department of Engineering Research* 1212 Willard Street
- JESSE EARL THORNTON, A.M., *Assistant Professor of English* 1547 Granger Avenue
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-

*Absent on leave, first semester 1927-1928.

**Absent on leave 1927-1928.

- IVAN HENRY WALTON, A.M., *Assistant Professor of English and Assistant to Editor of Publications, Department of Engineering Research* 59 Rosewood Street
- HARRY JAMES WATSON, B.M.E., *Assistant Professor of Mechanical Engineering* 1510 Morton Avenue
- PHILIP FRANCIS WEATHERILL, Ph.D., *Assistant Professor of General and Physical Chemistry* 1123 Church Street
- CHRISTIAN N. WENGER, Ph.D., *Assistant Professor of English* 420 South Fourth Avenue
- HARLOW OLIN WHITTEMORE, M.L.D., *Assistant Professor of Landscape Design* 1920 Norway Road
- RALPH A. WOLFE, Ph.D., *Assistant Investigator, Department of Engineering Research* 66 Harpst Street
- EDWARD YOUNG, B.S.E., *Assistant Professor of Geodesy and Surveying* 1600 Montclair Place

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- FREDERICK HOWARD ALDRICH, Jr., *Instructor in Freehand Drawing and Painting* 510 Forest Avenue
- WERNER EMANUEL BACHMANN, Ph.D., *Instructor in Organic Chemistry* 826 McKinley Avenue
- CHARLES RONELLO BARNUM, B.S.A., *Instructor in Architecture* 732 South Division Street
- WILLARD H. BENNETT, M.S., *Instructor in Physics* 408 Hamilton Place
- GEORGE MOYER BLEEKMAN, M.S.E., *Instructor in Geodesy and Surveying* 1432 White Street
- HENRY BLITON, *Instructor in Shop Practice* 523 East Washington Street
- EDWIN A. BOYD, *Instructor in Highway Laboratory Practice* 832 Brookwood Place
- HEMPSTEAD STRATTON BULL, M.S., *Instructor in Electrical Engineering* Ann Arbor Hills
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- MYRON BUTMAN CHAPIN, Ph.B., *Instructor in Drawing and Painting*
1027 Forest Avenue
- RUEL V. CHURCHILL, M.S., *Instructor in Mathematics*
28 Rosewood Street
- WENDELL MORRIS COATES, M.Sc., *Instructor in Mathematics*
745 East University Avenue
- MARIA LOUISA CRANE, *Instructor in Freehand Drawing*
923 Olivia Avenue
- CARL LEONARD DAHLSTROM, A.M., *Instructor in English*
508 South Division Street
- DAVID M. DENNISON, Ph.D., *Instructor in Physics*
530 North Division Street
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- LLOYD HAMILTON DONNELL, B.M.E., *Instructor in Engineering Mechanics*
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- WILLIAM G. DOW, B.S.E., *Instructor in Electrical Engineering*
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- NEVIN COTTON FISK, M.S., *Instructor in Mathematics*
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- ROSWELL EARL FRANKLIN, B.S.E., *Instructor in Engineering Mechanics*
1328 Pontiac Street
- ALOYSIUS JOSEPH GAISS, A.M., *Instructor in Modern Languages*
322 East Ann Street
- HARRY ROBINSON GAMBLE, A.M., *Instructor in Architecture*
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- GEORGE GLITZENHIRN, *Instructor in Shop Practice*
1140 Forest Avenue

- SAMUEL A. GOUDSMIT, *Instructor in Physics*
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- JOHN GRENNAN, *Instructor in Shop Practice*
719 South Seventh Street
- DONAL HAMILTON HAINES, A.B., *Instructor in Journalism
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514 Forest Avenue
- GORDON W. HARRISON, Ph.B., *Instructor in Modern Lan-
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806 Sybil Street
- LEWIS NELSON HOLLAND, M.S., *Instructor in Electrical
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- WILLIAM STUART HOUSEL, B.S.E., *Instructor in Civil En-
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1515 Cambridge Road
- THOMAS JOHN KNEEBONE, *Instructor in Shop Practice*
816 Brookwood Place
- WARREN LEE MCCABE, M.S., *Instructor in Chemical Engi-
neering*
711 Packard Street
- THOMAS ALOYSIUS MCGUIRE, A.M., *Instructor in Modern
Languages*
906 East Huron Street
- JULIAN E. MACK, A.M., *Instructor in Physics*
924 Forest Avenue
- *LEON ALEXANDER MAKIELSKI, *Instructor in Drawing and
Painting*
-

*Absent on leave.

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- LEWIS K. MARSHALL, Lieut. (j.g.), U.S.N.R., *Instructor in Aviation*
Flint, Michigan
- RAYMOND MATHEWS, B.S.A., *Instructor in Architecture*
1508 Brooklyn Avenue
- LAWRENCE CARNAHAN MAUGH, M.S., *Instructor in Civil Engineering*
1103 Church Street
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- FRANCIS SKILLMAN ONDERDONK, Dr. of Technical Sciences,
Instructor in Architecture
1331 Geddes Avenue
- HERBERT FREDERICK SCHIEFER, M.S.E., *Instructor in Astronomy*
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- VICTOR VAUGHAN SLOCUM, *Instructor in Modelling*
Dexter
- JAMES HARRY SPIERS, *Instructor in Shop Practice*
402 South Observatory Street
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1215 Packard Street
- JOHN D. STRONG, A.B., *Instructor in Physics*
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- WILLIAM TELFER, *Instructor in Shop Practice*
R. F. D. 8, Washtenaw Road
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- CHARLES D. WILLIAMS, JR., Lieut. U.S.N.R., *Instructor in Aviation*
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1514 Montclair Place
- BERNARD F. YOUNG, A.M., *Instructor in English*
710 East Ann Street
- HAROLD MEAD YOUNG, *Instructor in Architecture*
114 Englewood Avenue, Detroit

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- MARVIN CARSON ROGERS, *Teaching Assistant in Chemical
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- HARRY LANCASTER WILCOX, B.S.E., *Teaching Assistant in
Electrical Engineering* 719 Oakland Avenue
- FRANK WOREL, B.S.E., *Teaching Assistant in Electrical En-
gineering* 1016 East Ann Street

Research Assistants

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neering* 715 Church Street
- JAMES G. WOODBURN, *Research Assistant in Civil Engineer-
ing* 12 Geddes Heights

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- JENS VILHELM AXEL AARGAARD, B.S., *Student Assistant in
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- ROBERT DOUGLAS ARMSTRONG, *Student Assistant in Geodesy
and Surveying* 1037 Baldwin Avenue

- LOUIS SMITH AURAND, *Student Assistant in Civil Engineering*
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- DONALD POTTER BRAKE, *Student Assistant in Geodesy and Surveying*
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- HERMAN WOOD CARNES, *Student Assistant in Mechanical Engineering*
720 Arbor Street
- BERNARD CLIO CASE, *Student Assistant in Chemical Engineering*
Brighton
- HAROLD JOHN CHALK, *Student Assistant in Mechanical Engineering*
604 East Madison Street
- AKSEL OLUF LANGKILDE CHRISTENSEN, B.S., *Student Assistant in Chemical Engineering*
1210 Wells Street
- BURR DELINE COE, *Student Assistant in Mechanical Engineering*
503 East Huron Street
- CALVIN HENRY COREY, *Student Assistant in Chemical Engineering*
1224 Washtenaw Avenue
- CLINTON HUXLEY COULTER, *Student Assistant in Geodesy and Surveying*
218 Wildwood Avenue
- DONALD BIRD DUNHAM, *Student Assistant in Civil Engineering*
1315 Hill Street
- HERMAN JOHN EICHENHOFER, *Student Assistant in Civil Engineering*
826 Tappan Avenue
- HENRY STEWART FELIX, *Student Assistant in Civil Engineering*
507 Hill Street
- CAROLYN MARY FISHER, *Student Assistant in Engineering Mechanics*
516 East Madison Street
- JAMES BEVERLY FLORENCE, *Student Assistant in Mechanical Engineering*
1020 Michigan Avenue
- WILLIAM BUCKLEY FORTUNE, *Student Assistant in Engineering Mechanics*
1043 Baldwin Avenue
- WILLIAM KEITH FRIEND, *Student Assistant in Mechanical Engineering*
1923 Geddes Avenue
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- WILVAN ALONZO GARDNER, *Student Assistant in Mechanical Engineering*
1516 Geddes Avenue

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- JOHN CLEVELAND HASTIE, *Student Assistant in Electrical Engineering* 916 Catherine Street
- ALOISIUS MARTIN JANASIK, *Student Assistant in Mechanical Engineering* 807 South State Street
- HERBERT T. JENKINS, *Student Assistant in Engineering Mechanics* 520 East Jefferson Street
- ENGELBERT GEORGE JOHN, M.S.E., *Student Assistant in Chemical Engineering* 1419 South University Avenue
- MARTIN KATZIN, *Student Assistant in Electrical Engineering* 1221 South University Avenue
- AKSEL CHRISTIENSON KNUDSTRUP, *Student Assistant in Electrical Engineering* 327 South Division Street
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- ROBERT HOLLIS LYMAN, *Student Assistant in Civil Engineering* 417 South Division Street
- JOHN CHARLES MATHES, *Student Assistant in Civil Engineering* 826 Tappan Avenue
- GEORGE ALBERT MILES, *Student Assistant in Civil Engineering* 831 Brookwood Place
- ROBERT WENDELL MILLER, B.S.E., *Student Assistant in Marine Engineering* 128 College Place, Ypsilanti
- GRETCHEN ELAINE MULLISON, A.B., *Student Assistant to the Secretary* 326 East Ann Street
- PAUL AMANDUS NORDGREN, *Student Assistant in Civil Engineering* 410 South Division Street
- EVERETT SIDNEY POOR, *Student Assistant in Mechanical Engineering* 1923 Geddes Avenue
- JOHN LEHMANN POST, B.S.E., *Student Assistant in Chemical Engineering* 509 South Division Street
- ROBERT WILLIAM RICHARDSON, *Student Assistant in Mechanical Engineering* 1208 South University Avenue

- GORDON ERNEST RIKER, B.S.E., *Student Assistant in Chemical Engineering* 1311 Minerva Road
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- BASIL J. RYDER, *Student Assistant in Mechanical Engineering* 1436 Washington Heights
- ALLEN SALISBURY, *Student Assistant in Mechanical Engineering* 1001 East Huron Street
- MILLARD FRANCIS SAXTON, *Student Assistant in Shops* 416 Hamilton Place
- RUSSELL LOUIS SCHWING, *Student Assistant in Geodesy and Surveying* 1001 East Huron Street
- PERRY MONROE SHOEMAKER, *Student Assistant in Mechanical Engineering* 418 East Washington Street
- WHITMORE ALEXANDER FREMONT SMITH, *Student Assistant in Shops* 1317 Wilmot Street
- LORIMER CARLISLE SPOOR, *Student Assistant in Electrical Engineering* 1003 East Huron Street
- WESLEY OLIVER STEWART, *Student Assistant in Architecture* 604 East Madison Street
- FRED ERNEST THORNTHWAYTE, *Student Assistant in Chemical Engineering* 322 East Ann Street
- BERTRAM ORLANDO VANNORT, *Student Assistant in Geodesy and Surveying* 915 Oakland Avenue
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- HARRY CARL WALKER, *Student Assistant in Geodesy and Surveying* 344 South Division Street
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- GERALD DEXTER WILSON, *Student Assistant in Chemical Engineering* 520 Cheever Court

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WILLIAM ALAN WOOD, *Student Assistant in Shops*
1309 Geddes Avenue

WILMER RAY WRIGHT, *Student Assistant in Engineering Mechanics*
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STANDING COMMITTEE

DEAN M. E. COOLEY, ACTING DEAN G. W. PATTERSON, PROFESSORS H. C. SADLER, E. LORCH, C. T. JOHNSTON, A. H. WHITE, H. E. RIGGS, H. C. ANDERSON, B. F. BAILEY, H. W. MILLER, P. FIELD

COMMITTEES OF THE COLLEGE OF ENGINEERING

COMMITTEE ON CLASSIFICATION:

PROFESSORS A. J. DECKER, H. H. HIGBIE, C. H. FESSENDEN, C. E. LOVE, J. C. BRIER

COMMITTEE ON ENGLISH FOR FOREIGN STUDENTS:

PROFESSORS J. R. NELSON, H. W. KING, H. H. HIGBIE, MR. C. E. BURKLUND

COMMITTEE ON DELINQUENT STUDENTS:

PROFESSORS H. W. KING, L. M. GRAM, T. R. RUNNING

COMMITTEE ON DISCIPLINE:

PROFESSORS A. H. LOVELL, G. W. PATTERSON, A. MARIN

COMMITTEE ON EXTENSION OF TIME:

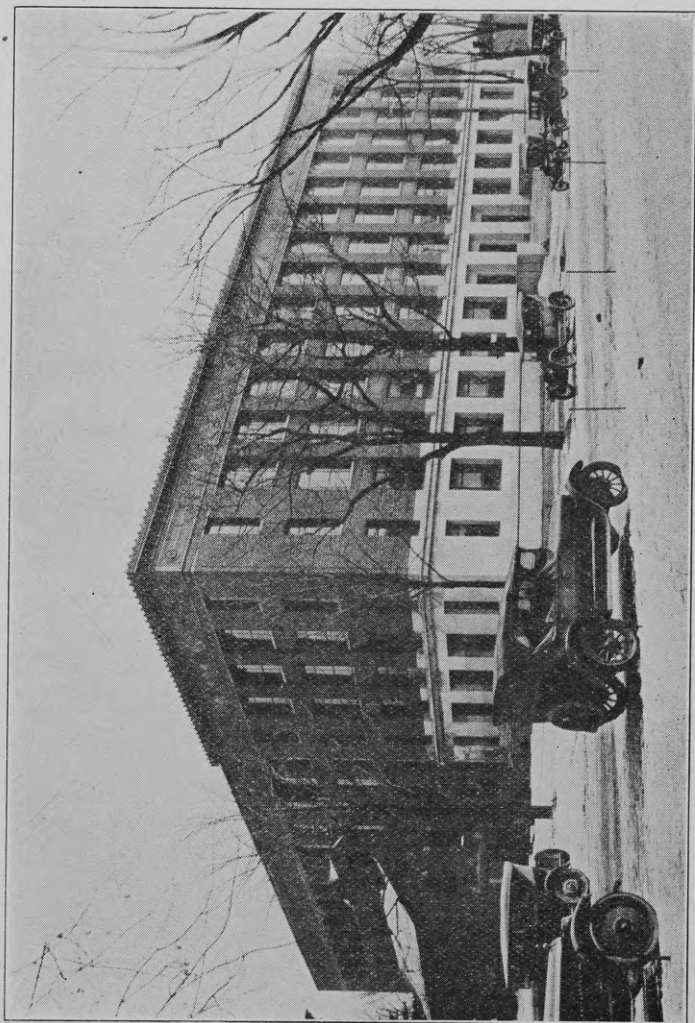
PROFESSORS C. E. LOVE, E. L. ADAMS, ASSISTANT PROFESSOR V. C. POOR

COMMITTEE ON HOURS:

PROFESSORS T. R. RUNNING, F. R. FINCH, O. W. BOSTON

COMMITTEE ON SUBSTITUTION:

PROFESSORS B. F. BAILEY, E. M. BRAGG, A. O. LEE



EAST ENGINEERING BUILDING

Part II

GENERAL INFORMATION

COLLEGES OF ENGINEERING AND ARCHITECTURE

HISTORY

1. The University of Michigan is a part of the educational system of the state, and derives from the state the greater part of its revenue. The University comprises the Colleges of Literature, Science, and the Arts, of Engineering, of Architecture, of Pharmacy, the School of Dentistry, the Medical School, the Law School, the School of Education, the School of Business Administration, the School of Forestry and Conservation, and the Graduate School, each of which publishes a separate annual announcement. The various Faculties include about seven hundred officers of instruction, and several hundred assistants, some of whom participate in the work of teaching. About 13,000 students, representing all the states and territories and many foreign countries, were registered at the University of Michigan during the last year.

In the legislative act under which the University was organized in 1837, provision was made for instruction in engineering and architecture. There are few older technical schools in the United States. Work was begun in this subject in 1853, and the first degrees were conferred in 1860. The engineering courses were included in the College of Literature, Science, and the Arts until the close of the collegiate year 1894-1895. At that time the College of Engineering was established by the Board of Regents as a separate Department of the University.

Instruction in Architecture was organized as a sub-department of the College of Engineering in 1906. In 1913 the College of Architecture was given control of its courses of study, and, in general, charged with the administration of its affairs.

The aim of these colleges is to lay a foundation of sound theory, sufficiently broad and deep to enable their graduates to enter understandingly on a further investigation of the several specialties of the engineering and architectural professions; and at the same time to impart such a knowledge of the usual professional practice as shall make the students useful upon graduation in any subordinate position to which they may be called. While the adaptation of theory to practice can be thoroughly learned only by experience, there are many matters in which the routine work of an engineering field party, office, or drafting room can be carried out, on a greater or less scale, in a training school. The technical branches are under the direct charge of those who have had professional experience as well as a full scientific training. The instruction fits the students, as far as possible, for the requirements of active practice. The Department of Engineering Research was established in 1920. The general function and purpose of this department is to co-operate in every proper manner with the industries of the state.

2. Students at the University of Michigan enjoy many privileges outside their curriculum. The Student Christian Association and the Ann Arbor churches minister to the spiritual, religious, and social needs of the student body; the pastors and assistant ministers have largely been chosen because of their effective work with young people.

The University Musical Society and the University School of Music provide unusual musical advantages, including several series of concerts, either at moderate price or without charge, in which leading artists of the country and from abroad and local musicians take part. The University has in its galleries a small art collection of great merit, and the Ann Arbor Art Association gives during the year several loan exhibitions.

University lectures are given without charge throughout the year by scientists, publicists, men of letters and others; the Oratorical Association conducts a course of lectures at moderate expense in which important lecturers appear.

**FIVE-YEAR PROGRAMS WITH BUSINESS
ADMINISTRATION**

3. A fundamental revision of the courses of study in Engineering and Architecture has been considered for several years with the purpose of broadening the programs during the four undergraduate years and postponing part of the specialization to a fifth year of professional graduate study.

The Board of Regents approved the principle involved in this revision and authorized the Faculty to submit a definite program. Progress has been made by the Faculty in drawing up definite recommendations, and it is expected that the projected enlargement of buildings will make possible the inauguration of a five-year program in the near future.

For the present, in addition to the four-year courses, five-year courses in co-operation with the School of Business Administration are in operation in Mechanical, Electrical and Chemical Engineering, leading to the degree of B.S. in Engineering (Mechanical and Industrial Engineering, Electrical and Industrial Engineering, or Chemical and Industrial Engineering). For details of these combined courses see sections 83, 85 and 87.

A five-year course in Highway Transport and Traffic Engineering has been authorized, but is not yet in operation.

Also students who have completed the first three years of prescribed work in the College of Engineering with the grade of at least 2.0 and who have taken at least 18 hours of Economics (not less than 6 semester hours in economic principles and 6 semester hours in accounting) may transfer to the School of Business Administration; and upon the satisfactory completion of two years of work in the latter School, may be granted the degree of Master of Business Administration.

THE ACADEMIC YEAR AND SUMMER SESSION

4. The academic year extends from September 17, 1928, to June 17, 1929. The Summer Session, between the student's first and second, second and third, or third and fourth years, extends eight weeks, from Monday following Commencement (June 25 to August 17, 1928).

Every student in the College of Engineering, in order to finish his course in four years, is expected to attend one Summer Session.

Students enrolled in the College of Architecture must spend four months in an architect's office before graduation, receiving four hours credit for this practical experience.

SUGGESTIONS AND DIRECTIONS

5. New students expecting to take the examinations for admission the first semester must present themselves September 10-14, 1928, for the second semester, January 31, to February 2, 1929.

All freshmen are required to report on Monday, September 10, for registration and the activities of Freshman Week. Every first-year student will be assigned to a faculty adviser who will personally assist him in registration, the selection of courses of study, and the solution of his personal problems through friendly counsel and advice. In addition, a full program of orientation and recreation will enable him to become thoroughly acquainted with his new surroundings before instruction begins. No freshman will be excused from attendance during Freshman Week except on account of illness. A complete program will be furnished to all freshmen accepted for admission.

Students on arriving in Ann Arbor can obtain information in regard to rooms and board by calling at the office of the Dean of Students, Room 2, University Hall. His secretaries are actively interested in assisting newcomers to find rooms and boarding places, and conduct a free employment bureau for the benefit of students.

When admitted, every student will be furnished with a booklet containing directions for subsequent procedure.

ADMISSION

6. The requirements for admission are the same for all students in Engineering and Architecture.

Applicants must be at least sixteen years of age, and must present satisfactory evidence of good moral character. The record of work done in the preparatory school must be presented on a form to be obtained from the Registrar of the University.

Students may be admitted on certificate, by examination, on credits from another college, or by a combination of these. They may also be admitted as special students.

FOREIGN STUDENTS

7. All students whose native language is other than English shall, upon matriculation and registration in the College of Engineering, be required to report at once to Professor J. R. Nelson, Chairman of the Committee on English for Foreign Students. Such students shall satisfy the Committee that they possess a sufficient knowledge of English to carry on work in the College of Engineering, before they may be classified.

On the recommendation of the Committee they may be referred to the proper classifier who will give them such a program of work as he deems best. For his first semester, however, every foreign student shall be considered as on trial. If at the end of the semester he passes his work, credit shall be given; if, however, in spite of conscientious effort, he fails, and his difficulties are, in the judgment of his instructors and of the Committee on English, due primarily to his lack of facility in the use of the English language, his record shall be disregarded but he shall then be remanded to the Department of English for such work in English as he needs, to the limit of eight hours.

If a student is judged by the Committee on English to be unfitted even for such a trial program as that outlined above,

he shall be required to take for one semester such work in English as the Committee thinks necessary, and may be allowed to visit such classes as may in the judgment of the Committee be profitable to him.

No advance credit is to be granted foreign students until they have been in residence at the University at least one semester.

PRESCRIBED PREPARATORY WORK

8. The subjects, and the number of units in each subject, prescribed for admission as a freshman without conditions are outlined below. Important explanations of these requirements are given in the paragraphs that follow:

	Units
English	3
Greek or Latin or French or German or Spanish.....	2
Algebra (through quadratics)	1½
Geometry (Plane, Solid, and Spherical)	1½
Physics	1
History	1
Units from List C	1½ or 2
Additional units from List A to make 12 units from that List	1½ or 1 or ½ or 0
Other units from List A or B	3
Total Units Required	
	15

LIST A

(With minimum and maximum number of units acceptable in each subject)

English, 3 or 4 units	Geometry, 1 or 1½ units
Greek, 2 or 3 units	Trigonometry, ½ unit
Latin, 2, 3, or 4 units	Physics, 1 unit
French, 2, 3, or 4 units	Chemistry, 1 unit
German, 2, 3, or 4 units	*Botany, ½ or 1 unit
Spanish, 2, 3, or 4 units	*Zoölogy, ½ or 1 unit
History, 1, 2, or 3 units	*Physiology, ½ unit
Economics, ½ unit	*Physiography, ½ or 1 unit
Algebra, 1, 1½, or 2 units	*Geology, ½ unit

*See paragraph on Science, on the following page.

LIST B

List B comprises any secondary school subjects not included in List A which are counted towards graduation by the accredited school.

LIST C†

Chemistry, 1 unit	Greek, Latin, German, French,
Trigonometry, Plane, $\frac{1}{2}$ unit	or Spanish, 2 units or additional 1
	Manual Training, 1 unit

Definition of a Unit.—The requirements for admission are stated in terms of units, a unit being defined as a course covering an academic year that shall include in the aggregate not less than the equivalent of one hundred and twenty sixty-minute hours of classroom work, two hours of manual training or laboratory work being equivalent to one hour of classroom work.

Provisional Admission.—An applicant for admission either on certificate or by examination, who lacks not more than two of the first twelve units prescribed may, if he presents fifteen acceptable units from Lists A and B, twelve of which units are from List A, be admitted provisionally; but these deficiencies must be made up during the first year of residence. No student who has an admission deficiency outstanding at the beginning of his second year of residence will be allowed to enter his classes until such deficiency is removed. Only those applicants may be admitted provisionally who, in addition to fulfilling the above conditions, are unqualifiedly recommended by their principals for admission.

English.—Under English are included grammar, composition, reading of English classics, and history of English literature. The history of English literature may form part of the work of either the third or fourth year. Four units in English should always be presented whenever it is possible to do so.

Foreign Language.—No less than two units of any language will be accepted for admission. Some modification in the re-

†See paragraph on Alternatives from list C, on the following page.

quirement may be allowed in the case of students whose native language is other than English.

Science.—In order that a half unit in science may be accepted for entrance, it must be supplemented by a second half unit in science. For this purpose the only groupings permitted are the following: Botany and Zoölogy; Zoölogy (or Botany) and Physiology; Physiography and Geology; Physiography and Physiology.

Alternatives from List C.—The 1½ or 2 units required from List C may be offered in any one of the following groupings:

Trigonometry	½	Manual training	1
Chemistry	1	Trigonometry	½
Chemistry	1	Chemistry	1
Foreign language (third unit)	1	Manual training	1
Foreign language (additional units)	2	Foreign language (third unit)	1
Foreign language (third unit)	1	Trigonometry	½
Manual training	1		

It is urgently advised that 1 unit of Chemistry and ½ unit of Trigonometry be offered. This will greatly facilitate the first year of college work.

Chemistry and Plane Trigonometry are placed in the Alternative Group, with German, French, Spanish, Greek, Latin, and Manual Training, so that all high schools with three or more teachers may offer full preparation for the Colleges of Engineering and Architecture even if they cannot teach Chemistry and Trigonometry. A student who presents the full requirements for admission without Chemistry or Trigonometry must take Chemistry 3 and Mathematics 1a in his first year, receiving full credit for the same as cultural studies. These courses are offered in the Summer Session to accommodate those students who wish instruction in them before entering one of the colleges.

VOCATIONAL UNITS

9. No more than three of the fifteen units required for admission will be accepted in vocational subjects and no more than two units in any one of them.

In Drawing and Manual Training, a unit means the equivalent of at least 360 periods, not less than forty-five minutes each.

All applicants must send courses of study or letters from instructors describing the work done when credit is asked in the vocational subjects,—Manual Training, Drawing, Agriculture, and Commercial Branches. In general, the standards set up by the Commission on Accredited Schools and Colleges of the North Central Association of Colleges and Secondary Schools will be recognized in adjusting high school credits in vocational studies.

The Manual Training accepted in the Alternative Group must be of such a character as to be equivalent to either or both Shop courses 1 and 2 (Wood Working and Metal Working and Treating) in the University.

DRAWING.—I. *Freehand Drawing.*—One-half unit allowed. The student should show that he can represent correctly in outline and in light and shade, geometric and simple natural or decorative form. Accuracy of proportion and perspective is essential. The pencil, charcoal, or brush may be used.

2. *Mechanical Drawing.*—One-half unit allowed. This work should cover:

(a) Exercises giving evidence of skill in the use of instruments and knowledge of materials used. The exercises should consist mainly of the accurate geometrical construction of the more important plane curves, with simple problems involving tangents and normals to the same.

(b) Graded exercises in the orthographic projections of simple geometrical forms and working drawings of some of the more elementary constructions in wood and metal, all fully dimensioned, and in which the conventional signs are properly used.

(c) Exercises in line shading, shade lining, and cross hatching, together with a reasonable skill in lettering.

3. *Design.*—One-half unit allowed. In this work a student should demonstrate some knowledge of the principles of design and the ability to apply them. The exercises should consist of compositions of straight and free curved lines and simple shapes and their use in the design of simple objects, such as book covers, etc. The exercises may be in black and white, various values, or

in colors, and may consist in part of objects executed in wood or metal, and the like.

Students who intend to study architecture are advised to offer one unit in drawing. This may consist of work in free-hand drawing, mechanical drawing, design, or a combination of two of these.

Manual Training.—Students may present one or two units. The work accepted may be:

1. Bench work, wood turning, cabinet making, and pattern making in the wood working laboratory.

2. Manufacturing of wrought iron and steel, effects on structure due to working, heat treating and equipment, case hardening, welding and brazing, protective coatings, etc.

Commercial Branches.—Not more than a total of two units will be accepted in these subjects, to be selected from the following list:

Advanced Arithmetic.—One-half unit. Credit will be allowed for arithmetic only if taken after at least one semester of algebra.

Double Entry Bookkeeping.—One-half or one unit. If credit to the extent of a full unit is sought, the student should devote at least ten periods of not less than forty-five minutes each in class each week for one academic year. The applicant should have a working knowledge of single and double entry bookkeeping in the usual lines of business. He should understand the use of the various books, such as the journal, cash book, sales book, invoice book, ledger, and special column journals and cash books. He should know how to prepare profit and loss statements and balance sheets, and to explain the meaning of the terms involved in both kinds of statements.

Commercial Geography.—One-half unit. The amount and character of work accepted in this subject is indicated by the scope of the best text-books in the subject.

Industrial History.—One-half or one unit. The scope of this work is indicated by such texts as Cheyney or Cunningham in English industrial history, or Wright, Coman, or Bogart in American history.

Elementary Economics.—One-half unit. The applicant should have a knowledge of the leading facts and principles in Economics, including such subjects as division of labor, the factors of production, the law of diminishing returns, demand and supply, value and prices and international trade. One of the better elementary texts in use will serve as a basis. This should be supplemented with discussions and problems.

Agriculture.—One or two units. Recitations and laboratory work in the various divisions of agriculture, including farm crops and horticulture, animal and dairy husbandry, soil physics, soil fertility, and farm mechanics. The study should be preceded by a course in Botany.

ADMISSION ON CERTIFICATE

10. Applicants presenting graduate certificates from any of the schools officially approved by the Committee on Accredited Schools will be admitted without examination to the Colleges of Engineering and Architecture, if they are recommended by the principal of the school in the units required for admission.

The approved schools of the University of Michigan do not necessarily include those accredited to or affiliated with other universities or colleges. It is expected that the principal will recommend not all graduates, but only those whose character, ability, application, and scholarship are so clearly superior that the school is willing to stand sponsor for their success at the University. The grade required for recommendation should be distinctly higher than that for graduation.

It is recommended that graduates from preparatory schools enter at once. If they do not, they must present evidence that they are, at the time of admission, prepared to do the work of the Colleges. They must show satisfactory preparation especially in mathematics, in English, and in the modern language presented for admission. This preparation may be shown by certificates of work done since graduation, by examinations at Ann Arbor, September 10 to 15, 1928, or by attendance at the Summer Session, June 25 to August 17, 1928, with a satisfactory record of eight hours of work, a part of which must be mathematics.

College credit may be given for studies presented in excess of the fifteen units required for admission, if these subjects are deemed equivalent to similar courses in the University. Such credit will be adjusted by the Assistant Dean. As a general rule no advanced credit will be given for work done in the usual high school course.

Students who for any reason have failed to secure certificate of graduation from an approved school and their principal's

recommendation will be required to pass the regular examinations for entrance in all subjects.

Applicants for admission should secure an application blank either from the High School principal or from the Registrar of the University. The completed blank should be sent directly to the Registrar by the principal as soon as possible following the applicant's graduation from the High School. If, on inspection, the data and recommendation are found satisfactory, the Registrar will forward a permit to register to the applicant entitling him to admission without examination, contingent only upon the passing of a satisfactory medical examination. This permit is to be presented in person at the time of registration.

Certificates from schools other than those officially approved by the University do not excuse an applicant from the admission examinations.

ADMISSION BY EXAMINATION

II. Fifteen units are required for admission. Eleven and one-half or twelve units are prescribed. The other three and one-half or three units may be presented in the subjects mentioned under admission requirements in section 8. In general, applicants will not be admitted with deficiencies in more than one and one-half of the prescribed units.

An outline of the preparatory work which a student should cover before presenting himself for examination in any one of these subjects is given at length in the report of the Director of the Division of University Inspection of High Schools. This will be mailed upon application to the Registrar of the University. Specimen entrance examination questions are not furnished.

All examinations are held at the University. The principal examinations for admission to the Colleges of Engineering and Architecture will be held in June and September, 1928. Another opportunity is offered in February, 1929. Applicants will not be examined at any but the regular time except on payment of a special fee of *five dollars* for examination in one or more subjects.

Applicants for admission on examination should make arrangements with the Registrar at least one month in advance of the time set for the examination.

An applicant who fails in some part of the examination, but passes fifteen units, may be admitted provisionally; but all deficiencies must be made up within one year.

ADMISSION TO ADVANCED STANDING

12. A student in another college or university, who intends to enter the College of Engineering or Architecture with advanced standing, should examine carefully the curriculum of the department in which he intends to specialize, and arrange his work accordingly.

As a rule he should have completed the required work in English, foreign language, mathematics, physics, chemistry and cultural subjects and in drawing and engineering mechanics if his institution offers adequate instruction in them.

He is advised to write to the Head of the Department in which he wishes to specialize for advice and for information not found in this bulletin. The Assistant Dean will be glad to give information concerning admission requirements or other matters of a general nature.

A. Graduates of the University and of other approved colleges are admitted without examination to advanced standing as candidates for a degree in Engineering or Architecture.

They should present to the Assistant Dean or, for Architecture, to Professor Lorch an official certificate of their graduation—not their diploma—and an official copy of the record of the studies they have completed, showing the subjects studied, the number of weeks devoted to each, and the number of class periods per week.

The remaining requirements for students of Engineering can usually be completed in two years, if the student takes as electives, while an undergraduate,* the mathematics required of Engineering students and Courses 1, 2 and 3 in Drawing.

Those students who hope to complete the program in Archi-

*A student enrolled in the College of Literature, Science, and the Arts, and desiring to elect any course in the College of Engineering or Architecture, which is not printed in the Announcement of the former College, must obtain the written permission of his classifier and of the instructor in charge of the course. A similar procedure is necessary in case a student of this College wishes to elect work in other Colleges.

ture in two years should also complete the equivalent of Drawing 21, 22, and 23, and Architecture 1, 4, 5, 6, and 21.

Students who have completed a regular four-year course at approved colleges and other institutions may be admitted to the Colleges of Engineering and Architecture as seniors provided that, in general, the course pursued covers substantially the equivalent of the work offered in the first three years of the required courses in their chosen departments of study at the University of Michigan.

The courses to be taken during their residence at the University will depend upon their previous training and will be determined by the Head of the Department concerned, subject to the approval of the Committee on Combined Courses.

Upon the satisfactory completion of such courses, covering at least one year's residence, they will be recommended for the degree of Bachelor of Science in Engineering.

B. A student who has completed at least one year of work in an approved college may be admitted to advanced standing without examination, except such as may be necessary to determine what credits he is entitled to receive.

An applicant must present a letter of honorable dismissal from college, an official copy of his college record, and an official record of his preparatory studies, similar to those required of students admitted on certificate. See section 10.

C. A student who has not completed a year's college work in an approved college, but before entering these colleges of the University has pursued studies beyond those required for admission, may be admitted to advanced standing. Entrance requirements in such cases may be satisfied by complying with the conditions stated in either section 10 or 11.

D. All advanced credits are adjusted by the Assistant Dean or the Professor of Architecture: and until a transcript or record at another institution or other like information is furnished, no one is authorized to say what credit may be received for work done elsewhere or what class a student may enter after having attended another college for a specified time.

The requirements for admission must be complied with before any advanced credit is given.

Advanced credit is given only upon examination or upon an official certificate covering the work done, and showing the scholarship or proficiency attained.

Advanced credit is given only for work equivalent to courses offered in the University of Michigan.

Applicants for admission in engineering should apply at the time of entrance at Room 255, West Engineering Building; and in architecture at the office of the College of Architecture, second floor, Architecture Building. It is desirable that credentials should be sent on in advance as much before these dates as practicable. Students desiring advanced standing in drawing must bring all drawings completed previous to entrance.

Advanced credits should be secured upon entrance. To apply for advanced credit at a later date, students of Engineering must secure the permission of the Assistant Dean, and students of Architecture the permission of the Professor of Architecture, giving a satisfactory reason for the delay in making the application.

ADMISSION FROM ALBION AND OLIVET COLLEGES AND THE COLLEGE OF THE CITY OF DETROIT

13. A combined course with Albion College has been arranged whereby a student may obtain the degree of Bachelor of Arts from that institution and the degree of Bachelor of Science in Engineering from the College of Engineering. The required work, covering a period of five years, is outlined in section 56. Students entering from Albion College will present a statement of their preparatory work, as well as a transcript of credits from that institution. Similar arrangements have been made with Olivet College and with the College of the City of Detroit. See sections 57 and 58.

ADMISSION AS GRADUATE STUDENTS

14. Higher degrees in Engineering and in Architecture are conferred in the Graduate School of the University. See the Annual Announcement of the Graduate School.

ADMISSION AS SPECIAL STUDENTS

15. Students who are pursuing work in these Colleges, and are not candidates for a degree, are designated Special Students.

Students over twenty-one years of age who wish to pursue particular studies in Engineering or Architecture, and who show by examination or by the presentation of satisfactory certificates that they are prepared to do good work in the selected courses, may be admitted as special students on the recommendation of the heads of the departments of instruction in which they wish to study. The object of this rule is to enable young men who are beyond the high-school age to secure technical training along special lines when they are properly prepared for the work. Two or more years of successful experience as teacher, draftsman, surveyor, engineer, or operative in engineering work will be given considerable weight in determining the fitness of the candidate. In general, a good working knowledge of English, algebra, and geometry is required in order to succeed in engineering studies. Applicants for admission as special students should send as early as possible to the head of the department concerned letters of recommendation, certificates of scholarship, and an exact statement of the courses desired.

A two-year course is provided for special students in Architecture. Such students must be qualified for the courses they wish to pursue and must have the approval of the head of the College of Architecture; they must be twenty-one years of age; must have had two or more years of experience in architects' offices, or its equivalent, and must have a practical knowledge of architectural drawing. Special students who wish to pursue courses in advanced building construction must present the regular entrance requirements in mathematics.

Students who desire to pursue a special course in Architecture should write to Professor E. Lorch as early as possible in order to learn how best to prepare for the work they may wish to do here. They should spend some time in study parallel with their office work before taking up university work, thus to review or master essential preparatory subjects and again to acquire the habit of study, the loss of which in certain subjects is often a

serious handicap to capable draftsmen otherwise well prepared to profit by some of the academic work. In general, a working knowledge of English, algebra, plane and solid geometry is required. Advanced credit can often be given such students for work done in the field and in offices.

College graduates are also admitted as special students and may take those courses for which their preparation is sufficient.

Candidates for admission as special students in either College should state their age and what their education and experience have been. They should send letters of recommendation from former employers and bring drawings to demonstrate their experience and ability.

Special students pay the same fees as regular students. Their work is assigned and regulated by the heads of the departments of instruction in which they register.

A special student may become a candidate for a degree by fulfilling the regular requirements for admission. See section 8.

A student who is a candidate for a degree cannot become a special student without the permission of the Faculty.

FEES AND EXPENSES

The Matriculation Fee and the Annual Fee must be paid in advance for the entire year, and no student can enter upon his work until after such payment.

16. Matriculation Fee.—Every student before entering any college or school of the University is required to pay a matriculation fee. This fee, which for citizens of Michigan is ten dollars, and for those who come from any other state or country, twenty-five dollars, is paid but once, and entitles the student to the privileges of permanent membership in the University.

17. Annual Fee.—In addition to the matriculation fee every student has to pay an annual fee for incidental expenses. The annual fee in the Colleges of Engineering and Architecture is, for Michigan students, \$108; for all others, \$133. The fee for the second semester is sixty per cent of that for the entire year.

These fees cover class instruction, use of libraries, outdoor physical education and admission to all athletic events on Ferry

Field, membership in the Michigan Union or Women's League, as well as medical attention from the University Health Service and dispensary.

Part-Time Fees.—(a) Teaching assistants, with bachelor's degrees, taking university work, may enroll in the Graduate School and pay a fee of \$10 per year for each five hours or less.

(b) Persons whose occupations are such as to afford them only a limited part of their time for study, but who are duly accredited for admission to any College or School of the University and who also give evidence of an interest in study wholly accordant with the purpose of the College or School to which they are accredited, may be admitted and may elect not more than five hours in any semester upon the payment of an annual fee of \$25. Such students, if entering the University for the first time, must also pay the usual matriculation fee. The part-time fee of \$25 covers only the usual privileges of study and tuition; Michigan Union or Women's League membership, Outdoor Physical Education, and Health Service are not included. These special privileges may be secured by paying the appropriate extra fees at the time of registration.

(c) Under certain conditions, in order to provide for the election of a considerable number of three-hour and four-hour courses, permission may be granted on application to the Dean of the Graduate School and the Secretary of the University to arrange a part-time schedule on the basis of ten hours per year instead of strictly five hours per semester.

LATE REGISTRATION.—Registration (i.e. enrollment, payment of fees, and classification) must be entirely completed before the first day of the semester. Students failing to complete their registration before the first day of each semester are required to pay a late registration fee of five dollars.

18. **Fee for Special Examination.**—An applicant for admission who desires to take the entrance examination at a time not announced is required to pay to the Treasurer a fee of five dollars before permission to take one or more examinations can be granted him. A supplementary examination given at any other time than that stated in this Announcement will be subject to the same fee.

19. **Graduation Fee.**—The fee for graduation is ten dollars, and the by-laws of the Board of Regents prescribe that no person shall be recommended for a degree until he has paid all dues, including the graduation fee. This fee will be received by the Treasurer of the University upon the presentation of a ticket to be secured at the office of the Secretary of the College in which the candidate is enrolled. To receive a degree at Commencement the candidate must be present in person and must have paid the graduation fee at least twenty-five days prior to Commencement Day. Others who have satisfied all the requirements for graduation, including the payment of the graduation fee, will receive their degrees at a subsequent meeting of the Board of Regents.

20. **Laboratory Fees.**—Laboratory fees are abolished, but students in laboratory courses must make a cash deposit to pay for materials used and for breakage. *Camp Fee.*—A fee of *ten dollars*, in addition to the regular tuition for the Summer Session, is required of students who take Course 3 in Surveying (at Camp Davis).

21. **Other Expenses.**—There are no dormitories for men and no commons connected with the University. Students obtain board and lodging in private families. Room rent varies from four to six dollars a week for each student. Board varies from six to eight dollars a week.

22. **Annual Expenses.** The expenses of the *average* student, during his first year in the College, not including clothing, railroad fare, and vacations, are estimated at \$818 for residents of Michigan, \$858 for non-residents. By practice of strict economy it may be possible to keep these expenses within \$3,000 for the four years. Many students are enabled to complete their course by withdrawing for a year or two to earn money to carry them through the remaining years.

A set of drawing instruments costs about \$25, and, if well selected, will be serviceable for many years.

The cost of attending the Camp Davis Summer Session is about \$125. See section 86.

REFUNDING OF FEES

23. The Board of Regents has made the following provisions for students withdrawing from the Colleges and for those entering the second semester.

(1) Any student who withdraws not more than two weeks after his registration shall be entitled to a refund of his entire annual fee, together with the matriculation fee.

(2) A student who withdraws thus more than two weeks and less than eight weeks after his registration is entitled to a refund of one-half his annual fee.

(3) A student who withdraws thus more than eight weeks after the beginning and not later than the end of the first semester is entitled to a refund of 40% of his annual fee.

(4) A student who registers at the beginning of the second semester is required to pay 60% of the prescribed annual fee. The 40% thus refunded at enrollment shall be included in determining any further refund under (1) and (2).

(5) No refund or reduction of the matriculation fee is made except in case of those withdrawing within the first two weeks after registration.

In order to obtain a refund of fees, a student must surrender his treasurer's receipt, his athletic book, his Michigan Union ticket, etc.

STUDENT EMPLOYMENT

24. The University does not undertake to furnish manual labor to students; yet a considerable number find opportunities in the city to meet a portion of their expenses. The Faculty suggests to such students that they should not attempt to carry the full amount of work outlined. Much more efficient work can be accomplished by taking a longer time to cover the course. Each student doing outside work should notify the Classification Committee of such fact at the time of classification.

Students desiring employment should apply in person or by letter before they come to Ann Arbor, to the Dean of Students, Room 2, University Hall.

FELLOWSHIPS AND SCHOLARSHIPS

25. There are several fellowships and scholarships in the Colleges of Engineering and Architecture. For details see sections 47-48 and 119.

There are also annually appointed about thirty-five assistants at salaries ranging from \$100 to \$250. For the most part, these assistants are graduate students and seniors who have shown themselves proficient in certain lines.

RELATION OF STUDENTS TO THE CIVIL AUTHORITIES

26. Students are temporarily residents of the city, and, like all other residents, are amenable to the laws. If guilty of disorder or crime, they are liable to arrest, fine, and imprisonment. A rule of the University Senate provides that, if a student is arrested, or is convicted by the civil authorities, he shall be cited to appear before the Discipline Committee of the University or Faculty of the college in which he is matriculated, and shall be liable to suspension or expulsion.

THE MICHIGAN UNION

27. The University of Michigan Union was organized and incorporated under the laws of the State of Michigan in 1904, to establish a University social and recreational center; to provide a meeting place for faculty, alumni, former students and resident students of the University; to furnish a home for alumni when in Ann Arbor, and a place for wholesome relaxation for students, so that their leisure time, their amusements, and their student interests, through the medium of the University atmosphere of the Union, might become a component part of their education. The Union, furthermore, seeks to inculcate educational ideals through its student activities, for as a social centre it encourages and stimulates activities that are for the welfare and enjoyment of the student body, and the result is a richer, more intense Univer-

sity life, a product of the students' own work. This develops group spirit, a sense of loyalty to the community served, pride in work accomplished, a widened circle of friends, and broadened experience and view in life. The Union, in emphasizing the social values of education, complements the work of the University in its endeavor to graduate broadly educated men and citizens.

The Union Building is exceptionally well appointed. Among its many attractions are a swimming pool, six bowling alleys, a barber shop, a billiard room with twenty-four tables, a lounging room, restaurant service including a cafeteria, a women's dining-room, a main dining-room, and an assembly hall adapted to use for banquets, meetings, conventions, smokers, concerts and dances, and forty-nine sleeping rooms for the alumni and guests of members accommodating sixty-eight persons. The building is the headquarters and gathering place for students, alumni, former students and faculty.

The student annual membership fee is \$10, fixed by the Board of Directors and by resolution of the Board of Regents. This fee is incorporated in the annual tuition of every male student of the University.

UNIVERSITY HEALTH SERVICE

28. The University of Michigan is fundamentally interested in the general health and physical welfare of its students. For this purpose, the University Health Service provides adequate means for administering free advice, care and treatment to sick students.

Dispensary.—A corps of physicians and nurses are available in the dispensary daily to render medical attention and ordinary medicines to ambulatory patients. Any student may consult any physician of the staff at choice. Prescriptions are filled in the Health Service Pharmacy. The staff of the Health Service includes several physicians who are also on the University Hospital staff, so that abundant opportunity is afforded for co-operation and consultation with specialists.

Two dentists on the staff co-operate with the Dental Clinic where care and treatment are given.

Infirmary.—The Health Service provides physicians, nurses, and equipment for the free-bed care of twenty-five patients; other cases are referred to the University Hospital when necessary. No charge is made for hospital service when first approved by the Health Service Director.

Room Calls.—Health Service physicians are on scheduled duty to make calls upon ill students at their rooms. For this service a minimum fee is charged.

Vacations.—The Health Service provides service during the Christmas and Spring vacations.

Summer Session.—All Summer School students who have paid the Health Service fee, have the usual privileges at the Health Service.

Summer Camp (Camp Davis).—A Health Service physician and a nurse are maintained at Camp Davis during the Summer Session.

FACILITIES FOR PHYSICAL EDUCATION

29. The University is provided with excellent gymnasiums, the Waterman Gymnasium for men, and the Barbour Gymnasium for women. The main floor of the Waterman Gymnasium which is a rectangle with truncated corners and dimensions of 246 by 90 feet, is well equipped with the various kinds of apparatus usually found in the best modern gymnasiums. A number of smaller rooms are devoted to administration, fencing, boxing, and other special purposes, while the basement is given up to baths, lockers, handball, and boxing. The main hall is lighted in the daytime by means of a large skylight 60 feet above the floor, and in the evening by electricity. A gallery makes room for an elliptical running track, ten laps to the mile, making it one of the largest gallery running tracks in the country.

All men entering the University for the first time are given a thorough medical and physical examination before University fees are paid. At this time also a measurement of various parts of the body is taken and plotted on an Anthropometric Chart. A comparison with the average measurements can be made in this

way, and any existing abnormalities corrected. A second measurement is taken after class work is finished, in order to note what changes have taken place. Abnormal posture conditions are corrected, and special exercises for strengthening weak parts are given. Realizing the fact that most college men have inferior chest development, the character of the class work is arranged to overcome this condition. Both athletic and gymnastic work is given, however, in order to produce variety and enthusiasm for exercise. An excellent outdoor elliptical board track, adjacent to the Gymnasium, has recently been installed, in order that outdoor exercise can be taken, especially during the periods when classes are being held, whenever weather conditions permit. Men qualifying for freshman football, cross-country, hockey, track, basketball, and wrestling teams are given gymnasium credit, while these sports are in progress, after which they are transferred to the regular gymnasium classes. Arrangements for the exchange of this work must be made with the Director of the Gymnasium, otherwise no credit will be given.

Barbour Gymnasium for women, contains, in addition to the gymnasium proper, offices of the Advisers of Women and the Director of the Gymnasium; a club room and parlors; and a hall (Sarah Caswell Angell Hall) accommodating 550 people, for lectures, meetings, theatrical entertainments, etc. The gymnasium is a large room with floor space of 90 x 80 feet, well lighted, well ventilated, and equipped with the necessary apparatus for individual and class work. The gallery has a running track 310 feet long. The basement contains dressing rooms, shower baths, and a swimming tank which, with instruction in swimming, is open to all women registered in the University.

The facilities of the Gymnasiums, including physical examination and instruction, are free for all students, the only charge being a rental of \$2 a year for a locker. Attendance twice a week is required of all first-year students in the Colleges of Engineering and Architecture, Literature, Science, and the Arts, and Pharmacy. Classes begin the third Monday in October.

The Athletic Field, known as Ferry Field, comprising seventy-eight acres of land, has been set apart and equipped for outdoor sports of every kind. Several football fields and baseball diamonds,

running tracks, soccer fields, indoor baseball diamonds, tennis courts and space for numerous other games afford possibilities for complete programs of Intramural and Intercollegiate Athletics. In addition to the playing field there are a new football stadium seating 82,000, a baseball stand accommodating 8,000, an Athletic Administration Building, and an indoor playground known as Yost Field House.

The Yost Field House provides accommodations for all kinds of athletics during the winter months when they cannot be conducted out of doors. The building is 342 feet long by 165 feet wide. It contains ample locker and shower facilities and seats 8,000 spectators in the main activities room. The activities room, itself, is 286 feet long by 160 feet wide and contains an eighth-of-a-mile track, a 75-yard straight-away, a basketball court and provisions for indoor practice in football and baseball. There are also provisions for handball and wrestling. All of which gives to Michigan a complete athletic plant that functions the year around.

The new Intramural Sports Building, similar in design and construction to Yost Field House, is being erected on the site of the old north (wood) football stands, and will contain almost every conceivable facility for indoor sport and recreation. It is not planned to provide facilities for spectators, but to utilize every foot of space for athletic activity. The new building will be entirely practical and will form the north side of a quadrangle which will include the Administration Building, concrete stand for track and field athletics, west tennis court unit, and Yost Field House.

THE ASSEMBLY AND MENTOR SYSTEM

30. Each class in the College of Engineering has its separate assembly at which the freshman class is brought together once a week and the sophomore, junior, and senior classes once a month. At these meetings faculty members and visiting engineers address the students and the regular business of each class is assured of attention by the class as a whole.

Closely connected with these assemblies is the mentor system. As soon as a student enters the College of Engineering he is assigned to a mentor who is to be his faculty adviser throughout

his college course, and definite arrangements are made for him to meet his mentor directly after the first assembly. Both socially and in his advisory capacity, moreover, the mentor is the personal representative of the Dean, so that each student may feel free to call on his mentor at any time with reference to any subject relating to his college life.

The students receive reports on each of their studies through their mentors or faculty advisers. These reports reach the mentor six weeks after the beginning of the semester, and four weeks before the final examinations, and he is therefore able to give the men in his group not merely general advice but definite information as to how they are getting along in their college work.

THE HONOR SYSTEM

31. The students of the College of Engineering have adopted the following system: All examinations and written quizzes in the College are held under the Honor System, the object of which is to create a standard of honor which is essential to a successful engineer and a good citizen. Students are expected to uphold the system or declare their objections to it, after having been duly instructed in all its rules. The instructor does not remain in the room during an examination. The students are placed upon their honor to refrain from all forms of cheating and to reprimand a fellow student who acts suspiciously, and in case he does not take heed, to report him to the Honor Committee. Every student must write and sign the following at the end of his examination paper, if he does not ask for an examination under a proctor:

“I have neither received nor given aid during this examination.”

The Honor Committee consists of one student elected annually from each class in the College of Engineering, and one from the College of Architecture, each member to serve two years.

WOMEN STUDENTS

32. All undergraduate women of the University must make arrangements for their rooms through the office of the Advisers of Women from the lists of approved houses. This ruling applies to the undergraduate women enrolled in the Colleges of Engineering

and Architecture. Individual adjustments can sometimes be made by securing special permission from the office of the Advisers of Women.

Matters of scholarship and attendance are handled by Assistant Dean Patterson for Engineering and Professor Lorch for Architecture. Assistant Secretary Green acts as educational mentor for the women in Engineering and Architecture.

RULES GOVERNING ELECTION OF STUDIES

33. (a) No student will be allowed to elect merely a part of a course without special permission of the Classification Committee.

(b) No credit will be allowed to a student for work in any course unless the election of the work is formally entered on his office classification card.

(c) After the first Saturday of each semester no study can be taken up or dropped without special permission of the Committee on Change of Classification.

(d) All requests to the Faculty must be made out on a printed form furnished by the Secretary of the College.

(e) A student is required to drop a part of his work at any time if he appears to be undertaking too much; or to take additional work if he is thought not to be sufficiently employed.

(f) Only such students as are regularly enrolled in a class will be allowed to take quizzes, tests, or final examinations in the same.

(g) The Faculty reserves the right to withdraw the offer of any elective study not chosen by at least six persons.

(h) After matriculation, a student cannot, without special permission of the Faculty, be admitted to examination in any one of the courses given until he has received in the University the regular instruction in such course.

EXCUSES FOR ABSENCES

34. Underclassmen in the College of Engineering must take the initiative in securing from the Assistant Dean excuses for absences from classes, which excuses must be applied for within five days after their return to classes. Upperclassmen* should explain irregularities of attendance to their instructors. Students in the College of Architecture should obtain excuses from Professor Lorch.

*For the definition of upperclassmen see section 35.

UPPERCLASSMEN

35. The Faculty recognizes as Upperclassmen: *a*, those students in good standing, i.e., not on probation, who have obtained at least 65 hours of credit, with an average grade of at least C for all work taken at the University of Michigan; *b*, all new students who have completed a four-year course at approved colleges and other like institutions; and *c*, other new students with good previous record who in the opinion of the department heads may qualify for graduation within one year.

An upperclassman's privilege will be withdrawn should his average grade for all work at the University fall below C or should he be put on probation, and will be restored when his delinquency is removed.

Upperclassmen are not required to obtain excuses for irregularities of attendance from the Assistant Dean, but should explain them to their instructors.

EXAMINATIONS AND ENTRANCE DEFICIENCIES

36. Examinations for admission are held before the beginning of each semester. See section II.

An applicant who fails, or is deficient, in some part of the admission requirements may, at the discretion of the Faculty, be admitted, provided he passes in fifteen units; but the removal of entrance deficiencies shall take precedence of all other work; any deficiency must be removed at one of the next two regular examinations for admission, but the Classification Committee is empowered and instructed to see that students entering this college with deficiency remove the same as far as possible during the first semester of residence.

No student who has an admission deficiency outstanding at the beginning of his second year of residence will be allowed to enter his classes until such deficiency is removed, unless for valid reason an extension of time is granted for its removal.

Examinations in college work are held at the end of each semester, but classes are liable to be examined at any time, without notice, or with one week's notice, on any portion of their work.

The regular examination in any course at the end of each semester is an essential part of the work of the course.

MARKING SYSTEM

37. At the end of each semester the quality of the work of every student in each course which he elects and completes is reported by the instructor as A (excellent), B (good), C (satisfactory), D (passed), or E (not passed).

When a student is prevented by illness or by any other cause beyond his control from taking an examination or from completing any other part of a course, or if credit in a course is temporarily withheld for any reason, the mark I may be placed before the grade to indicate that the course has not been completed. An incomplete course is thus reported IA, IB, IC, ID, or IE. The grade indicates the quality of work done in the part of the course which has been completed.

Any student absent from an examination is required to report to his instructor as soon thereafter as possible. If a student presents a valid excuse for his absence, he may take the examination at such time as may be arranged by the instructor. If such excuse is deemed unsatisfactory, the record shall be reported E. In order that credit for a course may be given it must be completed before the end of the semester of residence next succeeding that in which it was elected.

The final grade in a course which has been completed during the semester of residence following that in which it was elected will be based upon all of the work done in the course. It will not necessarily be the grade reported for the partially completed course.

At the time of completing a course students must obtain from the Secretary a blank form for presentation to the instructor. The blank when filled out must be deposited by the student with the Secretary within one week of the date entered upon it by the instructor. The same procedure is followed when an entrance condition has been removed.

RULES GOVERNING GRADES AND SCHOLARSHIP

38. (a) The average semester grade and the general average grade is computed for each student at the end of each semester and becomes part of his permanent record.

(b) The average grade is determined on the basis of A equals 4, B equals 3, C equals 2, D equals 1, and E equals 0.

(c) The average grade is computed by multiplying the number corresponding to the grade in each course by the hours of credit for the course and dividing the sum of these products by the total number of hours represented by all the courses considered.

(d) No student may graduate whose general average grade is below 2.0.

(e) When the average semester grade of a student falls below 1.6 he is automatically placed on probation.

(f) Students on probation must elect at least 12 hours work for semesters or 6 hours for summer sessions.

(g) Students on probation who obtain an average semester or summer session grade of 2.0 or more are automatically removed from probation.

(h) A student will be placed on the home list for any one of the following reasons:

1. If his average semester grade falls below 1.0.
2. If he is on probation and fails to obtain an average semester grade of 2.0.
3. If he has been on probation during any two semesters and subsequently fails to obtain an average semester grade of 1.6.

(i) In cases of extenuating circumstances, at the discretion of the Committee on Delinquent Students, students placed on probation may be removed from probation, and students placed on the home list may be continued on probation.

(j) Students having a general grade of less than 3.0 may not elect extra hours; students having an average of 3.0 or more may elect extra hours, the number of extra hours which such students may elect to be determined by the classifier.

(k) Students on probation may not elect less than 6 hours work in the summer session. When the average grade for the summer session of a student on probation becomes 2.0 or more he is automatically removed from probation.

SELF-SUPPORTING STUDENTS

39. The normal number of hours that students should carry each semester is between sixteen and eighteen. Students who support themselves wholly or in part are urged to elect a smaller number of hours. It is very difficult for a student supporting himself to carry a full schedule and retain his health. It is even more difficult under such conditions to carry a full schedule and do justice to his college work.

WITHDRAWAL FROM THE COLLEGES

40. A student should not withdraw from class even temporarily without obtaining permission.

Leave of absence will be granted to those who expect to return before the end of the year.

Honorable dismissal will be granted to those who wish to transfer to another College of the University and to those going elsewhere, provided in either case they are in good standing.

Engineering students must obtain this permission or dismissal from the Assistant Dean, and architectural students from the Professor of Architecture.

Part III

COLLEGE OF ENGINEERING GENERAL STATEMENT

DEPARTMENTS OF INSTRUCTION

41. The broad subject of Engineering has been defined as "the art and science of directing the great sources of power in nature to the use and convenience of man." It includes the discovery, conservation, and utilization of the resources of the earth, the waters, and the air. Discovery includes not only the exploration of mineral, timber, and other visible resources of the world, but also the experimental investigations of the laws controlling important phenomena and processes. Conservation includes the prevention of waste of all sorts, whether of natural resources or in manufacturing processes. Utilization includes the generation and transmission as well as the actual application of heat, light, and electricity by mechanical, electrical, and chemical means to serve useful purposes; the design and erection of structures and machines of all types, and the efficient operation of all processes, involving preparation, manufacture, transportation, or utilization of materials on a large scale. In the newer conception of Engineering efficient operation must consider not only the physical property but also the relation of the industry to the outside world, including its duty to stockholders, employees, clients, and the community in which it is situated.

Until a century ago engineering was divided into two branches, military and civil engineering. Since then civil engineering has developed in so many directions and to such an extent that new designations have come into use for its various branches.

The name *civil engineering* has been retained at the University of Michigan to designate the courses given by its civil engineering department.

The other departments, some of which are outgrowths of civil engineering and others of different origin, are *geodesy and surveying, mechanical engineering, electrical engineering, marine engineering and naval architecture, chemical engineering, and aeronautical engineering*, all degree-conferring departments. Until 1911 the department of civil engineering gave instruction in engineering mechanics, now entrusted to a separate department of instruction.

In addition to the degree-conferring departments, the College of Engineering has departments of instruction in mathematics, mechanism and engineering drawing, engineering mechanics, English, modern languages, and shop practice; and it uses, with the rest of the University, the departments of physics, chemistry, astronomy, military science, etc., which give special courses for engineering students; engineering students are allowed wide liberty to elect courses in history, philosophy, economics and other cultural subjects without additional cost.

Beside the departments of instruction, the College of Engineering includes the *department of engineering research* which was established by an act of the Regents in October, 1920. The purpose of this act was to establish a point of contact between the University and the technical and industrial interests in the State in the field of research.

The department, because of the extensive laboratory and library facilities available at the University, in addition to its ability to call upon members of the teaching staff to direct and supervise research, is in a position to undertake and investigate a large number of problems of varied character.

Full descriptions of the various departments, their scope, facilities for instruction and the courses offered, will be found elsewhere in this bulletin.

BUILDINGS AND OTHER EQUIPMENT

42. The work of the College of Engineering is carried on in several buildings belonging to the College, viz., the West Engineering and the East Engineering Buildings, the West Engineering Annex (the old Engineering Shops), the R. O. T. C. Headquarters (the old Power House), East Hall; the College shares with

the rest of the University the use of the Library, the East and the West Physics Buildings, the Chemistry Building, the Astronomical Observatory, the Gymnasium, etc. The summer work in surveying is carried on at Camp Davis located between Burt and Douglas Lakes in Cheboygan County. See section 86.

The West Engineering Building built about twenty-five years ago to house most of the work of the Colleges of Engineering and Architecture is now used by the College of Engineering for the departments of civil, mechanical, electrical, marine and aeronautical engineering, geodesy and surveying, mechanism and engineering drawing, engineering mechanics and mathematics.

The East Engineering Building completed in 1923, with a floor area of 160,000 square feet, houses the new engineering shops, and the departments of chemical engineering and engineering research, and provides additional space for aeronautical engineering and civil engineering (highway engineering).

The West Engineering Annex provides additional space for mechanical engineering (automobile engineering) and geodesy and surveying, the R. O. T. C. Headquarters houses the department of military science; and East Hall is used for offices and classrooms.

A new building has recently been completed for the College of Architecture, described in Part VI.

For the equipment of these buildings and Camp Davis, see later articles concerning the various departments of instruction.

The College recognizes that the benefits of instruction are far more dependent on the character of the instructors than upon any adjunct in the way of laboratory apparatus or of physical illustration, and with this in view the instructing staff has been selected from among those qualified both by technical training and practical experience; in addition extensive use is made of the ordinary supplementary aids.

43. The Libraries.—A large new library building, erected at the cost of \$615,000, was opened in January, 1920. This building has general and special reading rooms for eight hundred students at one time, and is equipped with modern appliances for the housing and serving of books. The University libraries receive over 3,600 periodicals annually.

The University Libraries contain at present about 600,000 volumes, of which many are of importance to engineers and architects.

THE WEST ENGINEERING LIBRARY, comprising over 20,000 volumes, is housed in the West Engineering Building. The latest and best books on professional subjects are added yearly to the library, where they are accessible to all, and frequent references are made to them in the classroom as the various subjects are brought forward. Over one-half of the collection consists of files of professional periodicals and proceedings of engineering societies. Funds being now available, extensive additions to the books and periodicals, particularly foreign periodicals, will be made during the coming year.

THE EAST ENGINEERING LIBRARY, opened in 1924, is housed on the third floor of the East Engineering Building. It is provided with 15,000 books, and 125 periodicals of particular interest to students in Chemical Engineering, Engineering Shops, and Aeronautics. A special collection of books is available to those students pursuing courses in English.

THE ARCHITECTURAL LIBRARY, formerly housed with the Engineering Library, has been transferred to the new building for the College of Architecture. For it see Part VI.

THE ENGLISH LIBRARY, in East Hall, contains a collection of reference books for the use of students in English courses.

THE CLEMENTS LIBRARY of American History completed in 1923, the gift of Hon. William L. Clements, B.S., 1882, houses the invaluable collection gathered by him and given to the University. The collection of books, manuscripts, and maps relating to the discovery of the western continent, its settlement, and later history, is especially rich in rare books and pamphlets dealing with our early colonial history and the period of the American Revolution.

44. University Power Plant.—The University Power Plant is a fine example of modern power plant construction and is available for instruction and for use. There have been installed eight 400 h.p. Wickes water-tube boilers with Murphy stokers, supplying steam at 150 pounds gauge pressure; an Allis-Chalmers cross-compound engine direct connected to a 625 kv-a generator producing 3-phase, 60-cycle alternating current at 2,300 volts; a 300 kv-a Curtis turbo-generator, equipped with Westinghouse-Le Blanc condenser; a 25 kw Allis-Chalmers motor-generator set; a 25 kw Allis-Chalmers turbine-driven exciter; a 15-ton engine room crane, a 3½ ton coal-handling crane; a pneumatic ash conveyor; two 2,000 h.p. feed-water heaters; two turbine-driven pumping units; two hot-well pumps; an air compressor; power and light-

ing transformers; and a distribution system for power and light. It is proposed in the future to obtain a supply of water from the river by means of an electrically-operated pumping station erected near the river. The feed-water heaters supply hot water to the boilers and also for domestic purposes. Coal is brought directly from the Michigan Central Railroad to the plant over an electrically-operated road, delivering the coal to a storage bin; thence, it is taken to a coal-crusher and delivered to the steel bunker above the stoker-hoppers. The ashes are carried by a pneumatic conveyor to a bunker over the track, from which they are loaded directly into the cars. Tunnels are provided for the underground distribution of steam, hot water, and electrical energy. There is available alternating current at 2,300 volts, 220 volts for lighting and other voltages for power; also direct current at 220 volts and 500 volts; high and low-pressure steam, and hot water.

45. Visits of Inspection.—The University is well situated for excursions to engineering industries. In Ann Arbor there are a large modern telephone exchange and a power substation of the electric railroad. The Detroit Edison Company has four hydro-electric power stations, one at Ann Arbor and the others within a distance of four miles. These stations are of recent construction and illustrate the very latest engineering practice in hydraulic and electrical design.

At Detroit there is much of interest to students of electrical engineering, including the main power houses and substations of the Detroit Edison Company, and of the Detroit Street Railway, the electrically operated Michigan Central Railroad tunnel under the Detroit River, and the new railroad terminal.

The classes in Hydraulics have been given the opportunity to assist in the tests of new power plants, and recently forty seniors spent four days on the tests of one of the largest plants in the state. The managements of the companies operating these plants are all in hearty sympathy and accord with the College of Engineering and afford the students every opportunity for inspection of the plants.

There are within forty miles two of the most complete modern classification yards in the United States, illustrating all types of humps and other modern sorting, the New York Central freight terminals at Toledo and the Michigan Central passenger terminals at Detroit. The Detroit River tunnel and the street railway properties in both cities afford exceptional opportunities for the inspection of important work. The co-operation of railways with the work of the department extends not only to giving students access to the properties but to giving freely to the University plans of all standard and special structures, for illustrative material, as well as courses of lectures by officers of the companies.

From the standpoint of automobile engineering, the University of Michigan has a strategic location at the very center of the automobile industry of the country. Detroit, Toledo, Flint, Jackson, Lansing, and Indianapolis, with the greatest automobile factories in the world, are within easy excursion distances and each year an inspection trip is made under the direction of the Automobile Department. These trips, while primarily for Engineering students, are open to any who are interested.

The classes in Chemical Engineering visit about forty industrial plants a year illustrating the transition of raw materials to finished products. The list includes large and modern plants illustrating the manufacture and treatment of iron and steel, copper, brass, and aluminum; Portland cement, clay products, and glass, salts, acids and alkalies, electrolytic and electric furnace products; gas, ammonia, tar, and other products from the destructive distillation of coal; petroleum; the vegetable fats and oils, including paint, varnish, and soap; sugar; food products, leather, and paper.

The students in Marine and Aeronautical Engineering have opportunities of visiting both Detroit and Toledo where various shipyards and aircraft factories are situated. The airports at the same places also afford an opportunity of inspecting the various types of aircraft and port equipment both for water and air transportation.

SOCIETIES

46. The Engineering Society.—The Engineering Society of the University of Michigan is an organization of students formed by the affiliation of sections from each department of the College of Engineering. Membership in the sections is voluntary and is regulated by the constitution of each section. Such membership entitles the students to all the privileges of the general society.

In the several sections of the society original papers are presented and the members are encouraged to take active part in the discussions, thus fitting themselves for a broader field of endeavor when they enter into the actual practice of their chosen profession. Helpful criticisms and suggestions are given by faculty members and the student is aided in every way in acquiring the art of public speaking.

The general society has as its primary purpose the creating of a broader field of vision for the Engineering student. This it attempts to accomplish by providing the opportunity for closer associations and the promotion of a social spirit among the students of the several departments; by securing as speakers at its meetings engineers of prominence in all fields of the profession; and by the publication of articles of general information to the student. As a further means to this end the society publishes

quarterly a journal, called *The Michigan Technic*, which contains papers read before the society, abstracts of theses, contributed articles from the alumni and faculty members, and other matters of interest to the student and the profession. A reading room is also maintained by the society where all the leading magazines and technical papers are accessible.

The sections of the general society are as follows :

Student Branch, American Society of Civil Engineers.—This Chapter was founded in 1923, and differs from other student chapters in that its membership is limited in numbers, and is confined to senior and junior students whose scholarship is above the college average.

Mechanical Engineering Section.—This section of the general society is also a **student branch of the American Society of Mechanical Engineers**. Meetings of the section are held about once a month. Some of the meetings are of a purely social nature while others are addressed by members of the faculty or by outside engineers and business men on subjects of general interest to the profession.

Electrical Engineering Section.—This section is a **student branch of the American Institute of Electrical Engineers**. In joining it, the student makes a connection which usually extends throughout his whole professional life after graduation, and which helps him materially in furnishing opportunities for advancement. The meetings, which are held twice each month, are managed entirely by the students, who procure speakers from among themselves or from professionals in the field, and who derive valuable experience in self-expression as well as technical knowledge from the discussions which they must make for themselves. Each member of the branch receives, in addition to the quarterly *Michigan Technic*, a copy of the Proceedings of the A. I. E. E., which are issued once each month.

Chemical Engineering Section.—This section is a **student branch of the American Institute of Chemical Engineers**. The student branch holds meetings where subjects of professional interest are discussed. It has been assigned a club-room in the East Engineering Building.

The Transportation Club is an organization formed by students with a mutual interest in the general subject of Transportation. It forms a common meeting ground for students in Railroads, Highway Engineering and Transport, Aeronautics, Marine Engineering, Business Administration and Economics. Because of its universal nature, it has developed a general appeal to the student body, and the monthly meetings are addressed by prominent engineers.

Tau Beta Pi, the national engineering honor society, has a chapter in the College of Engineering. For membership in this society good scholarship is essential.

The **National Society of the Sigma Xi** has a chapter in the University. The aim of the society is to encourage research. High scholarship and the promise of ability in research are required of its candidates.

FELLOWSHIPS

47. Roy D. Chapin Fellowship in Highway Transport.—This fellowship is offered to provide for the investigation of an approved subject relative to Highway Transport. It pays the sum of \$250, with an allowance of \$50 for expenses.

Roy D. Chapin Fellowship in Highway Engineering.—This fellowship is offered to provide for the investigation of an approved subject relative to hard-surfaced roads and pavements. It pays the sum of \$250, with an allowance of \$50 for expenses.

Detroit Edison Company Fellowships in Highway Engineering.—Two fellowships are offered for the investigation of approved subjects relative to moderate-cost country roads. Each fellowship pays the sum of \$250, with an allowance of \$50 for expenses.

Ray Sand and Gravel Company Fellowship in Highway Engineering.—This fellowship is offered to provide for the investigation of advisable methods of sampling and testing sand and gravel for construction purposes. It pays the sum of \$250, with an allowance of \$50 for expenses.

Reo Motor Car Company Fellowship in Highway Transport.—This fellowship is offered to provide for the investigation of the economic utilization and operation of motor busses. It pays the sum of \$250, with an allowance of \$50 for expenses.

Detroit Edison Fellowship in Boiler Scale Prevention.—The Detroit Edison Company has maintained, since 1924, a fellowship for the study of the fundamental phenomena connected with the deposition of boiler scale. The holder of this fellowship receives \$750 a year.

Thomas Berry Memorial Fellowship for Investigation of Protective Coatings. The holder of this fellowship receives \$750 a year.

Michigan Gas Association Fellowship.—This fellowship has been maintained continuously since 1900 with the exception of

interruptions during the war. The holder of the fellowship receives \$750.

The American Petroleum Institute Fellowship.—This fellowship is maintained for the purpose of studying the physical properties of petroleum and petroleum products. The sum of \$2,500 is annually available for payment of the fellowship and for special equipment.

The Association of Natural Gasoline Manufacturers maintains four fellowships for a study of the properties of natural gasoline. Holders of these fellowships receive \$750.

Detroit Edison Fellowship in Chemical Engineering.—By the generosity of the Detroit Edison Company, a fellowship in Chemical Engineering has been established with a stipend of \$750.

Detroit Edison Company Fellowship in Metallurgy.—In the fall of 1915, the Detroit Edison Company established at the University a fellowship in Metallurgy, but this fellowship was discontinued during the war. In the fall of 1922, the Company resumed support of it. One thousand dollars is available annually. Of this amount \$750 is paid to the appointee, the remainder being applied to expenses incident to the research or researches undertaken. The fellowship is for study of problems in Metallurgy relating to power plant construction and operation of the utilization of power.

Ordnance Fellowship.—A fellowship known as the Ordnance Fellowship was established in the fall of 1925, the funds being supplied from the United States Government Ordnance Research Fund which is at the disposal of the University. The fellowship carries a stipend of \$750.

SCHOLARSHIPS AND PRIZES

48. Cornelius Donovan Scholarships.—These scholarships were established in 1922 by bequest of Cornelius Donovan of the class of 1872. At present about \$3,500 yearly is available for award to meritorious students in engineering who are working their way through college.

Lloyds Register Scholarship.—A scholarship of \$500 per annum, tenable for three years, is given annually by the American Committee of Lloyds Register of Shipping. It is open to students who have completed the regular work of the first year in the College of Engineering.

The award is made subject to competitive examination in the subjects of the first year, and is based upon the results of the final examinations. The personality and general conduct of the student are also given consideration. It is awarded to those students who

intend to complete the regular course in Naval Architecture and Marine Engineering.

American Bureau of Shipping Prize.—A prize of \$100 is offered each year by the American Bureau of Shipping, to the student in Naval Architecture and Marine Engineering who shall obtain the highest average for the last two years of the course, in the regularly prescribed courses.

Robert Campbell Gemmell Memorial Scholarship.—This scholarship in memory of her brother, Robert Campbell Gemmell, B.S. (C.E.), '84, C.E., '95, Master of Engineering honorary, 1913, was founded by Mrs. Lillian Gemmell Boal (Mrs. S. H. Boal) of Oakland, California, by a gift of \$10,000 to the University.

"This scholarship is to be available for freshman and sophomore students in the College of Engineering of general worthiness and deserving character." The income may be divided among several beneficiaries if the committee in charge so determines.

Minnie Hubbard Smith Revolving Fund, founded by George H. Knutson, '08E., by a gift of \$500 and increased to \$1,000 by Frank Hubbard Smith, '93, '95L.

This fund is for juniors and seniors in the Department of Civil Engineering, "who have continuously been in one of the engineering departments of the University of Michigan at least two and one-half years prior to date of gift, who are enrolled in the Department of Civil Engineering, and who have need of financial assistance in order that they may remain in college, complete their courses, with the end in view of graduating without interruptions in their college course. The placing and approval of the gifts are to be at the discretion of the Professor of the Department of Civil Engineering." It is anticipated that beneficiaries of this fund will desire to contribute to this fund when able, so that it may continue.

LOAN FUNDS

49. **Students desiring loans** from any of the loan funds should make application to the Dean of Students, No. 2 University Hall.

In addition to the loan funds listed below, a number of general loan funds are also available, information on which will be sent on request by the Dean of Students.

George H. Benzenberg Trust Fund.—In the fall of 1920 Mr. George H. Benzenberg gave in trust to the University \$20,000, the interest of which is to be available to loan to engineering students in need of aid to complete their studies.

The Brosseau Foundation.—Established in 1927 by an initial gift of \$23,000 from Mr. and Mrs. Alfred J. Brosseau, New York City. The fund is available for loans to needy and worthy students in the University, students of such schools in the State of Michigan as shall be considered by the University as preparatory to an education at the University, and students in state supported schools and colleges in the State of Michigan which furnish education in collateral fields not covered by the University. No student in courses in law, medicine, the ministry, or the fine arts is to be aided or assisted by this fund. The donors' nephews and nieces and their descendants are to receive preference in the selection of beneficiaries, provided they meet the requirements applicable to other beneficiaries. Should any yearly contribution be in excess of requirements for that year, such excess may be used for fellowships and scholarships, the promotion of research in the University, or in fields generally, for the advancement of practical and technical sciences, or for the maintenance of an employment bureau for graduates and students. Should such yearly excess be devoted to fellowships and scholarships, or research, the same general restrictions which apply to student loans as outlined above are to be operative.

Class Fund of 1914.—A fund of \$400 was established by the Class of 1914 to be increased in the future by gifts from members of the class. Loans from this fund are limited to seniors in the College of Engineering. These loans are payable in two years without interest.

Class Fund of 1915.—A fund of \$232 was contributed by the Class of 1915 to be used as a loan fund for senior or junior engineering students.

Class Fund of 1917.—The class of 1917 contributed \$370 to be used as a loan fund for Engineering students.

The J. B. and Mary H. Davis Trust Fund.—In April, 1922, Mr. C. B. Davis, '01 Eng., presented to the Regents of the University \$10,000 to establish the J. B. and Mary H. Davis Trust Fund, the income to be devoted to the aid of students of either sex in any class in the Department of Geodesy and Surveying.

The John Frank Dodge Loan Fund.—Seniors and juniors of the College of Engineering may borrow from this \$10,000 fund to the amount of one hundred dollars for any one year when their records and needs warrant such a loan. All loans must be paid with five per cent interest two years after graduation, the interest being reckoned from date of graduation.

William James Olcott Scholarships.—In June, 1916, Mr. William J. Olcott of Duluth, Minnesota, gave to the University the sum of \$5,000 for the establishment of a loan fund open to students

in the College of Engineering. The amounts awarded, when repaid, shall accumulate towards the foundation of further scholarships.

Marian Sarah Parker Memorial Fund.—In April, 1923, Sarah Drake Parker gave to the University the sum of \$500 as the nucleus of a fund to assist girl students in the Colleges of Engineering and Architecture, in memory of her daughter, Marian Sarah Parker, 1895E (Mrs. Albert E. Madgwick), who was the first woman graduated from the College of Engineering.

If the fund increases sufficiently so that the income would warrant it the income may be used for the support of scholarships or fellowships or for prizes for excellence of scholarship or notable achievements by women in the field of engineering and architecture.

The Benjamin Sayre Tuthill Loan Fund.—The Benjamin Sayre Tuthill Fund was established in 1910, in memory of Benjamin Sayre Tuthill, of the Class of 1909 in Civil Engineering, who died at Albuquerque, New Mexico, May 30, 1910. This fund "is to consist of a sum of money, contributed by friends, which shall be available to students as a loan fund at a moderate rate of interest. When through the contributions added from time to time and the earnings of the loans, this fund shall have reached such proportions as will support a scholarship, it may be so used if advisable. It is the intent that the Memorial be used in the most practical way possible to aid struggling students."

Paul Wheeler Warriner Scholarship.—A loan fund of \$300 given in memory of Paul Wheeler Warriner, a member of the Engineering class of 1920, who died in his freshman year.

BEQUESTS AND GIFTS

The University of Michigan has in recent years become more and more frequently the object of bequests and donations from public-spirited alumni and citizens of Michigan and other states who see in the state university a means of serving the present and the future. From one-quarter to one-third of the University's permanent assets, in funds, lands, buildings and equipment have been contributed by such friends. Any correspondence on this subject may be addressed to the President of the University and all inquiries will receive prompt and candid replies.

For the benefit of those who may desire to make use of the same, a correct form of bequest is here given with the corporate title of the University:—

"I give, devise, and bequeath to the Regents of the University of Michigan (here insert the sum or the property bequeathed)for the following purpose (here insert the purpose of the bequest)....."

In the light of experience, even in so young a country as the United States of America, it is apparent that no one can unmistakably read the future. This fact has resulted in reducing almost to uselessness certain bequests made in earlier days to various institutions. With the idea of permitting most useful continuance of the benefaction in general accord with the purposes of the donor even if with the changes of the years the precise purpose of the gift should prove to be no longer a real need, it is suggested that all benefactions might wisely contain a clause similar in purpose to the following, which is quoted direct from an actual will:—

“In the event that the sums available hereunder for the purposes stated shall in the opinion of the said Regents at any time exceed the need therefor, then such excess income may be used by the Regents for the advancement of research and for educational purposes generally and for the needs of the University in such amount and in such manner as they may from time to time deem best.”

DEGREES CONFERRED IN THE COLLEGE OF ENGINEERING

51. The University of Michigan confers on all graduates of the College of Engineering the Degree of Bachelor of Science in Engineering, the diploma designating the branch of engineering which the student has pursued.

Graduate courses are offered in the Graduate School leading to the Degree of Master of Science in Engineering and to the Degree of Civil Engineer, Mechanical Engineer, Electrical Engineer, Chemical Engineer, Naval Architect, Marine Engineer, Aeronautical Engineer, and Geodetic Engineer.

All students who have received a bachelor's degree from the College of Engineering of this University or from some other university or technical school of recognized standing may enroll in the Graduate School for the degree of Master of Science in Engineering and for other higher degrees. See special bulletin of the Graduate School, which may be had on application.

Students enrolled in the Graduate School must have a subject of specialization but studies may not be selected exclusively in the single department concerned with the subject. Cognate subjects should be selected in other departments. While it is expected that at least half of the work will be in a single department and also that the work will have unity, narrow specialization is discouraged. After a student has selected his department of specialization he should confer with the professors under whom he expects to study and with them arrange the details of his course.

REQUIREMENTS FOR GRADUATION

52. To secure a degree in the College of Engineering, a student must meet the following requirements:

1. He must complete the required courses of his department.

2. He must complete a sufficient number of group options or other courses of University grade approved by the head of his department to make a total of 140 credit hours with an average grade of 2 or above. See section 38.

A credit hour represents as a rule one hour of recitation, preparation for which should require two hours of study; or in the case of laboratory work, the credit hours are one-half to one-third of the actual hours, the time required depending on the necessary home work.

A student may not, in general, offer as group options advanced credits earned in the preparatory school.

Hours of Work Required for the Degree of Bachelor of Science in Engineering

SUBJECT	Civ.	Mch.	Elec.	Chem.	Mar.	Aero.	Geod. Surv.
English	6	6	6	6	6	6	6
Language and Groups	16	16	16	16	16	16	16
Mathematics	18	18	18	16	18	18	18
Physics	10	10	14	10	10	10	10
Chemistry	5	5	5	28	5	5	5
Astronomy	0	0	0	0	0	0	5
Forestry	0	0	0	0	0	0	2
Geology	3	0	0	0	0	0	3
Drawing	8	8	8	8	8	8	11
Shop Practice	2	10	2	2	2	6	2
Engineering Mechanics	12	12	12	7	12	12	12
Civil Engineering	24	3	3	0	3	3	8
Mechanical Engineering	4	27	7	7	18	21	4
Electrical Engineering	4	4	30	4	4	4	4
Chemical Engineering	3	4	3	23	3	3	3
Marine Engineering	0	0	0	0	15	0	0
Aeronautical Engineering ..	0	0	0	0	0	14	0
Geodesy and Surveying	7	2	2	0	2	2	22
Economics	0	0	0	3	0	0	0
Group Options	7	0	14	0	18	0	0
*Military Science and Tactics	0	0	0	0	0	0	0
Elective	11	15	0	10	0	12	9
Total	140	140	140	140	140	140	140

*May be substituted for other courses with the approval of Heads of Departments.

COURSES COMMON TO THE DIFFERENT PROGRAMS IN THE COLLEGE OF ENGINEERING

53. The following required studies are common to all the programs in the College of Engineering:

English 1 and 2, Theme-writing and Oral Expression	4 hours
English 5, 6, or 14	2 hours
Modern Language and Cultural Electives	16 hours
Mathematics 1, Algebra and Analytic Geometry	4 hours
Mathematics 2, Pl. and Sol. Analytic Geometry	4 hours
Mathematics 3, Differential Calculus	5 hours
Mathematics 4a, Integral Calculus	3 hours
Physics 45, Mechanics, Sound, and Heat	5 hours
Physics 46, Magnetism, Electricity, and Light	5 hours
Chemistry 5, General Inorganic Chemistry	5 hours
Drawing 1, 2, 3	8 hours
Shop 2, Metal Working and Treating	2 hours
Eng. Mech. 1, Statics	4 hours
Eng. Mech. 2, Strength and Elasticity	3 hours
Mech. Eng. 3, Heat Engines	4 hours
Elect. Eng. 2, Electrical Apparatus 1 (or 2a)	4 hours
Chem. Eng. 1, Engineering Materials	3 hours

81 hours

The following studies are common to most of the programs:

Math. 4b, Differential Equations (except Chemical)	2 hours
Surveying 4, Use of Instruments (except Civil, Chemical, and Geod. and Surv.)	2 hours
Eng. Mech. 3, Dynamics (except Chemical)	2 hours
Eng. Mech. 4, Hydromechanics (except Chemical)	3 hours
Civil Eng. 2, Theory of Structures (except Chemical)	3 hours
Mech. Eng. 2, Elements of Mach. Design (except Civil, Electrical, and Geod. and Surv.)	3 hours

MODERN LANGUAGES AND CULTURAL ELECTIVES

54. All regular students in the College of Engineering are required to complete the equivalent of Course 4 in French, German, or Spanish, as given in the University, or Course 3 in Spanish if preceded by two years of Latin in the high school. Course 2 in Spanish if preceded by at least three units of Latin or Greek, will satisfy this modern language requirement. Students expecting to specialize in Chemical Engineering are advised to pursue either French or German on account of the large amount of scientific literature in these two languages. (Students in the College of Architecture are required to complete Course 3 in French or German.) Students whose language is other than English may

substitute English for French, German or Spanish, the maximum amount of English being seventeen hours.

After completing the foreign language requirement, students must elect courses from the following list, until they have sixteen hours of college credit in foreign languages and other cultural studies: English, Foreign Languages, Oratory, History, Political Science, Political Economy, Sociology, Philosophy, Fine Arts, Music.

Plane Trigonometry, Chemistry 3 and Military Science, not in excess of four hours, will be included in this list when college credit is given in these studies. Advanced courses in Mathematics may be counted as cultural or technical electives, at the discretion of the head of the technical department concerned.

To secure credit in Music, courses must be chosen from those scheduled in the College of Literature, Science, and the Arts.

Part IV

WORK OF THE COLLEGE OF ENGINEERING

STUDIES OF THE FIRST YEAR

55. There is a common first year for all students entering without deficiencies or advanced credits. After the first year, each student indicates the branch of engineering he expects to follow and is then registered as a student in that branch.

In the second year there is some variation among the curricula for the different branches of engineering, though not so great as to make transfers difficult; but in the third and fourth years there are marked differences and a student transferring from one course to another does so with difficulty and with some loss of time.

The schedule of studies for first year students is as follows:

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
*Modern Language	4	*Modern Language	4
Gen. Chem. 5 or Shop 2 and Engl. 1 and 2	5 or 6	Gen. Chem. 5 or Shop 2 and Engl. 1 and 2	5 or 6
Math. 1 (Anal. Geom. and Alg.)	4	Math. 2 (Pl. and Sol. Anal. Geom.)	4
Drawing 1	3	Drawing 2	3
Total hours	16 or 17	Total hours	16 or 17

Schedules of studies for later years will be found under the work of the various degree-conferring departments.

The above schedule assumes that the student has presented for admission the full requirement in algebra and geometry, and also trigonometry and chemistry of Group II (alternative requirements) described in section 8. Should the student have entered without trigonometry or chemistry, or both, the schedule will be modified by adding trigonometry and (or) Chemistry 3 followed by Chemistry 6 (in place of Chemistry 5).

*See section 54 for Modern Language requirement.

In case that the admission requirements have been fully met on entrance, trigonometry and Chemistry 3 will give credit toward graduation as cultural subjects. See section 54. Should the student have entrance deficiencies in advanced algebra, solid geometry, trigonometry, physics or chemistry, the deficiencies must be removed but without credit toward graduation.

A deficiency in foreign language introduces no irregularity in the schedule. See section 54.

The classifier in consultation with the student will arrange a schedule intended to adjust the irregularities as quickly as possible. Students are required to remove all deficiencies during this first year, unless granted an extension of time for their removal. See section 36.

COMBINED COURSES

56. **Albion College.**—At the November meeting of the Board of Regents, 1914, a schedule was approved for a combined course between Albion College and the College of Engineering.

In general, a student spends at least three years at Albion College and two succeeding years at the University. At the end of his first year's work at the University, provided the reports are satisfactory, he will receive the degree of Bachelor of Arts from Albion College; the latter institution being willing to accept the work done at the University as the equivalent for the fourth year.

Upon the completion of the requirements for graduation in the College of Engineering, the student will receive the degree of Bachelor of Science in Engineering.

The schedule of work for the first three years at Albion College is shown below.

First Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
French or German	3	French or German	3
English I	3	English I	3
Mathematics I	4	Mathematics 2	4
Physics I	4	Physics I	4
Drawing	2	Surveying	2

Second Year

French or German	3	French or German	3
Mathematics 3	4	Mathematics 3	4
Physics 2	3	Physics 2	3
Descriptive Geometry	2	Descriptive Geometry	2
Chemistry 1A	3	Chemistry 1A	3

Third Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Physics 3	3	Physics 6	3
Physics 6	3	Mathematics 6	3
Mathematics 5	3	Applied Mathematics 3	3
Chemistry 6	3	Applied Mathematics 4	2
Electives		Electives	

Electives

In Civil Engineering:

Geology, 6 hours; Physics 3, 3 hours.

In Mechanical and Marine Engineering:

Mathematics II, 4 hours; Physics 3, 3 hours; Electives, 2 hours.

In Electrical Engineering:

Physics 4, 6 hours; Mathematics II, 4 hours.

In Chemical Engineering:

Chemistry 2A, 5 hours; Chemistry 3A, 5 hours.

57. Olivet College.—The following schedule has been approved for a combined course between Olivet College and the College of Engineering of the University. In general, it is proposed that a student shall spend at least three years at Olivet College and two succeeding years at the University. After one year of satisfactory work in the College of Engineering the degree of Bachelor of Arts will be conferred by Olivet College. Upon the completion of the requirements for graduation in the College of Engineering, the student will receive the degree of Bachelor of Science in Engineering.

First Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
College Algebra	3	Analytic Geometry	5
Plane Trigonometry	4	English	3
English	3	Religion	1
Applied Psychology	1	French or German	5
French or German	5	Gymnasium	1/2
Gymnasium	1/2	Elective	2
Elective	2		

Second Year

Calculus	3	Calculus	3
Physics	5	Physics	5
Chemistry	5	Chemistry	5
French or German	3	French or German	3
Gymnasium	1/2	Gymnasium	1/2

Third Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Calculus	2	Calculus	2
Surveying	2	Descriptive Geometry	2
Descriptive Geometry	2	Mechanics	4
Mechanics	3	Elective	7
Elective	6	Gymnasium	½
Gymnasium	½		

Electives

Free-hand and Mechanical Drawing (4 hours); Mineralogy (3 hours); Qualitative Analysis (3 or 5 hours); Quantitative Analysis (3 or 5 hours); Economics (6 hours); Psychology (6 hours); Philosophy (4 hours).

58. **The College of the City of Detroit.**—In general, it is proposed that a student shall spend at least three years at the College of the City of Detroit and two succeeding years at the University; the satisfactory completion of the first year's work at the University will be accepted by the College of the City of Detroit as the equivalent of its fourth year's work, and the degree of Bachelor of Arts will be granted by that College. Upon the satisfactory completion of the requirements for graduation in the College of Engineering, the student will be recommended for the degree of Bachelor of Science in Engineering. The schedule for the three-year pre-engineering program follows:

First Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Modern Language	4	Modern Language	4
Rhetoric I or I E	3 or 4	Rhetoric 2	3
Math. 4 (Alg., Anal. Geom.)	4	Math. 5 (Anal. Geom.)	4
Drawing I (Mechanical)	3	Chemistry 3 (Gen. Chem.)	4
Shop 2 (Metal work)	2		
Total hours	16 or 17	Total hours	15

Second Year

Modern Language	4	Modern Language	4
Math. 6 (Calculus)	5	Math. 7 (Cal. and Dif. Eq.)	5
Chem. 4 (Qual. Anal.)	4	Physics I E	5
Descriptive Geometry	3	Surveying	2
Total hours	16	Total hours	16

Third Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Physics 2E	5	Engineering Mechanics	4
Economics I	3	Chemical Engineering	3
English	3	Economics 2, 3, 4, or 5	3
Social Science Elective	3	English	3
Other Elective	2 or 3	Other Elective	3
Total hours	16 or 17	Total hours	16

COMBINED COURSE WITH THE SCHOOL OF BUSINESS ADMINISTRATION

59. Students who have completed the first three years of prescribed work in the College of Engineering with the grade of at least 2.3 and who have taken eighteen hours of work in Economics (including Accounting and Statistics) may transfer to the School of Business Administration; and upon the satisfactory completion of two years of work in the latter School, may be granted the degree of Master of Business Administration.

See also the five-year programs in this College in co-operation with the School of Business Administration under Mechanical Engineering, Chemical Engineering, and Electrical Engineering, sections 87, 83 and 85.

NON-PROFESSIONAL DEPARTMENTS

60. In the following sections are listed courses given entirely, or primarily, for students in engineering or architecture, and in addition those courses which frequently are elected by them. The Colleges of Engineering and Architecture have their own departments of mathematics, English, and modern languages, distinct from those in the College of Literature, Science, and the Arts. Students, however, may elect with the approval of the deans courses in these studies given in the other college.

A course in another college, listed in any engineering curriculum may be elected by our students without special formality, but the approval of the deans, readily obtained, may be required when the course is not intended for engineers. Lack of proper preparation for the course is sufficient reason for approval to be refused.

Besides the departments listed below, in which our students make frequent elections, there are many others which freely and hospitably receive our students. The Colleges of Engineering and Architecture in the same way receive students from other colleges.

61.

ASTRONOMY

Professor CURTISS; Associate Professor ROSSITER*; Assistant Professors RUFUS and McLAUGHLIN; Mr. SCHIEFER, Dr. MAXWELL, Dr. LOSH.

The University Observatory is situated at the corner of Ann and Observatory Streets.

Its equipment includes a 37½-inch equatorial reflecting telescope, which is used for stellar spectrographic work; a 12½-inch equatorial refractor; a 6-inch meridian circle; a comet seeker; mean and sidereal clocks and chronometers, chronograph, theodolites, sextants, seismographs, computing machines, and measuring engines.

The Observatory Library contains about 3,000 volumes, devoted mainly to technical astronomy. It includes the more important works on theoretical and practical astronomy, many star catalogues, files of the leading astronomical periodicals, and the publications of the more important observatories.

The astronomical laboratory is located on the fifth floor and the roof of Angell Hall. The present equipment of this laboratory includes a ten-inch refractor, a three-inch astronomical transit, three portable refractors, a planetarium, celestial globes and other smaller instruments. A fifteen-inch reflector, a horizontal solar telescope, and a second astronomical transit are to be added to this equipment in the future.

Courses 31, 32, 33, 103, and 104 are recommended to those who wish to obtain a general knowledge of modern astronomy without entering far into its mathematical details. Courses 35, 101, 102, 154, and 201 are recommended to those who wish to obtain a knowledge of practical astronomy in its applications to engineering and geodesy.

Courses in addition to those mentioned below are listed in the Announcement of the College of Literature, Science, and the Arts. These include advanced work in theoretical astronomy, practical astronomy, and astrophysics. The larger instruments of the Observatory are intended primarily for research, and are available to that end to such students as have assigned problems requiring their use.

The first two years' work in any department of engineering constitutes good preparation for a curriculum looking toward the profession of Astronomy.

31. General Astronomy. The Solar System. A descriptive course, including the fundamental principles of astronomy, and a presentation of the leading facts concerning the sun, moon, planets, and comets. Lectures, recitations, and Observatory exercises. Three hours credit. Each semester.

*Absent on leave.

32. **General Astronomy. Stars and Nebulae.** A descriptive course, devoted mainly to stars and nebulae, including the study of the sun as a typical star. Lectures, recitations, and Observatory exercises. Three hours credit. Each semester.

33. **Elementary Observational Astronomy.** Constellation studies and telescopic examinations of the heavenly bodies. Selected problems with the celestial globe and equatorial telescope. Lectures, recitations, and Observatory exercises. *Open to those who have had or are taking Course 31, 32, or 35.* One hour credit. Each semester.

35. **Practical Astronomy.** The elements of Spherical and Geodetical Astronomy, with practical applications. Theory of the determination of time, latitude, longitude, and azimuth. This course is intended primarily for students in Engineering. Recitations and problems. *Open to those who have had trigonometry and analytical geometry.* Two hours credit. Each semester.

101. **Practical Astronomy.** Studies in Spherical Astronomy. Theory of the meridian circle and equatorial and their use in observational work. This course includes observational work with instruments and the reduction of measurements. Recitations, practical problems. *Open to those who have had trigonometry and analytical geometry.* Three hours credit. Each semester.

102. **Navigation.** The principles of pilotage, dead reckoning, and nautical astronomy. Lectures based on Bowditch's *American Practical Navigator*, supplemented by practical problems, chart exercises, and sextant observations. *Open to those who have had plane trigonometry.* Three hours credit. Second semester.

154. **Least Squares.** Theory of the error curve and of the combination of observational data according to the Method of Least Squares. Recitations, problems. *Prerequisite: calculus.* Two hours credit. Second semester.

201. **Theoretical Astronomy.** The elements of Celestial Mechanics, and the determination of parabolic and elliptic orbits of comets and planets. *Prerequisite: calculus.* Three hours credit. First semester.

Summer Session

Courses 31s, 32s, 33s, 101, 103, 151, 152, and 207 will be given during the Summer Session of 1928.

62. BACTERIOLOGY, AND WATER ANALYSIS

3E. Practical Bacteriology. This course is open only to students of Sanitary Engineering. Three afternoons each week during the second half of the first semester, beginning December 1. Assistant Professor HADLEY, Room 3542, East Medical Building.

5E. Water Analysis. Three afternoons weekly, M,W,F, during the first half of the first semester. This course is open to students of Sanitary Engineering and to others who are qualified. Assistant Professor EMERSON, Room 1548, East Medical Building.

63. BUSINESS ADMINISTRATION

Professors DAY, YOAKUM, PATON, GRIFFIN; Associate Professor MASSON; Assistant Professors BLACKETT, GORDY, MITCHELL, and others.

The courses listed below are those which are deemed of special interest to engineering students. For the full list of courses in Business Administration, see the announcement of the School.

101. Principles of Organization, Production, and Personnel I. This course consists of four parts. Part 1 begins with a survey of the historical and descriptive background of modern business and proceeds to some fundamental considerations relative to the individual enterprise as a whole, such as the factors influencing its size and location, and the major functional divisions found within the management of a typical business unit. Part 2 is devoted to a study of production as a function in different types of industrial and commercial activity; and part 3 deals with the personnel problems of business. In the final section, principles of managerial organization are discussed, and attention is directed to the problems involved in coordinating the various activities of the business through such means as accounting and statistical records and reports. Assistant Professor MITCHELL. Three hours credit. First semester.

102. Principles of Organization, Production, and Personnel II. This course is a continuation of B. A. 101. Assistant Professor MITCHELL. Three hours credit. Second semester.

161. Financial Principles I. This course undertakes an analysis of the financial principles underlying the organization and management of business enterprises. Attention is given to the means of securing permanent capital both in the initial stages of a business and in the expansion of a going

concern. The various methods of obtaining working capital are studied with special emphasis upon the distinction between temporary and permanent borrowing. Consideration is also given to the policies to be followed with respect to the earnings of a business, and to various other problems of internal finance connected with the purchase, production, and sale of goods. Assistant Professor MASSON. Three hours credit. First semester.

162. Financial Principles II. This course is a study of the the organization and financial administration of modern business corporations. The corporation is compared with other forms of business enterprise. The course deals with such subjects as corporate promotion, the nature and varieties of stocks and bonds, capitalization, the methods of corporate expansion, the sale of securities, the principles governing the administration of income, intercorporate relations, and the problems and procedure of re-organization. Associate Professor MASSON. Three hours credit. Second semester.

Summer Session

Courses 101s, 102s, 111s, 151s, 152s, 161s, and 162s will be given during the Summer Session of 1928.

64.

CHEMISTRY

Professors GOMBERG, BIGELOW, WILLARD, SMEATON, BARTELL, LICHTY, SCHOEPFLE; Assistant Professors CARNEY, MELOCHE, FERGUSON, MCALPINE, HODGES, WEATHERILL; Mr. COLE, Dr. SOULE, Dr. ANDERSON, Dr. CASE, Dr. BACHMANN, Dr. HALFORD.

The aims of the fundamental course in general chemistry, required of all engineering students, are primarily the development of a scientific attitude, the acquisition of such chemical facts as form a part of the store of knowledge of any well-informed person, and preparation for the succeeding required course in the chemistry of engineering materials. Further courses in analytical, organic, and physical chemistry are required of students in chemical engineering, and may be elected by other students having the requisite preparation. Students intending to specialize in chemistry are advised to obtain a reading knowledge of both French and German.

The chemistry building provides excellent facilities for the work in all the schools and colleges of the University. Lectures and class rooms, laboratories for class instruction and individual research, a fully equipped stock-room, and the chemical library are all located in the one building. The library contains about 8,000 volumes and is especially rich in complete sets of journals. Over 90 journals are currently received.

3. General and Inorganic Chemistry.* A study of the non-metallic elements and their compounds, with special emphasis upon the interpretation of chemical phenomena from the viewpoint of recent theory and investigation, accompanied by a systematically arranged course of laboratory experiments designed to illustrate the fundamental principles underlying the science. Two lectures, two recitations, two laboratory periods. Four hours credit. Each semester.

5E. General and Inorganic Chemistry.* The fundamental principles of chemistry are developed in such a way as to illustrate the scientific method. The descriptive chemistry of some of the non-metallic elements and of all the more important metallic elements is studied as further illustration of the fundamental principles, special emphasis being placed on such facts as are of importance to the engineer. Two lectures, two recitations, two laboratory periods. Open to students who have presented a unit of chemistry for entrance. An examination may be given to students enrolling in this course, and those whose preparation is shown to be inadequate will be transferred to Chemistry 3, credit for which will be counted as a cultural elective. Five hours credit. Each semester.

6. General and Inorganic Chemistry.* A continuation of Course 3 dealing chiefly with the chemistry of the metallic elements. Lectures, recitations, and laboratory. Four hours credit. Second semester only.

15. Qualitative Analysis. A study of the distinctive properties of some common substances in water solutions and the reactions used in the identification of such substances. Attention is directed to reactions which bear on problems met in engineering practice. Recitations and laboratory work. *Prerequisite: Chemistry 5 or 6.* Four hours credit. Each semester.

17. Qualitative Analysis. In this course the distinctive properties of some of the more common chemical compounds are studied, with special reference to their use in analysis. A considerable number of unknowns are analyzed, and the student is required to show an understanding of the theory of dilute solutions in discussing the reactions employed in the laboratory. Recitations and laboratory work. *Prerequisite: Chemistry 5 or 6.* Five hours credit. Each semester.

*Engineering students entering without Chemistry will elect Courses 3 and 6. The credit for Chemistry 3 will be allowed as a cultural elective if the student presented full entrance requirements, but otherwise will be entered as an admission requirement. Students presenting an approved unit of Chemistry for entrance will take Chemistry 5, unless three or more years have elapsed since they studied Chemistry, in which case they are advised to elect Chemistry 3 and 6.

41. Elementary Theoretical and Physical Chemistry. In this course special attention will be paid to the study of chemical equilibrium, velocity of chemical reactions, and application of physico-chemical theory. Lectures and recitations. *Prerequisites: Chemistry 17 or 53, Physics 36, and a knowledge of calculus.* Three hours credit. First semester.

42. Elementary Theoretical and Physical Chemistry. This course is similar in content to Course 41 and may be elected as an alternative. Lectures and recitations. *Prerequisite: Chemistry 17 or 53.* Four hours credit. Second semester.

43. Physical-Chemical Measurements. Methods for the determination of molecular weight, viscosity, surface tension, reaction velocity, solubility, etc., optical measurements with polarimeter, refractometer, spectroscope. Laboratory work. *Prerequisites: the student must have completed or must be taking Chemistry 41 or 42, and 57.* Three or four hours credit. Each semester.

53. Qualitative Analysis. A continuation of Chemistry 15. The course includes the identification of a wider range of substances and the analysis of more difficult mixtures, including some alloys, slags, and phosphates, also studies in oxidation and reduction. Recitations and laboratory work. Four hours credit. Each semester.

57. Quantitative Analysis. This course includes the study of gravimetric, volumetric, and electrolytic methods, and the analysis of simple mixtures. The solution of stoichiometric problems is emphasized. Recitations and laboratory work. *Prerequisite: Chemistry 17 or 53.* Five hours credit. Each semester.

67. Organic Chemistry. The properties and classification of carbon compounds. Lectures, recitations, and laboratory work. *Prerequisite: Chemistry 17 or 53.* Five hours credit. Each semester.

69. Organic Chemistry. Continuation of Course 67. Lectures, recitations, and laboratory work. Five hours credit. Each semester.

105. History of Chemistry and Development of Chemical Theory. Lectures and seminary. Two hours credit. Each semester.

111. Electrochemistry. An elementary treatment of the fundamentals of the subject. Lectures. *Prerequisites: Physics 36, and preceded or accompanied by Chemistry 41 or 42.* Two hours credit. First semester.

112. Applied Electrochemistry. Application of principles of electrochemistry to analytical and industrial processes. Laboratory work. *Prerequisite: Chemistry III.* Two hours credit. Second semester.

113. Electrochemistry. Measurements of conductivity, resistance of primary and secondary cells, current by means of coulometers, single electrode potentials, overvoltage, transport numbers, electromotive force, including hydrogen electrode, and methods of electrochemical analysis. Laboratory work. *Prerequisite: Open to those who have completed or are taking Course III.* Two hours credit. First semester.

125. Chemistry of Colloids. In this course the student will be given the fundamental principles of colloid chemistry. Lectures. *Prerequisite: Open only to those obtaining permission of the instructor.* Two hours credit. First semester.

127. Chemistry of Colloids. An application in the laboratory of the principles of colloid chemistry. Laboratory work. *Prerequisite: Must be preceded or accompanied by Course 125.* Two hours credit. First semester.

131. Physical-Chemical Measurements. A continuation of Course 43. The work includes electrical measurements such as conductivity, transport numbers, and electromotive force, work with the hydrogen electrode, experiments with colloids, and the determination of some of the more important physico-chemical constants. One to four hours credit. Each semester.

132. Advanced Theoretical and Physical Chemistry. A continuation of Course 41. Special attention is given to velocity of chemical reactions and chemical equilibria. The work includes a study of the principles of thermo-chemistry, applications of the phase rule, and a brief survey of recent advances in the field of physical chemistry. Lectures. Two hours credit. Second semester.

145. Advanced Quantitative Analysis. Application is made of the principles laid down in Course 57 to the analysis of some technical products, including coal, iron, and other ores, a silicate rock, and ferrous and non-ferrous alloys. Lectures and laboratory work. *Prerequisites: Chemistry 57 and Physics 36.* Four or five hours credit. Each semester.

147. Special Problems in Quantitative Analysis. A study of some of the more difficult and uncommon problems of quantitative analysis. The student is left largely to his own resources. Laboratory work. *Prerequisite: Five hours of Course 145.* Five hours credit. Each semester.

163. **Advanced Organic Chemistry and Ultimate Analysis.** Laboratory work and reading. *Prerequisites: Chemistry 67 and 69.* Two to five hours credit. Each semester.

165. **Advanced Organic Chemistry.** Lectures and reading. *Prerequisites: Chemistry 67 and 69.* Two hours credit. First semester.

166. **Advanced Organic Chemistry.** Lectures and reading. *Prerequisites: Chemistry 67 and 69.* Two hours credit. Second semester.

242. **Physico-Chemical Methods in Analytical Chemistry.** Lectures and laboratory work. *Prerequisites: Chemistry 41 and 145.* Two hours credit. Second semester.

Summer Session

Courses 3, 6, 17, 34s, 41, 43, 57, 63, 65, 69, 103, 105, 125, 127, 131, 145, 147, 153, 163, 166, as described for the regular session, will be given in the Summer Session of 1928.

65.

ECONOMICS

Professors DAY, SHARFMAN, PATON; Assistant Professors MAY, GOODRICH, VAN SICKLE, WATKINS, CAVERLY, and others.

Courses 53 and 54 listed below are of particular interest to those students in the College of Engineering who wish to get a general survey of economics and do not expect to take any considerable program in the subject. In addition, there are enumerated a number of courses in economics and business administration which will prove of interest and value to such students of Engineering as are able to devote a larger amount of time to outside fields of study. For a more detailed announcement of these courses and for additional courses in the field of economics, consult the annual Announcement of the College of Literature, Science, and the Arts.

Students who elect any course without first completing the necessary prerequisites will be denied credit in that course.

51. **Principles of Economics I.** This course and Course 52 constitute a general course in the principles of economics which usually precedes all other courses in economics except 53, 54, 153, and 155. Courses 51 and 52 should be elected by all students expecting to take any considerable program in the field of economics. Three hours credit. Each semester.

52. Principles of Economics II. This course is a continuation of Course 51, by which it must be preceded. Three hours credit. Each semester.

53. General Economics I. This course is designed to meet the needs of students, particularly in professional departments, whose work lies chiefly outside the field of economics, but who desire a general course in economic principles and problems. Opening with a brief description of present-day industrial organization, the course will consider the fundamental economic principles of production, exchange and distribution. It will then examine the application of these principles to current problems of labor, money and banking, public utilities, trust, and taxation. This course should be followed by Course 54. *No student can receive credit for both this course and Course 51, or Course 153.* Three hours credit. First semester.

54. General Economics II. This is a continuation of Course 53. During the second semester primary emphasis will be placed on questions arising out of the public relationships of industry. *Prerequisite: Course 53.* Three hours credit. Second semester.

101. Money and Credit I. This course undertakes an analysis of theories of money and credit. Attention is given also to monetary history and banking as an agency for capital supply and of the relationship between bank credit and money prices. Particular attention will be given to the federal reserve system. This course should be followed by Course 102 by all students expecting to specialize in economics or business administration. *Prerequisites: Courses 51 and 52, or 53 and 54.* Three hours credit. First semester.

102. Money and Credit II. A continuation of Course 101. *Prerequisites: Courses 51, 52, or 53 and 54, and 101.* Three hours credit. Second semester.

111. Land. The purpose of this course is to discover how a socially desirable utilization of the nation's natural resources may best be promoted. Our own land policy will be critically examined, and frequent reference to foreign experience will be made. As a basis for such an examination the following questions of principles will be discussed: the nature and significance of property rights, the characteristics of land, land income, land valuation, and the taxation of land. *Prerequisites: Courses 51 and 52, or 53 and 54.* Three hours credit. First semester.

121. Labor. This course is intended as an approach to the understanding of the problems of the workers and of the problem of labor unrest. After an introductory account of the rise of

permanent wage-working groups, it will consider the conditions under which these workers live and work in terms of such problems as wages and insecurity; and it will discuss the importance of turnover, strikes, and the growth of the labor movement as indications of industrial unrest. In conclusion, it will point to the directions in which different groups are looking for the solution of these problems. *Prerequisites: Courses 51 and 52, or 53 and 54. Not open to students who have had a previous course in labor.* Three hours credit. First semester.

131. Combinations and Trusts. This course is primarily concerned with the relationship of the state to the organization and functioning of commercial and industrial enterprises. After a brief consideration of the forms of business association, with special reference to the nature and significance of the corporate organization of industry, it traces the development of the combination movement in its various aspects, attempts to discover the basic causes and significant effects of concentration of control, examines the character and forms of "unfair competition," and subjects to detailed analysis the evolution of public policy toward association, combination, co-operation, and the plane of competitive conduct. *Prerequisites: Courses 51 and 52, or 53 and 54.* Three hours credit. Second semester.

133. Railroads. This course is designed to acquaint the student with the underlying principles of railroad economics and with the system of public control of railroads which has been developed in the United States. It considers the social and industrial significance of the transportation function, traces the course of American railroad development, examines the legal and economic characteristics of the railroad industry, analyzes the principal railroad problems which have emerged in the United States, and undertakes a detailed study of the character and development of government regulation. *Prerequisites: Courses 51 and 52 or 53 and 54.* Three hours credit. First semester.

153. Elements of Economics. For students having time for only one course in economics. The more significant laws and relationships of modern industrial society are explained and illustrated with the idea of furnishing the student a body of principles of use in interpreting current situations. The organization of production, monopoly, money and credit, banking, foreign trade and the tariff distribution of wealth and income, government regulation of industry, and problems of labor, are among the subjects treated. Students planning to take an extended program in economics should take Courses 51 and 52, or 53 and 54. Three hours credit. Each semester.

171. Principles of Accounting I. This introductory course consists primarily in a study of the principles of the double-entry system and an examination of the principal technical devices of accounting in terms of typical business transactions and conditions. Special attention is given to periodic operations, to the construction of simple financial statements, and to the classification of accounts for managerial and other purposes. *Prerequisites: Courses 51 and 52, or 53 and 54.* (Juniors may elect this course and Course 172 concurrently with Courses 51 and 52, and in the case of seniors, special students and students enrolled in other colleges and schools, the regular prerequisite will be waived.) Three hours credit. Each semester.

172. Principles of Accounting II. This course is a continuation of Course 171, by which it must be preceded. It includes an intensive study of the important groups of accounts, particularly with reference to the periodic adjustments, a discussion of working sheets, and examination of the leading types of income sheets and balance sheets, and of auxiliary and specialized statements and reports, a survey of the principal problems of valuation and income determination, a consideration of partnership accounting, and an introduction to corporate accounting. *Prerequisites: Courses 51 and 52, or 53 and 54, and 171.* Three hours credit. Second semester.

173. Elements of Accounting. This is a short course designed primarily for seniors, graduates and students in their last semester of residence, whose chief interest is in other departments but who wish to have some knowledge of accounting; and it may be elected by others only with the consent of the instructor. Unless special permission is granted it does not qualify for admission to any course in the Department of Economics or in the School of Business Administration for which Courses 171 and 172 are the regular prerequisite. The subject matter of the course is a condensation of that offered in Courses 171 and 172. Three hours credit. Each semester.

175. Economic Statistics I. This course and Economics 176 are designed to acquaint the student with the sources and analysis of the more important statistical data of economic science. The topics in analysis to which most attention is given in Economics 175 are frequency distributions, averages, dispersion, and correlation. *Prerequisites: Courses 51 and 52, or 53 and 54.* Three hours credit. Each semester.

176. Economic Statistics II. The topics to which most attention is given are time series, cycle analysis, and index numbers. Familiarity with the elements of statistical analysis as presented in Economics 175 will be presupposed. Students who have satisfac-

torily completed Mathematics 49 will be admitted without question. *Prerequisites: Economics 51 and 52 (or 53 and 54) and 175 or Mathematics 49.* Three hours credit. Second semester.

177. Elements of Statistics. This course is a condensation of Economics 175 and 176. For details regarding the purpose and scope of instruction see the description of those courses. The course is offered especially for those who cannot give more than a single semester to the subject. *Prerequisites: Courses 51 and 52, or 53 and 54.* Three hours credit. Each semester.

181. Public Finance. Course 181 deals with problems of public expenditures, budgetary procedure, public debt, and revenues other than taxes. Course 182 will be devoted to the central revenue problem,—taxation. European and American methods will be contrasted. Considerable attention will be given to questions of state and local taxation. The war and post war experiments both in spending and raising revenues will be examined. *Prerequisites: Courses 51 and 52, or 53 and 54.* Three hours credit. First semester.

182. Taxation. This course is a continuation of Course 181 of the first semester. *Prerequisite: Course 181.* Three hours credit. Second semester.

Summer Session

Courses 51s, 52s, 101s, 106s, 121s, 131s, 133s, 134s, 145s, 153s, 173s, 177s, and 179s, or similar courses, will be given during the Summer Session of 1928.

66. ENGINEERING MECHANICS

Professors PATTERSON, MENEFEE, VAN DEN BROEK, TIMOSHENKO, STEVENS; Assistant Professors SWINTON, OLMSTED, LIDDCOAT, DODGE; Mr. FRANKLIN, Mr. DONNELL.

Engineering Mechanics is the subject which, probably more than any other, tests the student's ability to use the technical training given him in preceding courses and at the same time prepares him for what is to follow.

No definition of engineering, from whatever angle given, is complete without some reference to forces. It is in mechanics that the student is given the engineer's conception and methods of handling forces. This is accomplished by

(1) A general required four-hour course in fundamentals, definitions, and conceptions of the ways in which mathematics, analytical and graphical, may be used with the laws of equilibrium,

to solve problems dealing with the various phases of forces, followed by

(2) A required three-hour course on strength and elasticity of materials, supplemented by a one-hour elective course in the laboratory.

(3) A required two-hour course in dynamics, supplemented by a one-hour elective course in the laboratory.

(4) A required three-hour course in hydro-mechanics with a demonstration room for illustrating principles of stream line flow, channel and weirs, pipe flow, orifices, etc.

Library. The general engineering library has books for collateral reading and study in mechanics.

The Physical Testing Laboratory occupies two adjoining large rooms with entrance at Room 102, West Engineering Building. The equipment comprises a 50,000, a 100,000, and a 200,000 lb. tension-compression machine, a 230,000 inch pound torsion machine with jaws for taking specimens $2\frac{7}{8}$ inches in diameter, an Olsen impact machine, an Upton Lewis endurance tester, an electrically driven bar bender for bars up to $2\frac{1}{2}$ inches diameter, a Brinell hardness tester, a wire tester, a transverse bending machine for cast iron arbitration bars and other short demonstration beams, a 9 ft. transverse bending machine and a power saw and grinder, an electric furnace, a polishing table and wheel with photographic equipment, and cement testing equipment for all standard cement tests.

1. Statics. Study of fundamental principles of mechanics and their application to the simpler problems of engineering. Forces, components, vectors, moments, couples, method of sections, cables, friction, centroids, moments of inertia, shear and bending moments. Recitations, lectures, problems. *Prerequisites: Mathematics 3, Physics 45, and preceded or accompanied by Mathematics 4.* Four hours credit. Each semester.

2. Strength and Elasticity of Materials. A study of the application of mathematics and principles of mechanics to solution of problems in stress and strain on engineering materials, including resistance to direct force, bending, torque, shear, eccentric load, deflection of beams by area moment method and compounding of simple stresses. Recitations, lectures and problems. *Prerequisite: E. M. 1.* Three hours credit. Each semester.

2a. Laboratory in Strength of Materials. (Elective.) Experiments with beams, struts, shafts, and engineering materials, supplementing text work. Attendance at laboratory once each week. *Prerequisite: E. M. 1. Must be accompanied or preceded by E. M. 2.* One hour credit. Each semester.

3. **Dynamics.** All motions of a particle, dynamics of moving bodies, Newton's Laws, simple harmonic motion, balancing, pendulums, impulse and momentum, gyroscopy and work and energy. Recitations, lectures, problems. *Prerequisite: E. M. 1.* Two hours credit. Each semester.

3a. **Experimental Dynamics.** Experiments with acceleration, vibration, balancing and gyroscopics. One hour laboratory period, with report, each week. *Must be preceded or accompanied by E. M. 3.* One hour credit. Each semester.

4. **Hydromechanics.** Pressures, centers of pressure, gages, effects of translation and rotation, Bernoulli's Theorem, orifices, tubes, weirs, pipes, open channels, meters, dynamic action of jets and streams. Recitations, lectures in Hydraulic Demonstration room, problems. *Prerequisite: E. M. 1.* Three hours credit. Each semester.

5. **Materials Testing.** (Required only of Architectural Engineers.) History of rapid development of the science; correlation with mechanics; study of testing machines, calibration, and particular function. Written reports, special emphasis on technique of report writing, and graphic presentation and interpretation of data. Laboratory work devoted to tests on steel, iron, wood, brick, and structural materials, including standard cement tests, water ratio theory, voids in sand and gravel, reinforced and unreinforced concrete beams, and granular metric analysis of sand. Lectures, laboratory, reports. *Prerequisite: E. M. 2.* Two hours credit. Each semester.

8. **Advanced Dynamics.** Lectures, problems. *Prerequisite: E. M. 3.* Two hours credit. Each semester.

9. **Advanced Strength of Materials.** Lectures, problems. *Prerequisite: E. M. 2.* Two hours credit. Each semester.

10. **Research.** Hours and credit to be arranged. *Prerequisite: E. M. 5 or E. M. 2a.* Each semester.

11. **Dynamics.** Two hours of credit in this course applies for credit in E. M. 3; the remaining hour is credited as advanced studies and demonstrations. *Prerequisite: E. M. 1.* Three hours credit.

Summer Session

Courses 1, 2, 2a, 3, 4, and 5 will be given during the Summer Session of 1928.

67.

ENGLISH

Professor NELSON; Assistant Professors THORNTON, SCHNEIDER, WENGER, EGLY, WALTON, BRACKETT; Mr. DAHLSTROM, Mr. BURKLUND, Mr. JOHNSON, Mr. YOUNG.

The work in English is based on the assumption that the student of engineering and of architecture needs to be able to speak and to write effectively. It is further assumed that he needs, as a means of wholesome and sensible enjoyment, as well as a means of extending his fund of ideas, a real and intelligent interest in reading. The general courses have, therefore, naturally grouped themselves under two heads, those which aim to develop the student's ability to express himself (Courses 1, 2, 3, 4, and 7); and those which aim to deepen his natural interest in books, and to make him more discriminating and critical (Courses 14, 20, 21, 22, 23, 24, 25, 26, 27, 29, and 30).

There are, in addition to these general courses, two technical and special courses (Courses 5 and 6), which have been designed to meet the particular needs of the engineering student, and Courses 16 and 17, which have been planned to aid the foreign student in his special problem.

Facilities.—The English Department has a collection of about six hundred volumes at present located in an alcove in the Chemical Engineering Library on the third floor of the East Engineering Building. Originally intended for classes in English 14, the collection has been enlarged considerably to supplement the General Library where its resources were inadequate for the other reading courses offered by this department. Most of the books are for class assignment or reference, and a sufficient number of copies of the more expensive works has been provided to relieve the student of the burden of a heavy financial outlay in those courses requiring extensive reading in recent copyright books.

General Requirement.—All regular students in the Colleges of Engineering and Architecture are required to take six hours of English. In the College of Engineering this consists of English 1 and 2 and a two-hour writing course in the junior or senior year, which must be chosen from the following: English 5, 6, or 14. No other courses can be substituted.

In the College of Architecture the student may take in addition to English 1 and 2 any two-hour English course. This course may be taken at any time during the four years, unless the student elects one of the courses open to juniors and seniors only.

Special Requirement for Foreign Students.—All students whose native language is other than English shall, upon matriculation and enrollment in these colleges, be required to report at

once to the Chairman of the Committee on English. Such students shall satisfy the Committee that they possess a sufficient knowledge of English to carry on work in these colleges before they may be classified. The rules further provide for the guidance of these foreign students until their knowledge of English is enough advanced for them to go on without further assistance.

All such students have laid out for them such a course in English, French, German, or Spanish as shall satisfy the modern language requirements for graduation. In the case of a foreign student, English may be substituted for another modern language, the maximum assignment being 17 hours, and it is understood that English shall be continued until the English faculty is satisfied that a good working knowledge of both written and spoken English is obtained. The two special courses outlined for foreign students can be taken throughout the first year, the work being specially planned to meet the requirements of individual cases. If on completing any of these special courses the student can satisfy the English Department as to his pronunciation, his written idiom and his ability to take dictation with reasonable accuracy, and if he is no longer hampered by his difficulties with English, he may be excused from the remaining special courses, provided that he take instead one of the regular composition courses offered for American students. This plan aims to economize the time and effort of the foreign student and to make sure that on graduation from an American university he may have a reasonable command of English.

Group I. Courses designed to assist the student to self-expression, and to prepare him for his special work:

1. **Theme-Writing.** Review of the fundamentals of composition; constant practice in writing, supplemented by study of works of recognized literary quality. Weekly prepared themes, frequent impromptus. This course, which must be taken at the same time as English 2, is a prerequisite for all courses in English, except 21. No foreign student may be classified in English 1 without written permission from Professor NELSON. Three hours credit. Each semester.

2. **Oral Exposition.** Practice course in public speaking, which must be taken at the same time as English 1. Two hours of class work. One hour credit. Each semester.

3. **Public Speaking for Engineers.** A study of the problems of organization, illustration, and effective presentation in public address, affording also frequent opportunity for practice and class criticism. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

4. **Advanced Public Speaking.** Twenty minute speeches based on a careful study of specific problems; emphasis on organization of material and total speech effects. *Prerequisite: English 3.* Two hours credit. Each semester.

5. **Scientific and Technical Papers.** The collection, organization, and presentation of scientific and technical material; emphasis upon methods of using illustrative devices and of interpreting technical subjects to non-technical readers and listeners. *Prerequisites: English 1 and 2. Open only to juniors and seniors.* Two hours credit. Each semester.

6. **Report-Writing.** The engineering report as a special type of exposition to which are applicable the fundamental principles of general exposition. Lectures, conferences, daily exercises, and two major assignments correlated as closely as possible with the technical work of the student. *Prerequisites: English 1 and 2. Open only to seniors.* Two hours credit. Each semester.

7. **Argumentation and Debate.** Study of problems most commonly met by engineers in furthering their projects; emphasis on clear, logical thinking, and convincing argument; frequent opportunity for extemporaneous presentation of material. *Prerequisite: English 3.* Two hours credit. Each semester.

14. **The Engineer and His Reading.** Readings in literature dealing with the problems and tendencies of modern society, which are the subject of the written work of the course. Lectures, discussions, frequent written reports. *Prerequisites: English 1 and 2. Open to juniors and seniors.* Two hours credit. Each semester.

Group II. Courses especially designed for foreign students:

16. **English for Foreign Students.** Correction of individual speech defects; dictation; drill on vocabulary and pronunciation; practice in conversation and in writing. Four hours of class work. Two hours credit. First semester.

17. **English for Foreign Students.** A continuation of English 16 for those foreign students whose knowledge of the language is still insufficient to enable them to enroll in English 1; drill in phonetics, reading, writing of themes, and conversation. Four hours of class work. Two hours credit. Second semester.

Group III. Courses designed to interest the student in reading and to develop a standard of critical judgment:

20. **Studies in Literary Masterpieces.** Introduction to works of exceptional merit in the various literary types. Lectures, discussions, and reports. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

21. **Readings in Contemporary Literature.** Rapid reading of representative works by outstanding authors of America, England, and continental Europe; study of these works as the expression of the spirit and ideals of modern life. Lectures, reports, recitations. Two hours credit. Each semester.

22. **Studies in the Novel.** Study of the method and form of the older English novels. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

23. **The Contemporary Novel.** A study of outstanding American and European novels of the present generation with emphasis upon their social significance, literary form, and stylistic qualities. Lectures, reports, discussions. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

24. **The Short Story.** Reading and analysis of a large number of short stories with a view to defining the literary genre, tracing its development, noting present tendencies, and formulating standards of judgment. Lectures and recitations. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

25. **Studies in the Drama.** Introduction to the drama as a type of literature; reading of representative Greek, French, German and English plays. *Prerequisites: English 1 and 2.* Two hours credit. First semester.

26. **The Contemporary Drama.** Study of the modern drama since the plays of Ibsen; emphasis on the development of intelligent standards of judgment and their application to the criticism of the contemporary theater. Lectures, discussions, oral and written reports. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

27. **Scientific Reading.** The literature of pure science; review of the work of the great historic figures in the scientific field, and readings from more recent and contemporary scientists. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

29. **Studies in American Prose Literature.** A rapid reading of the works of representative American essayists, dramatists, and writers of fiction, with emphasis upon their literary form, historical associations, and portrayal of American life. Lectures, reports, discussions. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

30. **Studies in Shakespeare.** Rapid reading and study of eight of the principal plays with a view to awakening keen and intelligent enjoyment. *Prerequisites: English 1 and 2.* Two hours credit. Each semester.

Summer Session

Courses 1, 2, and 14 will be given during the Summer Session of 1928.

68.

FINE ARTS**(History of Art)**

Associate Professor DONALDSON; Miss ADAMS

The courses offered in this Department purpose to give the student a comprehensive survey of the origin and development of the fine arts. Chief emphasis is placed upon the evolution of architecture, sculpture, and painting from prehistoric times to the present. The approach to the subject matter is essentially historical.

Fine Arts 101 is the prerequisite for all advanced courses and covers the material up to the general period of the Renaissance. The other courses are concerned with the Renaissance in Italy, France, and Spain, and American Art.

Students who elect these courses must report at Room B, A.M.H. between 10 and 12 or between 2 and 5 on registration days, for enrollment in class.

101. General Introductory Course in the History of Art. An investigation of the rise and development of the fine arts from prehistoric times to the Renaissance. A brief historical survey, intended both as a general cultural course and as a background for the further study of particular periods or phases of art. Illustrated lectures, required reading, and written tests. *Open to sophomores, juniors and seniors only.* Three hours credit. Each semester.

114. The Renaissance in France. The history of the fine arts in France from the fifteenth to the twentieth century. Illustrated lectures, required reading, and written tests. *Open to juniors and seniors who have completed Fine Arts 101 with a grade of B or better.* Two hours credit. First semester.

115. Italian Renaissance Architecture and Sculpture. The history of architecture and sculpture in Italy during the late fourteenth, the fifteenth, the sixteenth, and early seventeenth centuries. Illustrated lectures, required reading, and written tests. *Open to sophomores, juniors and seniors who have completed Fine Arts 101 with a grade of B or better.* Three hours credit. Second semester.

117. The Renaissance in Spain. The history of the fine arts in Spain, from the fifteenth through the nineteenth century. Illustrated lectures, required reading, and written tests. *Open to*

sophomores, juniors and seniors who have completed Fine Arts 101 with a grade of B or better. Two hours credit. Second semester.

128. American Art. The history of architecture, sculpture, and painting in the United States from colonial times to the present. Illustrated lectures, required reading, and written tests. *Open to juniors and seniors who have completed Fine Arts 101 and 114, 115 or 117 (preferably 115) with a grade of B or better. Three hours credit. First semester.*

130. Central Italian Renaissance Painting. A study of the development and character of painting in Central Italy from the Byzantine period to the nineteenth century, with special attention to the Florentine School of the fifteenth century. Illustrated lectures, required reading, and written tests. *Open to juniors and seniors who have completed Fine Arts 101 with a grade of B or better. Two hours credit. First semester.*

135. North Italian Renaissance Painting. A study of the development and character of painting in Northern Italy from the Byzantine period to the nineteenth century, with special attention to the Venetian School. Illustrated lectures, required reading, and written tests. *Open to juniors and seniors who have completed Fine Arts 101 and 130 with a grade of B or better. Two hours credit. Second semester.*

150. Oriental Art. An introduction to the fine arts of the Near East and Far East. A historical review of architecture in Mohammedan countries and of architecture, sculpture and painting in India, China and Japan. Illustrated lectures, required reading and written tests. *Open to juniors and seniors who have completed Course 101 and one course in the Renaissance with a grade of B or better. Two hours credit. Second semester.*

69.

FORESTRY AND CONSERVATION

31. General Forestry. The forester's work and problems he has to solve. Economic importance of forestry. History of forestry in the United States and abroad. Our timber resources and their distribution. Factors affecting tree-growth. Influences of forest upon climate, stream-flow, and erosion. How the forest is reproduced and cared for. Tree species desirable for different purposes. Forestry literature. Two lectures. This course is open to all students. No prerequisites. Two hours credit. Each semester.

33. Identification of Trees and Commercial Woods. This course may be taken as a separate course or as supplementary to Course 31 by students who desire field and laboratory work in

the identification of wood and of our common trees. This course is open to all students. Enrollment is limited to fifteen. Students must enroll with the instructor before electing the course. Four hours field and laboratory work. Two hours credit. Each semester.

39. Conservation of Wild Life. This course considers wild animal life from the standpoint of a valuable natural resource, and discusses the principles and methods applicable to its preservation and use. Our native animals are shown to constitute an economic and social asset of great importance, both in highly managed forests and in national and state parks and wilderness reserves. Emphasis is laid on the extent of these resources, their intelligent administration, and their relation to the public. Two lectures. Two hours credit. Each semester.

103. Wood Technology. Anatomical structure of native woods with special reference to properties, uses and identification. One lecture and one laboratory period. *Prerequisites: Physics 1 and Botany 35.* Two hours credit. First semester.

152. Timber Mechanics. Study of the mechanical properties of woods and of the factors which influence them. Tests for strength and resistance of representatives of our native species, under various conditions. Determination of shrinkage, specific gravity, moisture content. One lecture and one laboratory period. *Prerequisites: Physics 1, Botany 35, and Forestry 103.* Two hours credit. Second semester.

70.

GEOLOGY

Professor HOBBS and others

The Department of Geology is located in the Natural Science Building, occupying the northern half of the eastern front and extending through the four floors of the building.

31. Physical Geology. A general course leading to an understanding of the principles of physical geology; required of students of Civil Engineering and Geodesy and Surveying, and open to others as an elective. Lectures M, F, at 11 and 1-hour quiz, Tu at 10 or 11, W, at 10 or 11, and Th, at 11. Two hours of laboratory per week, M, Tu, or Th from 3 to 5. In the second semester the Tuesday period is omitted. Professor HOBBS and assistants. Three hours credit. Each semester.

For other courses in Geology to which students of Engineering are eligible, see the Announcement of the College of Literature, Science, and the Arts. It is suggested that Courses 32 (Historical Geology), 131 (Soil Geology), 133 and 134 (Economic Geology), are especially useful courses for Engineering students.

Summer Session

Courses 31s, 32s, 105s, 201, and 206 or similar courses will be given during the Summer Session of 1928.

71.

LANDSCAPE DESIGN

Professor TEALDI, Assistant Professor WHITTEMORE

These courses are not open to those below the rank of junior.

101. Introduction to the Study of Landscape Design. Lectures, collateral reading, and reports. Course 101 is designed to give a general knowledge of the variety of problems to be met with in the practice of landscape design. It is not intended as a technical course, such as a course in construction or design. The general problems are treated separately and special stress is laid upon the subject of good taste and common sense in all problems, from the simple arrangement of the city yard to the laying out of a country estate. The lectures are illustrated by the use of the stereopticon. Two hours credit. First semester.

102. City Planning and Civic Improvement. Course 102 is offered with the express purpose of stimulating civic spirit and a desire for further investigation among those who would like to keep abreast of the movement for civic improvement and who are interested in its sane development. Among the subjects treated are the following: city layout, streets, bridges, squares, public buildings, parks, trees, and other natural assets; city nuisances, problems of wires and advertisements as they affect the appearance of the city; dirt, smoke, and noise as they affect life in the city. Special stress is laid upon the housing problem, particularly as it is affected by the Garden City movement. Two hours credit. Second semester.

111. Professional Introductory Course. Course 111 includes a more technical presentation of the subject, time being devoted to the study of plans, elementary design, field trips, reports, etc. Three hours credit. First semester.

112. City Planning and Civic Improvement. This course includes a more technical presentation of the subject, time being devoted to the study of plans and elementary design. Reports and quizzes. It may be considered a practical introduction to city planning. Three hours credit. Second semester.

Summer Session

Courses 101, 102, 105, and 106 will be given during the Summer Session of 1928.

-72.

MATHEMATICS

Professors FIELD, RUNNING, HILDEBRANDT, LOVE, HOPKINS, POOR; Assistant Professors ROUSE, DENTON, SHOHAT; Mr. KAZARINOFF, Mr. COATES, Mr. CHURCHILL, Mr. DUSHNIK, Mr. FISK, Mr. MARQUIS, Mr. THOMPSON.

The object of the work of this department is not only to impart to the student the mathematical knowledge requisite for the study of the various branches of engineering, but also to train his mind in the methods of precise reasoning and accustom him to the proper application of general principles to particular cases.

Much time is devoted to the solution of problems in order to combine a fair knowledge of the elementary principles of higher mathematics with the necessary facility in applying these principles to concrete cases. The classes are divided into sections as small as practicable, so as to make it possible for the instructor to give his individual attention to the students.

For students who desire to pursue their mathematical studies beyond the required work, a considerable number of advanced elective courses are offered. Following are the courses offered in the College of Engineering for the year 1928-1929. Additional courses offered in the College of Literature, Science, and the Arts will be found in the Announcement of that College, or in the Announcement of the Graduate School.

The required work is the same for all students of engineering, except students of chemical engineering, and extends throughout the first two years. The first year is devoted to advanced algebra, and plane and solid analytic geometry; the second, to differential and integral calculus, including an introduction to the solution of differential equations. Students who do not have credit in trigonometry are required to complete this subject as early as possible.

***1. Algebra and Analytic Geometry.** Inequalities; theory of equations including Horner's method; permutations and combinations; determinants; complex numbers; curve tracing and locus problems in Cartesian and polar co-ordinates; straight line; circle. Four hours credit. Each semester.

***1a. Trigonometry.** Radian measure; coordinate systems; trigonometric ratios; trigonometric identities and equations; inverse functions; graphs; reduction and addition formulas; laws

*Students entering with credit in trigonometry will take Course 1. Students entering without trigonometry will take Course 1b, except that those whose high school records show unusual proficiency in Mathematics may take Course 1 and 1a instead. Permission to do this must be obtained from the Department of Mathematics at the time of classification.

of sines, cosines and tangents; theory and use of logarithms; orthogonal projection; solution of triangles. Two hours credit. Each semester.

***1b. Algebra and Trigonometry.** Elementary topics; special products and factoring; fractions; linear equations in one unknown; simultaneous linear equations; exponents; radicals; quadratic equations; systems of equations involving quadratics; ratio and proportion; progressions; binomial theorem; trigonometry, the same as in Course 1a. Four hours for two hours credit. Each semester.

2. Plane and Solid Analytic Geometry. Conic sections; change of axes; properties of conics involving tangents, diameters, asymptotes, parametric equations; surface tracing and locus problems in space; direction cosines; plane; straight line; quadric surfaces; space curves. Four hours credit. Each semester.

2a. Solid Analytic Geometry. Surface tracing and locus problems in space; direction cosines; plane; straight line; quadric surfaces; space curves. Two hours credit. First semester.

3. Calculus. Functions; limits; continuity; derivative; differential; differentiation and integration of the elementary functions, with applications to curve tracing, maxima and minima, time rates, curvature, plane motion; indeterminate forms; definite and improper integrals. Five hours credit. Each semester.

4. Calculus and Differential Equations. Topics the same as in Courses 4a and 4b combined. Five hours credit. Each semester.

4a. Calculus. Definite integral as the limit of a sum; applications to geometry, centroids, moments of inertia, fluid pressure; infinite series, including Taylor's series; partial and total differentiation. Three hours credit. Each semester.

4b. Differential Equations. Multiple integrals; simple types of ordinary equations of the first and second order; linear equations with constant co-efficients; applications to geometry and mechanics. Two hours credit. Each semester.

105. Differential Equations. Should be preceded by Course 4b. Solutions of differential equations by elementary methods. Two hours credit. First semester.

106. Advanced Differential Equations. Solutions of differential equations by infinite series; functions defined by differential equations. Two hours credit. Second semester.

*See footnote on page 103.

107. **Advanced Calculus.** Review of the fundamental theory of elementary calculus. Taylor's theorem. Explicit and implicit functions. Simple, multiple and improper integrals. Functions defined by integrals and other selected topics. Three hours credit. Each semester.

109. **Differential Equations for Chemical Engineers.** Solutions of equations arising from first order, second order, and simultaneous processes; determination of velocity constants. Graphical methods are stressed. Three hours credit. First semester.

137. **Projective Geometry for Engineers.** The elements of projective geometry, with particular attention to its application to problems of engineering. Three hours credit. First semester.

143, 144. **Elements of Mechanics.** Kinematics; rectilinear and curvilinear motion of a point, velocities and accelerations in the rigid body. Statics, mass, momentum, force, energy; statics of the particle and the rigid body, theory of attractive forces. Kinetics: free and restrained motion of a particle; motion of a rigid body. Two hours credit, each semester. Throughout the year.

145. **Celestial Mechanics.** Rectilinear motion of a particle; gravitational theory of the sun's heat; central forces; potential and attraction of bodies; problem of two bodies. Three hours credit. First semester.

146. **Celestial Mechanics.** Problems of three and n bodies; geometric introduction to the lunar theory; general perturbations; introduction to periodic orbits. Three hours credit. Second semester.

169. **Graphical Methods.** Graphical representation of functions; construction of graphical charts; graphical solution of equations; a study of the principles of differential and integral calculus by graphical methods applied to the solution of differential equations. Two hours credit. First semester.

170. **Empirical Formulas.** Curve fitting; graphical determination of constants in empirical formulas; application of the method of least squares; interpolation; numerical integration. Two hours credit. Second semester.

201, 202. **Theory of Functions of a Complex Variable.** Properties and manipulation of complex numbers; functions of a complex variable, their differentiation and integration and related theorems; developments in power series; properties of analytic functions; singularities; and similar topics; applications to mathe-

mathematical physics and to other branches of mathematics. Three hours credit, each semester. Throughout the year.

208. Infinite Processes. Infinite sequences, general properties of infinite series and products, power series, trigonometric series, series of complex terms, infinite integrals. Two hours credit. Second semester.

209. Partial Differential Equations of Physics. Derivation and solution of some of the principal partial differential equations occurring in the theories of sound, elasticity, hydrodynamics, electricity and light. Three hours credit. Second semester.

210. Fourier's Series and Harmonic Analysis. The development of Fourier's series, Legendre's coefficients, and Bessel's functions and their applications to certain problems in mathematical physics. Three hours credit. First semester.

211, 212. Selected Topics in Analysis: Definite Integrals. Existence and fundamental properties of Riemann's integral; various methods of evaluating definite integrals; differentiation and integration under the integral sign; differentiation and integration of infinite series; improper integrals; Euler's integrals; Fourier's series; existence and fundamental properties of Lebesgue and Stieltjes integrals; mechanical quadratures; asymptotic expressions for certain classes of definite integrals. Two hours credit, each semester. Throughout the year.

214. Mathematical Theory of Heat Conduction. Fourier's conduction equation; flow of heat in one dimension; Fourier's series; flow of heat in more than one dimension; solution of problems of the flow of heat in different substances. Three hours credit. Second semester.

215, 216. General Theory and Application of Tchebycheff Polynomials. Existence of Tchebycheff polynomials; fundamental properties; relation to continued fractions; trigonometric polynomials, polynomials of Legendre, Jacobi, Laguerre, Hermite; their difference—and differential equations; asymptotic and minimum properties of Tchebycheff polynomials; the closure equation; application to the general theory of polynomials, to mechanical quadratures, etc.; development of arbitrary functions in series of Tchebycheff polynomials, relation to orthogonal functions in general. Three hours credit, each semester. Throughout the year.

232. Advanced Mechanics. Analytical dynamics. Equations of motion in generalized co-ordinates, principles available for integration, problems of particle and rigid dynamics, theory of

vibrations, principles of Hamilton and Gauss, Hamiltonian systems. Three hours credit. Second semester.

233. Theory of the Potential. Newtonian attraction. Newtonian and logarithmic potentials, the equations of Laplace and Poisson, harmonic functions, the principle of Dirichlet, the problems of Dirichlet and Neumann and the Green function. Three hours credit. First semester.

234. Vector Analysis. A study of the formal processes of vector analysis, followed by applications to problems in mechanics and geometry. Three hours credit. Second semester.

235, 236. Elements of Elasticity and Hydrodynamics. In this course the classical theory of elasticity will be treated with hydrodynamics as the important special case. Modern developments in hydrodynamics and their applications to aeronautics will be considered as time permits. Two hours credit, each semester. Throughout the year.

237. Mathematical Theory of Aerofoils. Advanced study of the Jowkoosky, von Mises and Witosynski theory of wing profiles and the Prandtl theory of the induced drag, preceded by a brief review of the fundamentals of the mathematical theory of hydrodynamics. *Must be preceded by Course 4b and Course 201.* Two hours credit. First semester.

238. Advanced Stability. Advanced study of more complicated phenomena of stability according to Bryan, with Nairston's applications of experimentally determined resistance derivatives and rotary coefficients. *Must be preceded by Course 4b.* Two hours credit. Second semester.

245, 246. Advanced Celestial Mechanics. Studies in continuation of Course 146 will be arranged for those qualified to take them, analytic differential equations with applications to periodic orbits, cosmogony and stellar dynamics, lunar theory, and research in mathematical astronomy. Two hours credit, each semester. Throughout the year.

Summer Session

Courses described above, 1, 1a, 2, 3, 4a, 4b, and also the following courses will be offered in 1928:

Z. Solid Geometry. Topics covering the one-half unit of solid geometry required for admission and described in the General Catalogue. Two hours credit.

169. Graphical Methods. Two hours credit.

201s. **Theory of Functions of a Complex Variable.** Two hours credit.

232s. **Analytical Mechanics.** Two hours credit.

233s. **Theory of the Potential.** Two hours credit.

234s. **Vector Analysis.** Two hours credit.

73. MECHANISM AND ENGINEERING DRAWING

Professors MILLER, GOULDING, FINCH; Assistant Professors PALMER, HANSEN, POTTS, MORLEY, BUKOVSKY, CLARK, COLE, EICHELBERGER.

Drawing courses 1, 2, 3, and 4 carry the student through the subjects of elementary mechanical and machine drawing, descriptive geometry, drafting room practice, sketching, and mechanism. These four courses have been arranged for the first semesters of the four-year curriculum in order that they may form a continuous chain of instruction that will, first, fit those students who continue during the third and fourth years to take up with the least difficulty and proceed with the maximum efficiency in the courses in design, etc., and second, be of the maximum assistance to that large percentage of students who do not continue longer than from one to two years. Instruction is also given in statistical charting and advanced mechanism.

Courses in elementary mechanical drawing and sketching especially designed for dental and medical students are offered as Drawing *1d* and *1m*.

A long sought aim of the Department has been realized in the reduction of its classes to fifteen men or less. This gives the opportunity of that personal contact and acquaintance between the instructor and his students that is of so great value. The work is conducted in well-lighted and well-equipped drafting rooms, and all necessary facilities essential to the proper teaching of the subjects named are available.

1. **Mechanical and Machine Drawing.** The principles of orthographic projection; practice in the making of working drawings; correct drafting room practice in conventional representation; the use of instruments; practice in lettering, free-hand for dimensions and notes, and mechanical for titles; reading and checking of drawings; drill on geometric constructions; instruction on blue and brown printing; practice in tracing; original drawing on vellum. Three two-hour drafting room periods, three hours home work per week. Three hours credit. Each semester.

1d. Dental Drawing. Use of instruments; practice in lettering; practice in the making of working drawings, particularly of dental appliances; outline sketching of subjects of dental anatomy; pencil shading of sketches. Four hours drafting room per week. One hour credit. Each semester.

1m. Medical Drawing. Use of instruments; practice in lettering; outline sketching of subjects of human anatomy; pencil shading of sketches; practice in the making of working drawings, particularly of medical appliances. Four hours drafting room per week. One hour credit. Each semester.

2. Descriptive Geometry. Exercises, instruction, and drill through the medium of 80 printed plates of problems comprising combinations of the point, line, and plane, intersections, developments, tangent planes, and warped surfaces. Three two-hour periods drafting room, three hours home work per week. *Prerequisite: Drawing 1.* Three hours credit. Each semester.

3. Mechanism and Sketching. Sketching of die-cast models in orthographic, isometric and oblique projection; practice in the making of working drawings from sketches; free-hand lettering; special practice in, and applications of drawing. Two two-hour drafting room periods, two hours home work per week. *Prerequisite: Drawing 2.* Two hours credit. Each semester.

4. Mechanism. Principles of mechanism; purposes of variations of elementary mechanisms, gears, cams, bands, etc.; analysis of special machines, process and history of their development and their economic importance; systematic development of complicated machines to accomplish specified purposes. Two two-hour drafting room periods, two hours of home work per week. *Prerequisite: Drawing 3.* Two hours credit. Each semester.

6. Advanced Mechanism. Further instruction and drill in the development of complicated machines to accomplish specified purposes; proper description of designs for patent applications; history of development of type machines. Three hours drafting room per week. *Prerequisite: Drawing 4.* One hour credit. Each semester.

12. Statistical Charting. Analytical methods of charting; construction, use, and analysis of statistical charts, and applications to industrial, social, transportation or other statistical problems. Three hours drafting room per week. Two hours credit. Each semester.

Summer Session

Courses 1, 1d, 2 and 3 will be offered during the Summer Session of 1928.

74. MILITARY SCIENCE AND TACTICS

Professor MELBERG; Assistant Professors BRICKER, LOUISELL, SCHLOSBERG, TURNER.

Enrollments for Military Science are made at the Headquarters, Reserve Officers' Training Corps, on the campus. The student also elects his Military Science courses at the same time and place as he elects his other University courses and receives academic credit therefor which counts toward graduation.

Enrollments are for a period of four semesters; that is, for either a Basic Group or an Advanced Group in its entirety. The first four semesters constitute the Basic Group, and the second four semesters the Advanced Group. Once enrolled in either group the completion of that group becomes a prerequisite to graduation unless the student is discharged from this obligation upon the recommendation of the Professor of Military Science and Tactics.

A deposit of ten dollars to cover property responsibility is required of each student. The deposit is refunded upon return of all property and equipment.

There are three units in the Department.

Infantry.—Theoretical and practical work which will enable a student to understand and make proper use of Infantry weapons and handle a company of Infantry according to modern tactical principles. Open to anyone.

Ordnance.—For the first two years the student may follow any basic course. The Infantry is recommended. During the last two years he gets special technical training in design and manufacture of Ordnance and methods of supply and maintenance. In view of the fact that the Ordnance Department is a technical and manufacturing branch of the Army, a student during the advanced course takes certain technical subjects in his own college which tend to make him more of a specialist in his own line, and therefore, of more value to the Ordnance Department. Open to prospective Mechanical and Chemical Engineers.

Signal Corps.—After the first year, the student receives such instruction as will tend to make him expert in communication work. Open to prospective Electrical Engineers.

Course 1 is common to all units.

Course 2 is common to all units except the Signal Corps who take Course 12 second semester.

Upon election of a particular branch of engineering, R. O. T. C. students previously enrolled in an inappropriate unit may transfer to the unit to which their Engineering Department election makes them eligible without loss of credit.

The courses in Military Science and Tactics are designed to give a thorough groundwork in military subjects considered necessary as a part of the education of a commissioned officer in the Reserve Corps of the Army of the United States. Courses are offered in Infantry, in Ordnance, and in Signal Corps training organized as units of the Reserve Officers' Training Corps, in which membership is limited to male citizens of the United States who are physically fit for service in the field.

While taking work in Advanced Group members of the R. O. T. C. receive payment of commutation of subsistence from the government amounting to over \$200.

Students who enroll late may double up their courses. Four semesters' time must be put in, however, before they become eligible for payment of commutation.

In the Advanced Group, there is a summer camp of six weeks' duration. Attendance at the Advanced Camp is a prerequisite to graduation for students in the Advanced Group. Equipment is furnished and expenses at the camps are paid by the Government.

Students of Aeronautical Engineering may take the regular course in any one of the units, and, if physically qualified, may take the advanced Air Service camp instead of the advanced camp of the unit elected.

Successful completion of the courses in any unit of the R. O. T. C. will lead to a recommendation for a commission in the corresponding branch of the Officers' Reserve Corps, except that Aeronautical Engineers who successfully complete an Air Corps camp will be recommended for a commission in the Air Corps.

The courses must be elected in the same manner as any other course, and, in addition, the student must enroll at the R. O. T. C. Office.

Enrollment in any R. O. T. C. Group is not in any way an enlistment in any component of the Army nor does it carry with it any obligation for service at any time.

The following courses are given within the various units:

Signal Corps

BASIC GROUP

1. **Elementary Infantry.** Same as Course I, Infantry. One hour credit. First semester.

12. **Elementary Infantry and Telephony.** A general course of lectures and practical work in fundamental Infantry subjects, such as guard duty, military courtesy and discipline, Infantry drill, ceremonies, hygiene, and military telephony. One hour credit. Second semester.

13. **Military Telegraphy; Military Map Reading and Sketching.** Recitations, lectures and field work. One hour credit. First semester.

14. **Field Radio Sets.** Recitations, lectures, and laboratory work. Installation, operation, and care of radio sets, sending and receiving. One hour credit. Second semester.

ADVANCED GROUP

15. **Signal Corps Organization and Tactics; and Signal Communications.** Lectures and laboratory work in organization and tactics of the Signal Corps and the combined arms, and signal communications. Two hours credit. First semester.

16. **Military Law; Military History and Policy; Company Administration; Field Engineering.** Elements of common law, military law, moot court-martial, rules of land warfare, military policy, company organization and administration, supply and transportation, staff organization and duties, and field engineering. Two hours credit. Second semester.

17. **Communication Engineering.** See Physics 165. Take Course 165 in Physics (Vacuum Tubes in Radio Communication), which satisfies the requirements of this course. Two hours credit. First semester.

18. **Communication Engineering.** Take Course 10 in Electrical Engineering (Advanced Theory of Electrical Circuits) which satisfies the requirement of this course. Two hours credit. Second semester.

Infantry

BASIC GROUP

1. **Elementary Infantry.** Infantry drill regulations, marksmanship, and military policy. One hour credit. First semester.

2. **Elementary Infantry Continued.** Fundamental subjects in military training. Same as Course 2, Coast Artillery. One hour credit. Second semester.

23. **Musketry; Scouting and Patrolling; Automatic Rifle.** Lectures and practical work in use of the rifle, automatic rifle, grenades and other infantry weapons. Training in the methods of gaining information of the enemy prior to and during the combat. Construction, operation, and firing of the Browning automatic rifle. One hour credit. First semester.

24. **Infantry Weapons; Military Map Reading and Sketching.** Lectures and practical work in bayonet training, grenades, and map reading and sketching. One hour credit. Second semester.

ADVANCED GROUP

25. **Command and Leadership; Minor Tactics; and Field Engineering.** Theoretical and practical instruction in handling men, infantry organization, disposition of infantry weapons and units for defensive combat. Two hours credit. First semester.

26. **Accompanying Weapons, and Machine Guns.** Lectures and practical work in machine guns, 37-mm. gun, trench mortar, and in the exercise of command appropriate to all grades. Two hours credit. Second semester.

27. **Minor Tactics.** Lectures and practical work in organization and equipment of various units, offensive and defensive conduct of small units, tactical employment of infantry weapons, combined action, sand-table exercises, map and terrain problems. Two hours credit. First semester.

28. **Military Law, Military History and Policy, Company Administration.** Elements of common law, military law, moot court-martial, rules of land warfare, military policy, company organization and administration. Two hours credit. Second semester.

Ordnance

BASIC GROUP

The Basic Group of Infantry or Signal Corps to be elected.

ADVANCED GROUP

35. **Ammunition.** Ammunition and explosives, pressure and velocity determinations. Two hours credit. First semester.

36. **Materiel.** Guns, carriages, recoil and special mechanisms, tanks, tractors, and self-propelled mounts. Two hours credit. Second semester.

37. **Ordnance Engineering and Commercial Law.** Two hours credit. First semester.

38. **Administration.** Company administration, property accounting and ordnance, financial procedure, military organization, military law. Two hours credit. Second semester.

Air Corps

Arrangements have been made with the War Department by which those students of Aeronautics who are enrolled in the Advanced Group of any one of the above mentioned units of the R. O. T. C., and who desire a commission as second lieutenant in the Air Corps, Reserve Corps, may attend one Advanced Group

Camp of the Air Corps at which both theoretical and practical instruction in flying is given, provided that they have passed the physical examination for the Air Corps.

Students in Aeronautics may be enrolled in the Basic Group of either the Infantry, Ordnance or Signal units upon passing the usual physical examination. At the end of the course of the Basic Group those who desire a commission in the Air Corps, Reserve Corps, will be given the physical examination prescribed for members of Air Corps units. Those who qualify and who enroll in the Advanced Group will attend one Air Corps Advanced Camp. Upon satisfactory completion of the course in Aeronautics and the course of the Advanced Group of the R. O. T. C. unit elected, the student will be recommended for a commission as second lieutenant, Air Corps, Reserve Corps.

Those not physically qualified for the Air Corps may enroll in the Advanced Group of the unit originally selected, and upon satisfactory completion of the course will become eligible for a commission in the branch of the Officers' Reserve Corps represented by the unit selected.

General

INFANTRY DRILL WITH EACH COURSE.—Company drill for one hour a week is a required part of each course.

RIFLE AND PISTOL PRACTICE.—All R. O. T. C. students may practice on the indoor and outdoor ranges whenever practicable during scheduled periods. Membership on the R. O. T. C. Rifle or Pistol Teams depends on both excellence in marksmanship and a compliance with the rules governing attendance at practice and competitions. Hours of practice to be announced.

Summer Camps

ADVANCED

Attendance at an advanced camp is required and is a prerequisite to graduation. Transportation, equipment, quarters, rations, and medical attention are furnished by the Government. In addition the student draws pay for the seventh grade (70c a day in 1928). Ample time and facilities are allowed for recreation. All Camps are of six weeks duration and begin about June 20th.

Signal Corps—Fort Sheridan, Ill.

Infantry—Fort Sheridan, Ill.

Ordnance—Aberdeen Proving Ground, Md.

Air Corps—Chanute Field, Ill. For Aeronautical Engineers only.

NAVAL AVIATION

(Department of Aeronautical Engineering).

The Navy Department, in connection with the Naval Aviation Reserve, offers through the University of Michigan a ground school course in aviation open to male students in all schools and colleges of the University who are citizens of the United States and who are able to pass a satisfactory physical examination.

Upon successful completion of this course a student is eligible for selection for actual flight training leading to a commission as ensign in the United States Naval Reserve and qualification as Naval Reserve Aviator.

Flight training will be given in two forty-five day periods during the following summer or in two successive summers.

A detailed description of the course will be found below, and must be elected at the same time and in the same manner as other elective courses in the University. Preference will be given students who have completed the Basic Course in the R. O. T. C.

The course in Naval Aviation comprises ground school instruction in the following subjects: Practical Flying, Aviation Indoc-trination, Navigation, Aerology, Theory of Flight, Structure and Rigging of Airplanes, Scouting, Aviation Engines, Radio, Aircraft Communication, Instruments, and Regulations. It is to be given as a continuous course during two semesters, allowing two hours credit for each semester. Total credit is four hours. Those electing the course must follow through both semesters.

Instruction is given by members of the Faculty of the University and by officers of the United States Naval Reserve. During the school year it is intended that students be given an opportunity to take flights in airplanes of the U. S. Navy.

Elementary flight training is given during a forty-five day period, to be held during the summer following completion of the course. For this duty the student is sent to an active Naval Reserve Aviation Unit, expenses paid.

Advanced flight training, held the same or succeeding summer, is to be given at the U. S. Naval Air Station, Hampton Roads, Virginia. Upon completion of the advanced training, comprising qualification in more advanced types of airplanes, machine gunnery, bombing, photographing, and scouting, the successful candidate is commissioned and designated Naval Reserve Aviator.

To those who volunteer for the service, a year's active duty with the Aviation Squadrons of the Atlantic and Pacific Fleets is offered. Thursday evening, 7:15 to 9:15. Two hours credit. Each semester.

75. MINERALOGY AND PETROGRAPHY

Professors KRAUS, HUNT; Associate Professor PECK; Assistant Professor RAMSDELL; DR. SLAWSON.

The Mineralogical Laboratory comprises thirty-six rooms located in the northwest portion of the Natural Science Building. A suite of five rooms, designed especially for research, is located on the first floor. Three of these rooms have light-tight shutters, and are provided with piers equipped with water, gas, compressed air, and alternating and direct currents. The packing, store, and grinding rooms are also on this floor. The mineral collection, lecture room, model and apparatus rooms, and an office are on the second floor. The laboratories for the courses in general mineralogy, blowpipe methods, and mineral and rock analyses, several offices, and a stock room are on the third floor. On the fourth floor are laboratories of lithology, petrography, crystal measurements, and physical crystallography, a small lecture room, and offices for the staff and advanced students.

The laboratory is well equipped with crystal models, natural crystals, and lecture and working collections of minerals, rocks, and thin sections. There is an excellent equipment of goniometers, polarization microscopes, and other crystallographic-optical instruments necessary for the thorough study of minerals. These instruments are all of the most modern and approved types. The blowpipe and chemical laboratories possess every facility for the qualitative and quantitative determination of minerals and rocks. The equipment of the laboratory is such that special attention can be given to graduate work and special investigation in mineralogy and petrology.

31. Elements of Mineralogy. Includes the elements of crystallography, and the physical and chemical properties, occurrence, uses, and determination of the more common minerals. Lectures and laboratory work. *Prerequisite: A knowledge of elementary inorganic chemistry is necessary.* Two hours credit. Each semester.

32. Gems and Gem Materials. Lectures and demonstrations. This course discusses the general properties, occurrence, determination, and history of the various minerals used as gems and gem materials. The various methods of distinction, especially from imitations and synthetic gems, will also be considered. No previous training in mineralogy or the sciences is required, although an elementary knowledge of chemistry and physics is

highly desirable. Students who have completed Course 31 may elect Course 32 as Course 34 and receive one hour credit. Two hours credit. Second semester.

33. Determinative Mineralogy. Laboratory work. This course is intended for students who have finished Course 31 and wish to become more proficient in the determination of minerals. Two hours credit. Each semester.

104. Useful Minerals, Building and Decorative Stones. Designed especially for students of Architecture. Three lectures, and laboratory work two hours a week, to be arranged. The first half of the course is devoted to the physical and chemical properties, uses and determination of the common rock-forming minerals, and of those ores from which the metals commonly used for building purposes are obtained. The second half is devoted to a discussion of the origin, modes of occurrence, description, and uses of the common rocks, with special emphasis upon those used for structural and decorative purposes. *Prerequisite: a knowledge of elementary inorganic chemistry is necessary.* Three hours credit. Second semester.

105. Qualitative Blowpipe Methods. The use of blowpipe reactions upon charcoal and plaster tablets, as well as other chemical methods useful in the determination of minerals. Lectures and laboratory work. *Prerequisite: Course 31.* Two hours credit. First semester.

107. Lithology. The lectures include, aside from a review of the rock-forming minerals, a discussion of the classification, origin, and methods of determination of the more important rocks. In the laboratory the student is required to determine by means of the macro-physical properties a large number of rock specimens. *Prerequisite: Mineralogy 31.* Two hours credit. Second semester.

151. Quantitative Blowpipe Methods. Reading and laboratory work. Practice in assaying by blowpipe methods various kinds of ores, especially those of gold, silver, copper, and lead. *Prerequisite: Course 105.* Two hours credit. First semester.

Summer Session

Courses 31, 33, 105, and 107 will be offered in 1928. For other courses, see Announcement of the Summer Session.

76.

MODERN LANGUAGES**French, German, Spanish**

Professors LEE, ADAMS, KENYON, WILD; Assistant Professors ALBALADEJO, JOBIN, BRITTON; Mr. GAISS, Mr. MCGUIRE, Mr. HARRISON.

The study of a modern foreign language is considered of particular value to the student in the technical school as it serves to broaden his outlook on life by introducing him to a new literature and a new civilization. With such an asset of a cultural and social nature added to his practical training, the student should represent the ideal type of university man possessing a well rounded and complete education, beneficial both to himself and to society.

The aim of the instruction in French, German and Spanish is to help the student to a reading, writing and speaking knowledge of those languages. The elementary courses continue throughout one year, and their object is to familiarize the student with the forms and the construction of the languages and to furnish him with practice in reading and speaking them.

The courses of the second year review grammatical principles, introduce the student to modern literature and give him a practical knowledge of the life and customs, literature, art and philosophy of the foreign nations. Some of these courses are conducted wholly or in part in the language studied.

The object of the courses of reading in scientific literature is to acquaint the student with the terminology and special vocabularies of the various sciences, and thus enable him to consult books and periodicals bearing on his professional work with facility and profit. Many students read, beside the work assigned for the classroom, scientific articles in the numerous foreign periodicals to be found in the Engineering Library. This is of value to the student in the pursuit of much of his advanced work. In some of the more important courses in the College of Engineering a reading knowledge, at least, of one of these languages is required.

Elective courses of two types are offered: (1) Advanced courses in the language studied for those who wish to pursue work beyond actual requirements, (2) General courses in foreign literatures for cultural purposes. These literatures are studied in translation and no previous knowledge of the specific language involved is required.

For graduation requirements in foreign languages, see section 54.

French

1. **Elementary French.** Grammar, composition, reading, dictation and conversation. Four hours credit. Each semester.

2. **Elementary French Continued.** Grammar, composition, dictation, conversation; reading of selections from modern authors. Four hours credit. Each semester.

3. **Intermediate French.** Reading of modern French prose (short story, novel, or drama); composition based on a thorough review of grammar; dictation and conversation. Four hours credit. Each semester.

4. **Outline History of French Literature.** Survey of French literature from its origins to modern times; illustrative readings in outstanding works from the seventeenth century to the twentieth. Lectures, discussions, oral and written quizzes. Four hours credit. Each semester.

5. **French Life and Civilization.** General information concerning French life and civilization; aim is to furnish the student with a practical knowledge of French. Conversation, reading and lectures. Conducted in French. Two hours credit. Second semester.

7. **Victor Hugo and the Romantic School.** Reading and discussion of some of Hugo's works with particular emphasis on the novels and plays; selections from the works of Lamartine, Musset and Vigny. Lectures, assigned readings and reports. *Prerequisite:* French 4 or its equivalent. Two hours credit. First semester.

9. **French Chemical Reading.** Object is to familiarize the student with technical terms used in French chemical literature; reading of standard treatises and important articles in current French chemical journals. One hour credit. Second semester.

Summer Session

1s. **Beginners' Course.** Six hours credit.

1. **Beginners' Course.** Four hours credit.

German

1. **Elementary German.** Grammar, composition, reading, dictation and conversation. Four hours credit. Each semester.

2. **Elementary German Continued.** Grammar, composition, dictation, conversation; reading of selections from modern authors. Four hours credit. Each semester.

3. **Intermediate German.** Reading of modern German prose (short story, novel, or drama); dictation and conversation; grammar review to suit the needs of the class. Four hours credit. Each semester.

4. **Intermediate German Continued.** Reading of scientific literature and masterpieces of classical and modern writers (drama, novel, story); discussion, conversation, interpretation. Four hours credit. Each semester.

5. **German Scientific and Technical Literature.** Selected readings assigned to each student with reference to his special line of work; reading and reports upon articles in the various German journals dealing with topics in which the student is interested. Two hours credit. Each semester.

9. **German Chemical Reading.** Similar to French 9 (French Chemical Reading) described above. Equivalent to Chemistry 101 (see Literary Announcement). Two hours credit. First semester.

Summer Session

Courses 1s, 2s, and other courses will be offered during the Summer Session of 1928.

Spanish

1. **Elementary Spanish.** Grammar, composition, reading, dictation, conversation. Four hours credit. Each semester.

2. **Elementary Spanish Continued.** Grammar, composition, dictation, conversation; reading of selections from modern authors. Four hours credit. Each semester.

3. **Intermediate Spanish.** Reading of modern Spanish prose (short story, novel, or drama); composition based on a thorough review of grammar, dictation and conversation. Four hours credit. Each semester.

4. **Intermediate Spanish Continued.** Reading of modern prose; composition with special emphasis on commercial correspondence. Four hours credit. Each semester.

5. **Spanish Life and Thought.** Study of the life and customs of the Spanish people, their literature, art and philosophy, with special reference to the present day. Informal lectures, assigned readings and reports conducted in Spanish. Two hours credit. Each semester.

6. **Spanish Literature in English.** Outline of development of Spanish literature. Intended as a general cultural course. No knowledge of Spanish required. Lectures, assigned readings and reports. Open to students who have completed the regular language requirements and to those taking French or German. Two hours credit. Each semester.

Summer Session

Courses 1, 2, and other courses will be offered during the Summer Session of 1928.

NAVAL AVIATION

For full information about the courses in Naval Aviation, see page 115.

77.

PHILOSOPHY

For full information about the courses in Philosophy and Psychology, see the Announcement of the College of Literature, Science, and the Arts.

78.

PHYSICS

Professors RANDALL, WILLIAMS, COLBY, SMITH, RICH, LINDSAY, BARKER, SAWYER; Assistant Professors MEYER, DUFFENDACK, CORK; Dr. UHLENBACK, Dr. GOUDSMIT, Dr. DENNISON.

The instruction in general physics covers a thorough course with the use of trigonometry and extends throughout an entire year. The first semester is devoted to mechanics, sound, and heat; the second to electricity and light. The subjects are amply illustrated with appropriate experiments accompanying the lectures. One period a week is devoted to laboratory work. The numerous courses, both experimental and theoretical, which the department offers are open to students wishing additional work in physics.

Physics Laboratories

WEST PHYSICS BUILDING.—The elementary work in general physics is carried on in the West Physics Building. The first floor contains the laboratories for electricity and light, a recitation room, the storage battery room, and the instrument shop. On the second floor are the large lecture rooms for demonstrations in general physics, a smaller lecture room, one laboratory for mechanics, consultation rooms, and apparatus rooms. The third floor contains two general laboratories and four recitation rooms.

EAST PHYSICS BUILDING.—Advanced work and research in physics have been removed to the first unit of the East Physics Building just completed, the second unit of which, when built, will contain the large lecture rooms, laboratories, class, and consultation rooms for the elementary courses. The new laboratory has two wings 144 feet and 132 feet in length and each 60 feet wide. It is of reinforced concrete construction with specially deadened floors. There are 4 stories, a basement, and a first and second sub-basement, all 7 floors connected by an elevator.

Laboratories are provided for heat and high temperature measurements, sound, light and applied optics, radio activity, electrical measurements, and vacuum tubes, all supplied with adjacent apparatus, research, and consultation rooms. Sound has a two-story structure extending through the basement and first sub-basement entirely disconnected from the walls of the surrounding building. X-ray research has ample quarters in the basement and first sub-basement. The high potential generators are housed in a two-story room which permits ready distribution of power to a number of adjacent research rooms. Spectroscopy both in the photographic and infra-red regions has a series of laboratories. In addition, there are single and multiple unit research rooms available for any purpose. All rooms are provided with numerous storage battery connections and both the 110 v. A.C. and 220 v. D.C., as well as water, gas and compressed air. Three storage batteries contain altogether 640 cells, and switchboards make possible a universal distribution of power. In addition, there are 2 instrument shops, a wood shop, a glass blowing room, and general apparatus rooms. The building also contains necessary offices, four rooms for lectures and classes in advanced courses, a library, and a faculty room.

Description of Courses.—For all courses beyond 100, except Course 130 which requires 45 only, Physics 45 and 46 are prerequisites. The individual courses may have particular prerequisites besides. Courses 45 and 46 (formerly 1E and 2E) are required of all engineering students. Calculus is a prerequisite for courses numbered above 130.

5. Physics for Admission.—This course is intended for students who have not presented the required unit of entrance Physics. This course or its equivalent is required for admission to Courses 35 and 45. M, W, Th, and F, at 5. No credit will be allowed for this course. First semester.

41. General Physics—Mechanics, Sound, and Heat. This course, which is equivalent to Course 35 without laboratory work and Course 37 together, is the regular one for students in Architecture 1 and 2. Four hours credit. First semester.

45. Mechanics, Sound, and Heat. Lectures, recitations, and laboratory work. For Course 45 a knowledge of plane trigonometry is indispensable. No student is admitted to the class who has not had a preparatory course in Physics. In Course 45 at least half of the semester is devoted to elementary mechanics; the remainder of the time to sound and heat; all with experimental illustrations. All members of the class have one period a week in the laboratory. Five hours credit. Each semester.

46. Electricity and Light. Lectures, recitations, and laboratory work. Course 46 must be preceded by Course 45 and by Course 5E in Chemistry, or an equivalent. It is a continuation of Course 45 and takes up the fundamental phenomena and laws of these subjects, with ample class illustrations. Laboratory work as in Course 45. Courses 45 and 46 are required of all Engineering students. Students transferring their credits from the College of Literature, Science, and the Arts will be required to offer Courses 35, 36, 37, and 38 as equivalents of Courses 45 and 46. Five hours credit. Each semester.

105. Modern Physics. Informal lectures and discussions, with demonstrations treating radioactivity, X-rays, the vacuum tube, and other electron and allied phenomena which lead to the theory of matter. The course will be non-mathematical, requiring as prerequisites Courses 35 and 36 or 45 and 46. Course 105 undertakes to meet the needs of those students who desire accurate information about recent work for the purpose of general culture and of those specializing in other sciences in which the newer physics has an increasing importance. Students specializing in Physics will also find it suitable introduction to advanced courses. Two hours credit. First semester.

120. X-ray Equipment and Apparatus. Lectures and laboratory work. This course is intended primarily for students not specializing in physics. The work is partly experimental and will be conducted in the Department of Physics and in the Department of Roentgenology in the University Hospital. It will consist of the study of the underlying electrical principles and the electrical apparatus necessary; various types of tubes and their characteristics; the production and fundamental principles of X-rays, including demonstration of present day measuring instruments, their use, and the practical dosage of X-rays in therapy. *Prerequisite:* Course 36 or Course 46. Two hours credit. Second semester.

130. Architectural Acoustics. Lectures, with illustrative problems on sound transmission, distribution, and absorption, and an experimental study of the acoustic properties of certain rooms. *Prerequisite:* Course 45 (or 35). Two hours credit. Second semester.

145. Electrical Measurements. Lectures, recitations, and laboratory work. In the class work the principles of electrical behavior are critically studied and discussed. The laboratory exercises are designed to illustrate and emphasize these principles, and to give the student some personal experience in the careful use of electrical measuring instruments. The course includes the modern methods of measuring current, resistance, electromotive force, and power, and the calibration of the instruments employed. Four hours credit. First semester.

147. Electrical Measurements. Lectures and laboratory work. The course includes the modern methods of measuring current, resistance, electromotive force, capacity, inductance, and hysteresis of iron, and the calibration of the instruments employed. This course (formerly 5E) is the regular one for engineering students. *Prerequisites: Course 46 and calculus.* Four hours credit. Each semester.

154. Electrical Measurements. Lectures and laboratory work. This is a continuation of Course 145 or 147 and includes measurements of capacitance, self and mutual inductance, and the fundamental measurements with alternating currents. Especial attention is given to the theory of the magnetic circuit and the determination of the magnetization and hysteresis curves of iron and steel. Four hours credit. Second semester.

156. Electron Theory and Radioactivity. Among the topics considered in this course are the radioactive disintegration of atoms, the nature and properties of alpha, beta, and gamma rays, the determination of the electronic charge, the arrangements of electrons and protons to form atoms, electrical mass, positive rays, isotopes, thermionic currents, and metallic conduction. Two hours credit. Second semester.

158. Radioactivity. The laboratory work is largely with radioactive substances. The distinguishing characteristics of alpha rays, beta rays, and gamma rays are studied, and the half life periods of several substances are determined by each student. *Must be preceded or accompanied by Course 156.* One hour credit. Second semester.

164. Alternating Currents. While this course treats primarily the theory of alternating currents, some of the laboratory exercises will be devoted to the operating characteristics of direct current generators and motors. The course is preparatory to the work in vacuum tubes and high frequency measurements but should be useful to students preparing to do any kind of experimental research. *Prerequisite: Course 145 or 147.* Three hours credit. Second semester.

165. Vacuum Tubes in Radio Communication. The theory of the transmission of electricity through gases and through vacua is treated in this course together with a study of the different types of tubes used in radio work. The experimental work deals with the characteristics of tubes, the different types of detector action, the determination of amplifying factors, and the operation of power tubes. Electrical circuits for the use of tubes in connection with high frequency phenomena are treated in detail. *Prerequisite: Physics 154 or 164 or an equivalent.* Two hours credit. First semester.

166. High Frequency Electrical Measurements. A laboratory course consisting of selected problems. Open to a limited number of students who have had adequate preparation. *Prerequisite: Course 165.* Two hours credit. Second semester.

171. Mechanics. The mechanics of solids, liquids and gases. The various types of motion, statics, dynamics, elasticity, friction, viscosity, capillarity, and an introduction to the mechanics of the atom. Elementary operations with vectors are employed in certain problems. Three hours credit. First semester.

175. Sound. The class work is based on Barton's *Text Book on Sound* with lectures and reference reading. Laboratory work two periods per week. Four hours credit. First semester.

181. Heat. The classroom work covers the fundamental principles of heat phenomena. It includes such subjects as expansion, specific heats and temperature, change of state and Van der Waals' equation, elementary kinetic theory, and the absolute scale of temperature. In the laboratory special emphasis is placed on modern accurate methods of measuring various heat quantities, the need of the determination of which often rises in the course of scientific experimentation and research. The student is made familiar with the gas thermometer, thermopile, interferometer measurement of thermal expansion, measurement of specific heats, heats of fusion and of vaporization, thermal conductivities, etc. Four hours credit. First semester.

182. Measurements of High Temperature. An experimental course accompanied by lectures covering the present methods of high temperature measurements. It includes the calibration and use of the resistance thermometer, the resistance thermometer bridge, the thermocouple, the thermocouple potentiometer, the various technical types of indicators and recorders, the total radiation and optical pyrometers, and laboratory methods of producing high temperatures. The subject matter is taken up from both a practical and a theoretical standpoint. Two hours credit. Second semester.

186. Light. Lectures, recitations, and laboratory work. This is an intermediate theoretical and experimental course. Four hours credit. Second semester.

187. Geometrical Optics. A course in the fundamental methods and principles of geometrical optics and the design of optical instruments. Thick lens optics, the ideal optical instrument, the aberration theory of Abbé, a study of the characteristics of optical instruments and exercises in the design of simple instruments, and discussions of the various types of optical glass. Lectures, recitations, and occasional laboratory exercises. Three hours credit. First semester.

203. Molecular Physics. An introduction to the theory of matter. Emphasis on gas theory and mean free path phenomena. Elementary theory of solids. This course is intended primarily for students in Chemical Engineering. Three hours credit. First semester.

204. Molecular Physics. A continuation of Course 203 introducing (1) the quantum hypothesis, with a discussion of the modifications which it requires in the treatment of several of the problems previously presented; (2) spectroscopy considered as a tool for the study of the structure and properties of matter. Three hours credit. Second semester.

205, 206. Electricity and Magnetism. These courses are devoted to a mathematical as distinguished from an experimental study of electrical phenomena. A fundamental treatment of the Maxwell Electromagnetic Theory. *Prerequisite: Course 154 or its equivalent.* Two hours credit. Each semester.

210. Atomic Structure. A review of recent developments in the theory of atomic and molecular structure, with numerous references to current literature. Three hours credit. Second semester.

215. Thermodynamics. A discussion of the two laws, their foundation and their applicability. Three hours credit. First semester.

216. The Kinetic Theory of Gases. Development of the statistical method of Boltzmann, in connection with the kinetic interpretation of the Second Law of Thermodynamics; extension to the quantum theory; fluctuation phenomena and other applications. Discussion of statistical questions in the new quantum mechanics. Three hours credit. Second semester.

231. Theory of Heat. In this course certain selected topics in the Theory of Heat are discussed in lectures. Two hours credit. First semester.

250. X-rays. The fundamental facts and theories connected with the production and properties of X-rays, together with a study of the development of the subject and its bearing on modern ideas of the structure of matter. Considerable emphasis is placed on spectroscopy, and opportunity is afforded to do some experimental work. Three hours credit. Second semester.

265. Conduction of Electricity Through Gases. Electron theory of conduction through gases: general theory, electric spark, glow discharge, electric arc. Origin of spectra: ionizing and radiating potentials, energy levels in line and band spectra, properties of atoms in excited states. Three hours credit. First semester.

285. German Reading. In this course the subject of Physics is studied in German to acquaint the student with the technical terms used in modern German Physics. This course may be taken only by such students as convince the instructor of their satisfactory preparation. One hour credit. First semester.

Summer Session

Course 5, intended for students preparing for entrance to the College of Engineering, and Courses 35, 36, 37, 38, 39, 40, 45, 46, 105, 116, 145, 154, 156, 158, 160, 165, 171, 186, 205s, 210s, 215s, 220s, 231, 250s, 262, 265s, 280, and 281 described for the regular session, will be offered in the Summer Session of 1928.

79. SHOP PRACTICE

Professor BOSTON; Associate Professor CAMPBELL; Assistant Professor PERKINS; Mr. TELFER, Mr. GRENNAN, Mr. GLITZENHIRN.

The object of the shop courses is to acquaint engineering students with fundamental principles, modern methods, and industrial applications. Each course consists of classroom periods in which texts, notes, lectures, lantern slides, etc., are used and laboratory periods during which the application of principles and methods are demonstrated. As occasion permits, trips are made to industrial plants to observe the practice which is treated in these courses.

The Engineering Shops occupy four floors in the south wing of the East Engineering Building. Classrooms and locker rooms are arranged adjacent to the laboratories. Special care has been taken in the selection and arrangement of equipment to facilitate instructional and research work. A chemical laboratory is provided to aid in the control of foundry operations. An electric freight elevator serves all floors. Electric power is used throughout the laboratories, furnishing good examples of group and individual drives.

The Machine Tool Laboratory, 60 by 130 feet, is on the first floor and has been very carefully arranged to demonstrate the two types of machine shop methods, tool room and production. One part of the laboratory contains one or more of each of the principal types of machine tools, such as lathes, planers, grinders, shapers, drilling and milling machines, boring mills, and broaching machines, also many others of more special types, used in tool rooms. In another part of the laboratory, the machines are arranged to give the student a perspective of the machines, tools, and methods used in the manufacture of articles in production. Machine tools for this purpose are the turret lathe, screw machine, automatic screw machine, punch press, die casting machine, drill presses, and milling machines equipped with jigs and fixtures, automatic gear cutters, etc. A third part of the laboratory is occupied by a grinding room which contains grinding, polishing, and buffing machines and auxiliary equipment. This room is connected with an air cleaning system. Centrally located in the laboratory is a well-organized tool crib, 25 by 36 feet, under the supervision of an attendant, containing a comprehensive equipment of measuring instruments, gages, and small tools for machine and hand use. Adjoining this tool crib and under the same supervision is a production room where material for mass production is stored. The equipment of the laboratory offers favorable opportunity for research work on the subject of forming and cutting metals.

The Instrument Shop on the second floor is equipped for fine instrument work. In this shop, research apparatus for the entire University is constructed and also general service work rendered in the repair of equipment. This work is handled by a permanent staff of machinists and is independent of instruction given to students.

The Woodworking Laboratory, 45 by 60 feet, is located on the second floor. The north side of the laboratory contains the work benches and portable power-tools needed for hand work, together with the tools necessary for pattern making. On the south side, are arranged a variety of woodworking machines, making the laboratory a very complete unit. Adjoining the laboratory on the west side is the pattern and wood storage room.

The Metal Working and Treating Laboratory, 60 by 100 feet, on the third floor, is equipped with forty forges, a power hammer, lathes, shapers, grinders, drilling machines, and work benches. For instruction in heat treating, one electric furnace and five gas-fired furnaces with necessary accessories are installed. The welding equipment consists of an oxy-acetylene welding outfit, electric arc welding and electric resistance welding equipment, a thermit welding outfit, and two brazing tables. A universal testing machine of 50,000 pounds capacity, Shore scleroscope, Rock-

well hardness and Brinell hardness testing instruments are provided for instructional and research purposes. Nickel-plating and Parkerizing equipment are available for demonstrations.

The Foundry Laboratory, 60 by 130 feet, on the fourth floor, is divided into the melting, molding, core-making, and cleaning divisions. The melting equipment consists of an electric arc furnace of 200 pounds capacity, a 32-inch cupola, a 12-inch cupola and a crucible furnace. Special equipment is available for making castings in metal molds. Six standard types of molding machines are available for general uses. Benches, racks, ovens, and miscellaneous equipment are provided for the making of cores. The cleaning equipment consists of a sand-blast machine, tumbling barrels, and grinding stands. A cyclone air cleaning system is attached to all of these machines. Materials are delivered to the cupola charging floor by an electrically operated elevator. A two-ton electric traveling crane serves the molding floor.

Shop Courses

1. **Woodwork.** Bench, lathe, and simple pattern work. Classroom one hour, laboratory three hours per week. Two hours credit. Each semester.

2. **Metal Working and Treating.** A study of the principles and practice applied to the working and treating of wrought iron and steel. Classroom one hour, laboratory three hours per week. Two hours credit. Each semester.

2a. **Advanced Metal Working and Treating.** Further work on subjects scheduled in Course 2 may be elected by making arrangements with the instructor.

3. **Foundry.** A study of the principles and practice applied to cast metals including gray iron castings, malleable iron castings, steel castings, and various types of non-ferrous castings. Classroom two hours, laboratory six hours per week. *Prerequisite:* Shop 2. Four hours credit. Each semester.

3a. **Advanced Foundry.** For those students who are especially interested in the foundry branch of engineering, advanced foundry instruction is offered on special problems. Arrangements are to be made with the instructor.

4. **Machine Shop.** Studies are made of the following subjects: the cutting of metals—lathe work, milling, drilling, reaming, tapping, broaching, grinding, polishing, and buffing—also gear cutting, jigs, special tools, standards, gages, manufacturing layouts, automatic machines, cutting fluids, die-casting, punch and die work, spinning, as well as associated subjects, such as, indus-

trial organization, accounting, stock records, standardization, time study, and routings. Classroom two hours, laboratory six hours per week. *Prerequisite: Shop 2.* Four hours credit. Each semester.

4a. Advanced Machine Shop Practice. This course may be elected to suit individual requirements. Special topics incidental to machine shop practice, such as technique of processes, research work; and advanced tool room work are included. Arrangements are to be made with the instructor.

6. Pattern Making. Construction of wood or metal patterns from working drawings. Classroom and laboratory to be arranged. *Prerequisite: Shop 1.* Two hours credit. Each semester.

7. Jig and Fixture Design. Consists of drawing periods supplemented by assignments which treat of the principles underlying the design, construction, and application of such accessories to manufacture. Drawing periods to be arranged. Two hours credit. Each semester.

8. Foundry Costs and Organization. A study of foundry cost methods, foundry records, and standard instructions for foundry operations. Lectures and assignments. *Prerequisite: Shop 2.* Two hours credit. Second semester.

9. Standardization of Labor. Treats of the employment of labor, wage payment in relation to standardized conditions and the problem of labor in manufacture. Lectures and assignments. Two hours credit. Second semester.

Summer Session

Courses 1s, 2s, 2as, 3s, 3as, 4s and 4as will be given during the Summer Session of 1928.

80.

ENGINEERING RESEARCH

Professor A. E. WHITE, Director; Professor NELSON, Editor of Publications; Mr. HUTCHINGS, Special Representative; Mr. E. S. PETTYJOHN, Investigator; Mr. JOMINY, Associate Investigator; Assistant Professor GOOD, Assistant to the Director; Mr. SMALL, Assistant to the Director; Assistant Professor FIRESTONE; Assistant Professor WALTON, Assistant to the Editor of Publications; Mr. HAINES, Publicity Agent; Messrs. SCHNEIDEWIND, PHILIPP, ABBOTT, THOMAS, WOLFE, VINCENT, Assistant Investigators.

The Department of Engineering Research was established in October, 1920, to afford an official department through which the laboratory facilities of the University, when not being utilized for instructional purposes, could be made available to the civic and technical interests in the State and elsewhere.

The Department does not offer course work to students in the University, but with the research problems brought to the University through the medium of the Department, opportunity is in many cases afforded graduate students to work on special research problems under the technical supervision of members of the faculty or the staff of the Department. These problems are of more or less practical and immediate value to the industries.

Besides such problems several industrial fellowships are administered through this Department, although the actual technical work is done in the various departments of the College. At present these fellowships are:

Detroit Edison Fellowship in Chemical Engineering.

Detroit Edison Fellowship in Metallurgy.

Michigan Gas Association Fellowship.

The U. S. Army Ordnance Fellowship.

Association of Natural Gasoline Manufacturers Fellowships (four).

Acme White Lead and Color Works Fellowship.

The function of the Department is largely administrative. The actual technical direction of the researches in most cases being in the hands of members of the regular faculty.

The facilities available through the Department include the libraries of the University and the engineering and other technical laboratories. The work in the laboratories is conducted by members of the staff connected with those laboratories, thus insuring a maximum of efficiency in their utilization.

Part V

WORK OF THE COLLEGE OF ENGINEERING—PROFESSIONAL DEPARTMENTS

81. THE GROUP SYSTEM OF ELECTIVE STUDIES

In July, 1912, there went into effect a complete revision of all the programs in Engineering by which it was made possible for a student in his senior year to have a much wider range of elective work than formerly. The new system provides that of the 140 hours of credit required for graduation, 125 to 131 hours are prescribed and 9 to 15 hours may be elected. These elections may be made from announced groups of study or from other courses approved by the head of the department.

The group system allows the student to receive his instruction in the advanced subjects from a specialist. It also permits a student desiring to take up a fifth year of study to specialize in some particular branch of engineering. A student in any group will be allowed to elect work in the other departments of engineering or in the other colleges or schools of the University, subject to the approval of the head of his department. A student desiring to obtain special scientific knowledge or special business training by building on the fundamental subjects of engineering may be allowed to elect scientific courses or courses in economics or business administration under the direction and approval of the head of his department.

Information regarding the several professional departments of the College of Engineering, facilities for instruction, requirements for graduation, schedules of study, etc., will be found in the following pages.

82. AERONAUTICAL ENGINEERING

Professors SADLER, PAWLOWSKI, KERBER; Associate Professor STALKER; Mr. UPSON.

The work in this Department has been arranged to cover all problems entering into the design and construction of machines that utilize the air as their means of support and transportation. In this connection the two main types are classified in the following groups:

Heavier than Air Craft, which comprises a study of the general question of aerodynamics, problems relating to the lift and drag of various types of wing sections, the determination of stresses and the general design of structure for all parts of an aircraft, and the design of propellers and propelling machinery.

Lighter than Air Craft, which includes all studies similar to those mentioned above, but with special reference to this type of structure; together with the principles involved in balloons and dirigibles, and their navigation.

The Courses offered by the Department are arranged to cover the essentials of aerodynamics necessary for the proper understanding of the action of wings, propellers and problems connected with stability and maneuvering; and form the basis for the application of such studies to the design, construction and analysis of performance of all types of aircraft.

The Department of Aeronautical Engineering from its inception, has always realized that in the utilization of the air as a means of transportation, the problems confronting the designer and the future development in this field, must rely upon a thorough foundation of aerodynamic theory. As a preparation for this, and for design purposes, besides the usual mathematics, courses in theory of structures, mechanical engineering, including gas engine design and hydromechanics, also are essential. In the design of aircraft, the student is given a chance to apply such studies, so as to obtain the best solution to any given set of conditions.

The wind tunnel offers facilities for experimental work in all problems relating to this subject, and is available for research work for advanced students.

The Department is in constant touch with the Government and industrial concerns which demand well trained men in this field. The development of this newest element in which a large part of high speed transportation must inevitably be carried on in the future, will continue to call for numbers of properly trained engineers, both in the design and research fields.

Aeronautics Laboratory.—For students taking aeronautical courses, facilities are provided in various laboratories of the Engineering College for special investigations of strength of materials and parts of aircraft structure, motor testing, comparative study of resistance of bodies in the naval tank; also studies are made of aerodynamical properties of various bodies and aerofoils in an air current, 3 x 3 feet, velocity 40 miles an hour, provided by an air blower, in connection with which two dynamometers are used. One dynamometer is of a type for a simultaneous determination of lift, drag, and center of pressure of aerofoils; the other for determination of thrust and torque of propeller models two feet in diameter.

A new aerodynamic laboratory is under construction comprising a model shop and two new wind tunnels. The larger tunnel will be equipped with a choice of throats, 5, 6, 7 and 8 feet in diameter, and is intended for wind velocities up to 250 miles per hour; the smaller tunnel will be used with throats of 12, 16 and 20 inches in diameter and for wind velocity approaching the velocity of sound. The tunnels will be equipped with several dynamometers of different types for various types of aerodynamic research.

Combined Courses have been arranged with Albion and Olivet Colleges and the College of the City of Detroit. For detailed information see sections 56-58.

Advice to Students of other colleges and universities, with regard to planning their courses before coming to the University, is to be found in section 12.

Military Science.—The attention of prospective students in aeronautical engineering is called to the Reserve Officers' Training Corps. Students in aeronautical engineering are particularly well qualified to take the work offered in preparation for air service. Those who consider taking Military Science are urged to enroll at the beginning of their course. For further details see section 74.

CURRICULUM IN AERONAUTICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering, Aeronautical Engineering, are required to complete the curriculum detailed below. For the definition of an hour of credit see section 52.

- a. Preparatory Courses.
- | | |
|--|----------|
| English 1, and choice of English 5, 6, or 14 | 6 hours |
| Modern Language and Cultural Electives | 16 hours |
| Mathematics 1, 2, 3, 4 | 18 hours |
| Physics 45, 46 | 10 hours |
| Chemistry 5 | 5 hours |
| Drawing 1, 2, 3 | 8 hours |
| Shop 2, Metal Working | 2 hours |
| Total | 65 hours |
- b. Secondary Courses.
- | | |
|--|---------|
| Shop 4, Machine Shop | 4 hours |
| Surveying 4, Use of Instruments | 2 hours |
| Engineering Mechanics 1, Statics | 4 hours |

E. M. 2, Strength and Elasticity	3 hours
E. M. 3, Dynamics	2 hours
E. M. 4, Hydrodynamics	3 hours
C. E. 2, Theory of Structures	3 hours
M. E. 2, Elements of Machine Design	3 hours
M. E. 3, Heat Engines	4 hours
M. E. 5, Thermodynamics	3 hours
M. E. 6, Theory of Machine Design	4 hours
M. E. 7, Mechanical Laboratory	2 hours
M. E. 15, Internal Combustion Engines	3 hours
M. E. 32, Mechanical Laboratory	2 hours
E. E. 2, Elec. Apparatus and Circuits I	4 hours
Ch. E. 1, Engineering Materials	3 hours
Total	49 hours

c. Technical Courses and Electives.

Aero. 1, General Aeronautics	2 hours
Aero. 2, Theory of Aviation	2 hours
Aero. 3, Theory of Design and Propellers	3 hours
Aero. 4, 4a, Aeroplane Design	4 hours
Aero. 5, Aeronautical Laboratory	1 hour
Aero. 6, Design of Aeronautical Motors	2 hours
Electives	12 hours
Total	26 hours

Summary:

Preparatory Courses	65 hours
Secondary Courses	49 hours
Technical Courses and Electives	26 hours
Total	140 hours

First Year

FIRST SEMESTER		SECOND SEMESTER	
*Modern Language	(§ 76) 4	*Modern Language	(§ 76) 4
Chem. 5	(§ 64) 5	Chem. 5	(§ 64) 5
or Shop 2	(§ 79)	or Shop 2	(§ 79)
and Engl. 1, 2,	(§ 67) 6	and Engl. 1, 2	(§ 67) 6
Math. 1	(§ 72) 4	Math. 2	(§ 72) 4
Drawing 1	(§ 73) 3	Drawing 2	(§ 73) 3
Total hours	16 or 17	Total hours	16 or 17

*For the Modern Language requirement see section 54.

Second Year			
FIRST SEMESTER		SECOND SEMESTER	
*Modern Language	(§ 76) 4	*Modern Language	(§ 76) 4
Math. 3	(§ 72) 5	Math. 4	(§ 72) 5
Physics 45	(§ 78) 5	Physics 46	(§ 78) 5
Surv. 4	(§ 86) 2	E. M. 1	(§ 66) 4
Drawing 3	(§ 73) 2		
	18		18
Total hours		Total hours	

Summer Session

Shop 4	(§ 79) 4
E. E. 2a	(§ 85) 4
	8
Total hours	

Third Year

E. M. 2	(§ 66) 3	E. M. 4	(§ 66) 3
E. M. 3	(§ 66) 2	M. E. 5	(§ 87) 3
M. E. 2	(§ 87) 3	M. E. 6	(§ 87) 4
M. E. 3	(§ 87) 4	Ch. E. 1	(§ 83) 3
M. E. 7	(§ 87) 2	C. E. 2	(§ 84) 3
Aero. 1	(§ 82) 2	Aero. 2	(§ 82) 2
	16		18
Total hours		Total hours	

Fourth Year

M. E. 15	(§ 87) 3	Engl. 5, 6 or 14	(§ 67) 2
Aero. 3	(§ 82) 3	M. E. 32	(§ 87) 2
Aero. 4	(§ 82) 4	Aero. 5	(§ 82) 1
Group options	(§ 82) 6	Aero. 6	(§ 82) 2
		Group options	(§ 82) 5
	16		12
Total hours		Total hours	

COURSES IN AERONAUTICAL ENGINEERING

1. **General Aeronautics.** Lectures and recitations. An introductory course giving the essential principles of aeronautics (balloons, dirigibles, ornithopters, helicopters, aeroplanes, helicopters, and kites), history of flight and description of modern aircraft. Open to all students. Two hours credit. First semester.

2. **Theory of Aviation.** Lectures and recitations. The course deals with the following: general discussion of modern aerodynamical theories of lift and drag; the results of wind tun-

*For the Modern Language requirement see section 54.

nel and flight experiments, and the performance of airplanes, including stability and balance studies. *Prerequisite: Courses E. M. 1 and E. M. 3.* Two hours credit. Second semester.

3. Theory and Design of Propellers. Lectures, recitations, and drawing. Theory of propellers and analysis of propeller performance on the Drzewiecki system; Eiffel's method of propeller analysis and graphical method of determining propellers for specified conditions; analytical and graphical methods of investigating the strength of propellers and influence of gyrostatic moments in quick turns. The student will design a propeller and analyze the distribution of stresses in the blades. *Must be preceded or accompanied by Course 2.* Three hours credit. First semester.

4. Aeroplane Design. Lectures and recitations. This course includes the investigation of the design of the aeroplane from the aeronautical and strength standpoints. The strength and design of all the details are discussed and a completed design prepared. *Must be preceded or accompanied by Course 3, and preceded by M. E. 6 and C. E. 2.* Two hours credit. First semester.

4a. Aeroplane Design. Continuation of preceding course. Drawing only. Two hours credit. Second semester.

5. Aerodynamic Laboratory. An elementary course covering use of instruments, investigation of aerodynamical properties of the various combinations of bodies and aerofoils used in aeroplanes and airships, test of propellers. *Must be preceded or accompanied by Courses 2 and 3, and preceded by M. E. 7.* One hour credit. Second semester.

6. Design of Aeronautical Motors. Lectures and drawing. Complementary course to M. E. 15 or M. E. 30, dealing with special features of the aeronautical motors, a more refined method of cam design, analysis of vibration and balancing of motors, critical study of various types of motors, and complete general plans of a motor of a certain type are prepared. *Prerequisite: M. E. 15 or M. E. 30.* Two hours credit. Second semester.

7, 8. Lighter-than-Air Craft. Lectures and recitations. This course is concerned with the following: aerostatics, and major aerodynamic and structural design problems of non-rigid, semi-rigid and rigid aircraft. Two hours credit. Second semester.

10. Design of Aerodromes and Hangars. Lectures, recitations, and drawing. Planning and equipment of aerodromes and aero-ports; study of construction of transportable and stationary hangars. General plans of an airdrome are prepared. *Prerequisite: Courses 2 and 7.* Two hours credit.

11. **Advanced Stability.** Lectures and recitations. Advanced study of more complicated phenomena of stability according to Bryan with Bairstow's applications of experimentally determined resistance derivatives and rotary coefficients. *Prerequisite: Course 2 and Math. 4b (Differential Equations.)* Two hours credit. First semester.

12. **Seminary.** Reading and reports on selected aerodynamical and aeronautical problems. *Open only to graduates and seniors who receive special permission.* A reading knowledge of French and German is most desirable. Credit to be arranged.

13. **Advanced Design.** Continuation of Course 4a, taking up some of the more complex or special problems. *Open primarily to graduates.* Credit to be arranged.

14. **Research.** Continuation of Course 5, offering an opportunity for students to pursue advanced experimental and analytical investigations of any problems in connection with aeronautics. The work of the course consists of investigations for securing data on the more difficult problems of aeronautics and mathematical interpretation of the results. *Must be preceded by Math. 57 and 58. Open primarily to graduates.* A reading knowledge of French and German is desirable. Credit to be arranged.

15. **Mathematical Theory of Aerofoils.** Lectures and recitations. Advanced study of the Joukovsky, von Mises and Witoszynski theory of wing profiles and the Prandtl theory of the Induced Drag, preceded by a brief review of the fundamentals of the Mathematical Theory of Hydrodynamics. *Prerequisite: Course 2, Math. 4b (Differential Equations) and Math. 201 (Theory of Functions of a Complex Variable.)* Two hours credit. Second semester.

16. **Air Transportation.** Engineering and economic aspects. Two hours credit. Each semester.

For information on flying, see Military Science and Tactics, and Naval Aviation.

83.

CHEMICAL ENGINEERING

Professors A. H. WHITE, A. E. WHITE, BADGER, LESLIE, BRIER, UPTHEGROVE, WOOD, BROWN; Assistant Professor BAKER; Instructors MCCABE, CARR.

The chemical engineer finds his primary work in the design or operation of plants in which materials undergo chemical as well as physical changes. In our complex industries there must be specialization and some chemical engineers become experts in design of equipment, some in the operation of particular manu-

facturing processes, and some in the development of processes from the laboratory to the manufacturing scale. The chemical engineer's work must be based on a thorough knowledge of chemistry but he is not a laboratory chemist. His relation to the chemist is very similar to that which the electrical engineer bears to the physicist. As is the case with all engineers, the mature chemical engineer may become a business executive, utilizing his scientific knowledge and manufacturing experience in directing industrial enterprises.

The activities of the chemical engineer do cover a broad field. He finds his work, not only in those industries usually thought of as purely chemical, such as the manufacture of acids, alkalis, and salts; but in such industries as the manufacture of sugar, paper, leather, rubber, soap, fuels, petroleum products, paints and varnishes, cement, plaster, glue, food products, dyes, textiles, and many others. The metallurgist and the ceramist are chemical engineers with specific training for their particular work.

The work of the chemical engineer is often thought of in connection with what are usually called "unit operations." These are such operations as heating, evaporating, filtering, distilling, crushing, extracting, drying, etc., as carried out on the commercial scale. Any manufacturing process with which the chemical engineer deals is made up of a sequence of such operations. It is in his knowledge of these that his distinction from the chemist is most marked; and they also differentiate between the chemical engineer and the mechanical engineer.

The field is so broad that more or less definite subdivisions have arisen. Some of these are: metallurgical engineering, industrial engineering, and general chemical engineering.

Metallurgical Engineering embraces the extraction of metals from their ores, the melting, refining, alloying and casting, fabrication and heat treatment of metals, and their utilization in the various industries. The metallurgical engineer finds his field of endeavor not only in the industries involved directly in the production of metals and metal products but to an ever increasing extent in the industries utilizing and dependent for their existence on metals and metal products. No better example is to be found than that offered by the automotive industry, where he is concerned primarily with the heat treatment and use of metals, and where he is recognized as an important member of the organization. In the metallurgical industries proper he is concerned with the quality and general improvement of both product and process. Constantly diminishing natural resources and the ever increasing demand for new alloys of superior qualities offer unlimited opportunities for research in both extractive metallurgy and the development of new products.

Industrial Engineering in the chemical field relates particularly to the economic side of processes, cost accounting and control, administration of manufacturing organizations, and direction of sales effort in the field of chemical engineering equipment.

General Chemical Engineering may be subdivided into many other special branches of engineering and such terms as Gas and Combustion Engineering, Ceramic Engineering, Petroleum Engineering, Electro-chemical Engineering, and others are not unfamiliar.

At the University of Michigan, pronounced distinction is not made in the various fields of Chemical Engineering and all instruction is given under the administration of the Department of Chemical Engineering. The first two years of undergraduate work are devoted largely to acquisition of fundamental subjects as tools required for an understanding of the more specialized subjects. In these years the student should become familiar with mechanical drawing, mathematics, physics, and chemistry, and begin his work in chemical engineering. He also should acquire some proficiency in the use of the English language, and it is advisable that he obtain a reading knowledge of German, so that there will be available to him valuable publications appearing in the German chemical literature.

In the last two years, attention is divided between studies in Chemical Engineering, advanced work in Chemistry, and the fundamentals of other pertinent engineering subjects, such as engineering mechanics, machine design, heat engines, and electrical machines and circuits. An introductory knowledge of economics is obtained and elective subjects provide opportunity for a limited amount of study in such subjects as history, philosophy, and political science.

The work in Chemical Engineering subjects is designed to give the student as broad a foundation as possible, avoiding marked specialization and yet carrying his training in one direction sufficiently far so that upon graduation he may be immediately useful to some organization. Our chemical engineers, even on graduation from a four-year course, often accept positions where they become the sole chemical or metallurgical engineer in the organization, and these men must consequently be fitted to accept and creditably carry such responsibility.

The required work in Chemical Engineering includes courses in engineering materials, fuels and combustion, heat treatment and properties of metals, inorganic and organic chemical technology, theory of Chemical Engineering, and an introduction to research work. This research work may be in any field chosen by the student, and, taken with other elective work, offers opportunity for moderate specialization.

GRADUATE WORK

The mere fact that the chemical engineer must have considerable attainments in the important fields of chemistry, physics, and mathematics, as well as in Chemical Engineering, indicates the need of a course of more than four years. The formative state of Chemical Engineering and its rapid development, which is certain to continue for many years, makes it important that a young man entering the profession be equipped not only to keep abreast of its progress, but also to do his part in advancing his chosen subject during his active professional life. This is definitely recognized by many of the larger corporations, who prefer men with a Master's degree to one with a Bachelor's degree on the ground that the man with post-graduate training advances faster and farther than an equally able man without it. They recognize this, not only by being more willing to employ men with advanced degrees; but by paying higher salaries to such men. Some of the larger corporations are now demanding a Doctor's degree or its equivalent for men for their more important research positions.

The laboratories completed in 1923 provide unsurpassed facilities for the study of processes and apparatus. Generous provision in the way of private laboratories has been made to meet the needs of the advanced student.

Forty-one graduate students are making Chemical Engineering their major subject in 1927-1928. Twenty-two of them are candidates for the doctorate.

FACILITIES FOR INSTRUCTION

Excellent facilities are available for theoretical and laboratory studies of the various branches of chemical engineering.

The Chemical Engineering Library is shelved with the other departmental libraries on the third floor of the East Engineering Building. The library is 33 by 60 feet and has shelves for 15,000 books and seats for 80 readers. There is a rich collection of journals dealing with industrial chemistry, chemical engineering, and chemistry. The total number of journals currently taken by the Department of Chemical Engineering is 106, and most of them are represented by complete sets. In addition to 6,000 books dealing distinctively with Chemical Engineering, there are many others dealing with more general engineering lines.

The General Chemical Engineering Laboratory is devoted primarily to equipment for studying the fundamental elements of Chemical Engineering and has facilities for the following unit processes.

EVAPORATION.—The evaporator laboratory occupies a space 26 by 69 feet extending from the basement through the first floor. The principal equipment is a set of evaporators and accessories which are the gift of the Swenson Evaporator Company of Harvey, Illinois. It is the most complete and extensive equipment of its kind in the country. The evaporators include a standard vertical tube unit, a standard horizontal tube unit, a semi-film unit, a true-film unit of the Yaryan type, and a special Yaryan apparatus fitted with glass tubes. Each of the three evaporators first mentioned has a maximum evaporation capacity of 4,000 pounds of water per hour. Each is completely equipped with accessories for weighing and controlling feed, removing crystal, and measuring condensate; and each has the greatest possible flexibility to permit adaptation to process development.

DISTILLATION.—Facilities for the study of batch and continuous distillation, and of dephlegmation, are available. The equipment includes a 250 gallon electrically heated still provided with a 20-foot 10-inch packed column, and a bubbler-cap column of the same size. Either column may be operated continuously or as an apparatus of batch type. Suitable condensing, metering, and instrument equipment is available. A 4-inch column and 30 gallon still fitted for continuous distillation and several smaller stills and columns complete the equipment of this division of the laboratory. All of the apparatus is designed with a view to studying the fundamental principles of fractional distillation and fractional condensation.

GAS ABSORPTION.—There is an absorption column which can be filled with various types of tower packing.

FILTRATION.—The present equipment consists of a 24-inch washing plate-and-frame press, with an assortment of special frames. There is also a deLaval centrifugal clarifier and filter; and a 10-inch Weston centrifuge.

CRYSTALLIZATION.—For this work there is a special 30-foot single deck Swenson-Walker continuous crystallizer, with dewatering attachment, a special vertical batch crystallizer, and a smaller continuous unit made of glass.

STIRRING AND MIXING.—One of the laboratory's tanks is equipped with paddle stirrers and with devices for studying agitation. Facilities are also available for the study of propeller stirrers.

GENERAL.—In addition to special equipment of the types enumerated the laboratory is well equipped with storage, reaction, and weighing tanks, pumps, blowers, motors, scales, condensers, digestors, autoclaves, and all necessary accessories. Soft water may be obtained from two Zeolite water softeners and a supply of

condensed water nearly as pure as distilled water is also on hand. Additions will be made to the equipment of the laboratory as these become necessary or desirable. The aim at all times will be to provide facilities for fundamental investigations rather than to equip a museum of chemical machinery.

Gas, Fuel and Combustion Laboratories.—In this group are included laboratories for general class work in the analysis and calorimetry of industrial gases and fuels, and special testing and research laboratories for petroleum products, motor fuels, combustion, furnaces and gas manufacture.

The subject of gas manufacture and utilization has been given special attention in the department for over twenty years. No prescribed curriculum has ever been required and it is not felt that a special degree need be given. The undergraduate program in Chemical Engineering gives the necessary fundamental courses and the options in the senior year provide room for some special courses. Those desiring to specialize in Gas Engineering should, preferably, continue as graduate students, and choose subjects in other engineering branches as well as Chemical Engineering.

It is worthy of mention that the American Gas Association has delegated an important portion of its research program to the University, and that the Michigan Gas Association has greatly extended its research program and employed Mr. E. S. Pettyjohn as an investigator to make his headquarters at the University and carry on his research at that location or in various plants as the need arises. Students in Gas Engineering have unusual opportunities to assist in plant tests.

THE GAS AND FUEL LABORATORIES occupy three large rooms on the fourth floor of the north wing. They contain apparatus for the analysis of flue and fuel gases; calorimeters for gas liquid and solid fuels; and equipment for testing boiler water, lubricants and fuels.

THE PETROLEUM LABORATORY has facilities for study of motor fuels and other petroleum products. These are supplemented by the equipment available in the general chemical engineering laboratory, the fuel research laboratory, and in the automobile engineering laboratory.

THE FUEL RESEARCH LABORATORY is especially equipped to study the various factors involved in the utilization of motor fuel. Two electric absorption dynamometers and typical automobile engines are available for making engine performance tests, and a special high compressing engine for making anti-knock tests. The laboratory is also supplied with ammonia refrigeration for conducting tests at low temperatures. Special columns for fractional distillation of fuels and special equipment for measuring volatility are available in addition to the standard equipment.

THE COMBUSTION LABORATORIES have special facilities for research and testing in the field of gaseous explosions, particularly the explosion of hydrocarbon air mixtures in a closed vessel as occurs in internal combustion engines. These are supplemented by equipment in the fuel research and automotive laboratories.

THE FURNACE LABORATORY contains furnaces equipped for making heat balances, and for determining the properties of furnace materials and the laws of heat transfer and gas flow as applied to furnaces.

THE GAS ENGINEERING LABORATORY contains furnaces for manufacture of gas on a small scale and for measuring and testing the finished products. This laboratory is largely devoted to the research work of the Michigan Gas Association.

Metallurgical Laboratories.—The metallurgical laboratories are located on the fourth floor of the East Engineering Building, adjacent to the Foundry and Metal Working and Treating Laboratory of the Department of Engineering Shops, and the Gas and Fuel Laboratories of the Department of Chemical Engineering, so that these facilities are also available. Equipment for heat treating and melting is provided in a large furnace room equipped with standard electric and gas furnaces. Facilities are provided for electro-metallurgical work and experimental electric furnace work in this room. Power is furnished through three 50 k. w. transformers.

For instruction in *metallography* facilities are provided in the way of a large grinding and polishing room, a microscope and camera room, and well equipped dark rooms. A smaller room fully equipped with polishing and microscopic equipment, and special camera and dark rooms, are available for graduate students.

For testing *physical properties* of metals a 60,000 lb. Olsen testing machine is equipped for studies at elevated temperatures. Special instruments such as the Brinell Hardness machine, Shore Scleroscope, Rockwell Hardness Tester, Lewis Upton Toughness machine, Izod Impact and others are available. General physical testing equipment is available in the Engineering Mechanics Laboratory.

In the *Pyrometry Laboratory* unusual facilities are provided. The equipment includes several types of millivoltmeters, indicating and recording potentiometers, a transformation point apparatus, optical and radiation pyrometers, various types of thermocouples, and ample facilities for calibrating and checking pyrometric apparatus. The arrangement and equipment of the laboratory are all aimed to supply the student with information which will enable him to take charge of the installation and control of commercial pyrometric and temperature control systems.

The Technology Laboratories.—This group consists of a number of small laboratories, each equipped with facilities especially adaptable for study and research on the problems arising in the respective industries.

THE CEMENT LABORATORY is equipped with a small rotary kiln and accessory apparatus for burning Portland cement under controlled conditions and for testing the properties of cements.

THE CERAMICS LABORATORIES consist of a kiln room, preparation room and laboratory. The kiln room is equipped with oil and gas fired recuperative kilns for pottery, high temperature work, and for testing the burning properties of clays and refractory products. The preparation room includes a dry pan for fine grinding of shales and hard clays, two mixers, a pug mill and extruding machine, glass topped tables, and other equipment used in preparing clays for burning. The laboratory is supplied with a Fairbanks testing machine, a volumeter, and means for analyzing and testing the raw and burned clay, and foundry sands.

THE ELECTROCHEMICAL LABORATORY provides research facilities for electrochemical work. Equipment for the study of electrothermal and high temperature electrolytic processes are also available as part of the facilities of the metallurgical laboratories.

THE PAINT AND VARNISH LABORATORY provides facilities for the study of the manufacture and application of paints, varnishes, nitrocellulose lacquers, enamels and other finishing materials. In addition to regular laboratory facilities the equipment includes grinding apparatus, washed air drying kiln, oven for baking japans and varnishes at high temperatures, as well as spray gun equipment for the application of all kinds of finishing materials. A quartz mercury vapor lamp furnishes ultra-violet light which is used as an accelerated weathering test for paint, varnish, and lacquer films. Additional facilities are also available in the general Chemical Engineering laboratories.

General Laboratories.—Undergraduates whose work does not place them in one of the special laboratories have space assigned to them in one of two large laboratories which are equipped with the usual facilities of laboratory tables, water, compressed air, direct, alternating and storage battery current, analytical balances, and tables for study and computation of results.

Graduate students working on special problems have assigned to them individual graduate laboratories which are equipped with general laboratory facilities.

Visits of Inspection.—The educational value of visits of inspection is well recognized and inspection trips are regularly made in connection with the various courses in chemical engineering.

The wonderful industrial development of the neighboring cities of Detroit and Toledo as well as other points in Michigan within easy reach of Ann Arbor allows a varied range of industries to be visited at small expense. Week-end trips are frequent. The opportunities are so abundant that the list varies from year to year.

Summer Employment

Each student is urged to obtain employment in a factory for at least one summer, in order that he may acquire the viewpoint of the worker in an industrial organization. If he may also acquire professional knowledge, so much the better. The manufacturers of Michigan co-operate in this movement, and, except in time of severe business depression, positions are usually available. At least one summer's work in an approved plant is required in the five-year program in Chemical and Industrial Engineering.

Combined Courses have been arranged with Albion and Olivet Colleges and the College of the City of Detroit. For detailed information see sections 56-58.

Advice to Students of other colleges and universities, with regard to planning their courses before coming to the University, is to be found in section 12. Prospective students of Chemical Engineering are strongly urged to select German as the language to be studied, and to avoid specialization along the lines of Chemistry and Chemical Engineering in their preparatory work. Students in doubt of elections to be made in the first three years' work are cordially invited to correspond with the Department of Chemical Engineering.

Military Science.—The attention of prospective students in Chemical Engineering is called to the Reserve Officers' Training Corps. Students in Chemical Engineering are particularly well qualified to take the work offered in the Ordnance Unit. Those who consider taking Military Science are urged to enroll at the beginning of their course. For further details see section 74.

CURRICULUM IN CHEMICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering, Chemical Engineering, are required to complete the curriculum detailed below. For the definition of an hour of credit see section 52.

Programs, embodying certain required courses, have been established for the four-year course in Chemical Engineering and

the five-year course in Chemical and Industrial Engineering. Both of these programs provide some elective courses. The only limitation placed on these elections is that these courses shall be so chosen as to make a logically arranged curriculum.

i. *Outline of Required Courses.*

a. Preparatory Courses.

English 1 and 2, and choice of English 5, 6, or 14..	6 hours
Modern Language and Cultural Electives	16 hours
Mathematics 1, 2, 3, 4a	16 hours
Physics 45, 46	10 hours
Chemistry 5, 17	10 hours
Drawing 1, 2, 3	8 hours
Shop 2, Metal Working and Treating	2 hours
<hr/>	
Total	68 hours

b. Secondary and Technical Courses.

Chemistry 41, Theoretical Chemistry	3 hours
Chemistry 57, Quantitative Analysis	5 hours
Chemistry 67, Organic Chemistry	5 hours
Chemistry 69, Organic Chemistry	5 hours
Economics	3 hours
Eng. Mech. 1, Statics	4 hours
Eng. Mech. 2, Strength and Elasticity, or	
Eng. Mech. 6, Strength of Materials	3 hours
Mech. Eng. 2, Elements of Machine Design ...	3 hours
Mech. Eng. 3, Heat Engines	4 hours
Elec. Eng. 2a, Elec. App. and Circ.	4 hours
Chem. Eng. 1, Engineering Materials	3 hours
Chem. Eng. 2, Technology of Fuels	3 hours
Chem. Eng. 3, Metallurgy	3 hours
Chem. Eng. 4, Organic Technology	2 hours
Chem. Eng. 5, Organic Technology	4 hours
Chem. Eng. 9, Unit Processes	3 hours
Chem. Eng. 12, Special Problems	5 hours
Chem. Eng. 29, Unit Processes Laboratory	2 hours
<hr/>	
Total	64 hours

Summary :

Preparatory Courses	68 hours
Secondary and Technical Courses	64 hours
Electives	8 hours
<hr/>	

Total required for the B.S. degree140 hours

First Year			
FIRST SEMESTER		SECOND SEMESTER	
*Modern Language	(§ 76) 4	*Modern Language	(§ 76) 4
Chem. 5	(§ 64) 5	Chem. 5	(§ 64) 5
or Shop 2 and	(§ 79)	or Shop 2 and	(§ 79)
Engl. 1 and 2	(§ 67) 6	Engl. 1 and 2	(§ 67) 6
Math. 1	(§ 72) 4	Math. 2	(§ 72) 4
Drawing 1	(§ 73) 3	Drawing 2	(§ 73) 3
	—		—
Total hours	17 or 16	Total hours	16 or 17
Second Year			
*Modern Language	(§ 76) 4	Math. 4a	(§ 72) 3
Math. 3	(§ 72) 5	Phys. 46	(§ 78) 5
Phys. 45	(§ 78) 5	Chem. 57	(§ 64) 5
Chem. 17	(§ 64) 5	Chem. Eng. 1	(§ 83) 3
	—	Draw. 3	(§ 73) 2
	—		—
Total hours	19	Total hours	18
Summer Session			
Chem. 41	(§ 64) 3		
Chem. Eng. 2	(§ 83) 3		
Economics	(§ 65) 3		
	—		
Total hours			9
Third Year			
Chem. 67	(§ 64) 5	Chem. 69	(§ 64) 5
Chem. Eng. 9	(§ 83) 3	E. M. 2	(§ 66)
E. M. 1	(§ 66) 4	or E. M. 6	(§ 66) 3
M. E. 3	(§ 87) 4	*Modern Language	(§ 76) 4
Chem. Eng. 3	(§ 83) 3	Chem. Eng. 4	(§ 83) 2
	—	Engl. 5, 6, or 14	(§ 67) 2
	—	Chem. Eng. 29	(§ 83) 2
	—		—
Total hours	19	Total hours	18
Fourth Year			
Chem. Eng. 5	(§ 83) 4	E. E. 2a	(§ 85) 4
Chem. Eng. 12	(§ 83) 5	Elective	4
M. E. 2	(§ 87) 3		
Elective	4		
	—		—
Total hours	16	Total hours	8

*Students taking Chemical Engineering are urged to elect German. For the Modern Language requirement see section 54.

FIVE-YEAR COURSES IN CHEMICAL AND INDUSTRIAL ENGINEERING

	HOURS
1. English	6
2. Modern Language or Cultural Electives	16
3. Mathematics	16
4. Physics	10
5. Chemistry	28 or 22*
6. Drawing and Descriptive Geometry	8
7. Shop Work	2 or 5*
8. Engineering Mechanics	7 or 8*
9. Mechanical Engineering	7
10. Chemical Engineering	20 or 22*
11. Electrical Engineering	4
12. Economics and Business Administration	36
13. Summer Plant Work 8 weeks	1
14. Electives	15
Total required for degree of Bachelor of Science in Chemical and Industrial Engineering	176

First Year

FIRST SEMESTER	SECOND SEMESTER
Modern Language (\$ 76) 4	Modern Language (\$ 76) 4
Chem. 5 (\$ 64) 5	Shop 2 (\$ 79) 6
or Shop 2 and Engl. 1 and 2 (\$ 79) 6	and Engl. 1 and 2 or Chem. 5 (\$ 67) 6
Math. 1 (\$ 67) 6	Math. 2 (\$ 64) 5
Drawing 1 (\$ 72) 4	Drawing 2 (\$ 72) 4
Military Science (\$ 73) 3	Military Science (\$ 73) 3
	Military Science (\$ 74) 1
Total 17 or 18	Total 17 or 18

Second Year

Math. 3 (\$ 72) 5	Math. 4a (\$ 72) 3
Physics 45 (\$ 78) 5	Physics 46 (\$ 78) 5
Chem. 17 (\$ 64) 5	Chem. 57 (\$ 64) 5
Economics 53 (\$ 65) 3	or Ch. E. 1 (\$ 83) 6
Military Science (\$ 74) 1	and Ch. E. 2 (\$ 83) 6
	Economics 54 (\$ 65) 3
	Military Science (\$ 74) 1
Total 19	Total 17 or 18

*Options for students in metallurgy who substitute Chem. 63 for Chem. 67, and Ch. E. 6 or 7, Shop 3 and E. M. 2a for Chem. 69.

Third Year

FIRST SEMESTER		SECOND SEMESTER	
Chem. 57	(§ 64) 5	E. M. 1	(§ 66) 4
or Ch. E. 1	(§ 83)	Chem. 67	(§ 64) 4
and Ch. E. 2	(§ 83) 6	*or Chem. 63	(§ 64) 5
M. E. 3	(§ 87) 4	Economics 131	(§ 65) 3
Economics 121	(§ 65) 3	Economics 172	(§ 65) 3
Economics 171	(§ 65) 3	Chem. Eng. 9	(§ 83) 3
Total	15 or 16	Total	17 or 18

Summer Session

Chem. Eng. 3	(§ 83) 3
Chemistry 41	(§ 64) 3
Total	6

Fourth Year

Chem. 69	(§ 64) 5	Modern Language	(§ 76) 4
or Shop 3* and	(§ 79) 4	Ch. E. 4	(§ 83) 2
Ch. E. 6 or 7*	(§ 83) 2	M. E. 2	(§ 87) 3
and E. M. 2a	(§ 66) 1	Business 114	(§ 63) 3
E. M. 2	(§ 66) 3	Business 142	(§ 63) 3
Business 121	(§ 63) 3	Chem. Eng. 29	(§ 83) 2
Business 131	(§ 63) 3		
Draw. 3	(§ 73) 2		
Total	16 or 17	Total	17

Summer Session

Plant Work	1
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Fifth Year

Modern Language or		Ch. E. 12	(§ 83) 5
Cultural Elective	(§ 76) 4	Engl. 5, 6, or 14	(§ 67) 2
Ch. E. 5	(§ 83) 4	Business 152 or 162	
E. E. 2	(§ 85) 4	or 206	(§ 63) 3
Business 161 or		Elective	7
151 or 205	(§ 63) 3		
Elective	3		
Total	18	Total	17

*Options for students in metallurgy who substitute Chem. 63 for Chem. 67; and Ch. E. 6 or 7, Shop 3 and E. M. 2a for Chem. 69.

COURSES IN CHEMICAL ENGINEERING

1. **Engineering Materials.** An elementary study of the manufacture and properties of the ferrous and non-ferrous alloys, cements, clay products, protective coatings, fuels and water softening. Lectures and recitations. *Prerequisites: Chem. 5 and Shop 2 (except for Architects).* Three hours credit. Each semester.

2. **Fuels and Furnaces.** A study of the preparation, combustion and utilization of fuels; including temperature measurement, analysis of gases and fuels, determination of heating values, and furnace efficiencies, the computation of heat balances, maximum temperatures, and relative costs of heating. Lectures, recitations and laboratory. *Prerequisites: Ch.E. 1 and Phys. 46.* Three hours credit. Each semester.

3. **Structure and Properties of Metals.** A microscopic study of the structure of metals as affected by composition and by thermal and mechanical treatment; the relation of these to the physical properties of metals; consideration of the factors that determine or limit the uses of metals and common alloys. Lectures, recitations and laboratory. *Prerequisites: Ch.E. 1 and Phys. 46.* Three hours credit. Each semester.

4. **Chemical Technology of the Inorganic Industries.** A descriptive study of the processes and manufacturing methods used in the more important industries based on inorganic chemical technology. Lectures, recitations and laboratory. *Prerequisites: Ch.E. 2, Chem. 41 or 42, and Phys. 46.* Two hours credit. Each semester.

5. **Chemical Technology of the Organic Industries.** A descriptive study of the processes and manufacturing methods used in the more important industries based on organic chemical technology. Lectures and recitations. *Prerequisites: Ch.E. 2, Chem. 67 and 41 or 42.* Four hours credit. Each semester.

6. **Iron and Steel.** A critical study of the metallurgy of the ferrous metals; raw materials, the production of pig iron; the manufacture of steel, wrought iron, cast iron and malleable iron. Lectures and recitations. *Prerequisites: Ch.E. 2, or Ch.E. 1 and M.E. 3.* Two hours credit. Each semester.

7. **Non-Ferrous Metallurgy.** A course in the metallurgy of copper, zinc, lead, tin, nickel, and aluminum, covering extractive processes, fabrication, production and properties of alloys. Lectures and recitations. *Prerequisites: Ch.E. 2, or Ch.E. 1 and M.E. 3.* Two hours credit. Second semester.

8. **Physical Metallurgy.** An advanced study of the thermal, mechanical and magnetic properties and the macroscopic and microscopic structures of metals. Laboratory, reports and discussions. *Prerequisites: Ch.E. 3, Chem. 41 or 42.* Two hours credit. First semester.

9. **Unit Processes.** An elementary discussion of the theory of the unit processes of Chemical Engineering and of typical equipment for carrying out these processes. Lectures and recitations. *Prerequisites: Ch.E. 1 and Phys. 46; preceded or accompanied by Chem. 41.* Three hours credit. Each semester.

10. **The Utilization of Fuels.** A course designed especially for Mechanical Engineering students covering in a limited way the material offered in Ch.E. 2. Laboratory work. *Prerequisites: Ch.E. 1, Chem. 5, Phys. 45; accompanied by M.E. 7.* Not open to students in Chemical Engineering. One hour credit. Each semester.

11. **Principles of Chemical Engineering.** A study of the application of the principles of the three fundamental laws of energy to Chemical Engineering processes. Lectures and recitations. *Prerequisites: Ch.E. 2, Chem. 41 or 42, and Math. 4 or 4a.* Three hours credit. First semester.

12. **Special Problems.** The purpose of this course is to train the student in methods of independent research. Each student is, after consultation, assigned a subject connected with some manufacturing process which he is to study intensively both in the library and laboratory. Wide latitude is allowed in the choice of a subject, and the student is, so far as possible, urged to select one that interests him most. Laboratory. *Prerequisites: Ch.E. 4, Chem. 41, Phys. 46 and such other courses as are essential to a knowledge of the subject selected.* Three to eight hours credit. Each semester.

13. **Evaporation, Filtration, and Transportation of Liquids.** An advanced study of the principles of transportation, heating and evaporation, and filtration of liquids; and the construction of commercial types of equipment for carrying out these operations as illustrated by trade bulletins and blueprints of actual installations. Lectures and recitations. *Prerequisites: Ch.E. 4 and 9.* Two hours credit. Second semester.

15. **Equipment and Processes for Drying, Distillation and Extraction.** An advanced study of the fundamental theory of and equipment for carrying out these processes. Lectures and recitations. *Prerequisites: Ch.E. 4 and 9.* Two hours credit. Second semester.

16. **The Manufacture of Illuminating and Fuel Gases and Motor Fuels.** A study of the manufacture of coal gas, water gas, producer gas, oil gas, natural gas, gasoline and motor fuels. Lectures and recitations. *Prerequisites: Ch.E. 5 and 9, and M.E.*

3. Two hours credit. Second semester.

17. **Furnace Design and Construction.** A study and application of the principles of furnace design, the properties of refractory materials; and their use in furnace construction. Lectures and recitations. *Prerequisites: Ch.E. 2 and 9.* Three hours credit. First semester.

18. **Metallography of the Non-Ferrous Metals.** An advanced study of the microscopic structure of the common non-ferrous metals and alloys, and of the effect of heat treatment, mechanical work, and composition on their structure and properties. Lectures and laboratory. *Prerequisite: Ch.E. 3.* Two hours credit. Second semester.

19. **Pyrometry and Furnace Control.** A study of the theory, construction, calibration and use of commercial pyrometers, their application and limitations. Lectures and laboratory. *Prerequisites: Ch.E. 2, Phys. 45 and 46.* Two hours credit. Second semester.

20. **Summer Work in Factories.** Credit is given for a report on some phase of work in a factory. Application must be made for registration in this course and the nature of the problem must be approved before entering upon the work. One hour credit.

22. **Applied Thermodynamics.** An advanced analytical study of Chemical Engineering processes from the standpoint of quantitative thermodynamics and physical chemistry. Lectures and recitations. *Prerequisite: Ch.E. 11.* Two hours credit. Second semester.

23. **Design of Chemical Plants.** A simple chemical process is selected, and the student proceeds to plan the steps in the process and select the type of apparatus for each. Lectures and recitations. *Prerequisites: Ch.E. 13; and preceded or accompanied by Ch.E. 14 and a course in Machine Design.* Two hours credit. Second semester.

26. **Advanced Ferrous Metallurgy.** A study of the constitution of irons and steels and the effect on their properties of composition, heat treatment, and mechanical work. Lectures and recitations. *Prerequisite: Ch.E. 3.* Two hours credit. Second semester.

27. **Design of Chemical Machinery.** The student selects some piece of chemical machinery and makes a complete set of drawings that would be required for its actual construction. Conferences and drafting. *Prerequisites: Ch.E. 13 and a course in Machine Design.* Two hours credit. Each semester.

29. **Chemical Engineering Laboratory.** A laboratory study of the unit processes of chemical engineering comprising a series of performance tests on various types of chemical engineering equipment. Laboratory. *Prerequisite: Ch.E. 9.* Two hours credit. Each semester.

30. **Seminar in Metallurgy.** Reading and reports on metallurgical subjects. *Prerequisites: Open to graduates and to seniors who receive permission.* Two hours credit. Each semester.

32. **Explosives and Pyrotechnics.** A study of the processes used in the manufacture of commercial and military explosives and pyrotechnic materials, as well as their properties and uses. Lectures and recitations. *Prerequisites: Ch.E. 5.* Four hours credit. Second semester.

33. **Seminar in Heat Transfer.** Conferences and problems in heat transfer. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Two hours credit. Second semester.

34. **Petroleum Refinery Engineering.** A study of the processes and apparatus used in the manufacture of petroleum products and natural gasoline. Among the subjects treated are distillation, cracking, chemical treatment, heat transfer, and fluid flow, as these are concerned with the operations in the petroleum refinery and natural gasoline plant. Lectures and recitations. *Prerequisites: Ch.E. 5 and Ch.E. 9.* Two hours credit. First semester.

41. **Advanced Ferrous Metallurgy.** Research work on the structure and properties of iron and steel. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

42. **Hydraulic Cements.** Research work on the properties of hydraulic cements as influenced by chemical composition and temperature of burning; also studies of constancy of volume and permanence of concrete structures. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

43. **Evaporation.** Research work on the design of evaporators and on problems connected with handling of liquids on the commercial scale. Laboratory. *Prerequisite: Open to grad-*

uates, and to seniors who receive special permission. Five to eight hours credit. Each semester.

44. Gas. Research relating to the manufacture, properties, and uses of coal gas, water gas, oil gas, and producer gas. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

45. Paint and Varnish. Research work on problems connected with the manufacture, properties, and uses of paints, varnish and pyroxylin lacquers. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

46. Advanced Electrochemistry. Research relating to electrodeposition and electrochemical processes. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

47. Advanced Non-Ferrous Metallurgy. Research work on structures and properties of non-ferrous metals and alloys. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

48. Petroleum and Motor Fuels. Research work related to the distillation, cracking, and refining of petroleum and its products. Laboratory. *Prerequisites: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

49. Motor Fuel Utilization. Research work related to problems involved in the utilization of gasoline and other motor fuels. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

50. Distillation. Research work on the theory, design, and performance of distillation equipment. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

51. Cast Metals. Research work on processes for producing metal castings. Laboratory. *Prerequisite: Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

52. Refractories and Furnace Design. Studies of the thermal and physical properties of refractory materials, combustion, and heat transfer at high temperatures. Laboratory. *Pre-*

requisite: Open to graduates, and to seniors who receive special permission. Five to eight hours credit. Each semester.

61. Research Seminar. Discussion of research of staff and graduate students. No credit. Each semester.

Summer Session

Courses 1, 2a, 6, 9, 10, 12, 41 and 47, and 43 and 50 will be given during the Summer Session of 1928.

84. CIVIL ENGINEERING

Professors RIGGS, KING, HOAD, GRAM, DECKER, WORLEY, CISSEL, WISLER, MORRISON, SHERLOCK, EMMONS; Assistant Professors SWINTON, ALT, SADLER; Mr. HOUSEL, Mr. MAUGH.

Civil Engineering is divided into groups which correspond to the specialties of practicing Civil Engineers. Since these divisions have come about gradually through the requirements of actual practice, it is inevitable that there should be considerable overlapping of their respective fields. The competent Civil Engineer must have a broad understanding of the scientific principles underlying all of the groups, as well as a high degree of skill in applying these principles to the specialized problems of his own group.

While the training of the Civil Engineer is essentially technical, it is not always as a technician that he achieves his greatest usefulness. It has come to be quite generally recognized that the habits of thought developed by the practicing Civil Engineer fit him admirably for administrative and executive positions. This is especially true in the constantly expanding transportation field, in municipal and public affairs, and in many industrial and commercial fields, where a background of technical training, and experience in planning and executing important work, is a valuable aid to the administrator. Many graduate Civil Engineers are successfully engaged in highway, railroad, municipal, or building contracting.

The main divisions of Civil Engineering are as follows:

Structural Engineering, which deals with the theory, design and construction of structures such as bridges, buildings, dams, retaining walls, etc., involving the use of steel, masonry (including reinforced concrete), and timber.

Hydraulic Engineering, which takes up the problems of irrigation, drainage, water power development, navigable rivers and harbors, and deals with the measurement of water and the design and construction of dams, locks, wharves, irrigation works and all other forms of hydraulic construction.

Transportation Engineering, which deals with railroads, highways, waterways, and other forms of transportation; location, design and construction, maintenance, operation and also the history and economics of transportation systems. The administration, organization and financing of highway improvements and the management, methods and regulation of highway transport.

Sanitary Engineering, which deals with the design and construction of water works, sewers, water purification and sewage disposal works and with all matters related to public sanitation. It offers many opportunities for advanced work and research along the line of prevention of disease by the proper construction and operation of engineering structures.

Municipal Engineering, which deals with the design, construction, and maintenance of paving, sewers, sidewalks, street drainage, waterworks, and other municipal public works, the laws controlling their construction and operation, the proper design and laying out of cities and villages, and the construction and regulation of street railways and other utilities.

The Courses offered the student are designed to give him a knowledge of the principles underlying the general field as outlined above. The system of "group options," described later, is designed to give the student more thorough training in one of the above groups.

The Department of Civil Engineering tries to anticipate the future requirements of society by seeking the advice of successful graduates, men of affairs in industry, commerce, and public life, and friends of the University generally, so that the graduate may be enabled to render the maximum of service to his community, not only in a technical way, but in social and political ways as well.

The student is required to elect such courses in mathematics and the general sciences as are necessary to a proper understanding of the technical and cultural courses which follow. He is also required to elect courses in Mechanical, Electrical, and Chemical Engineering, as well as in Civil Engineering, since too narrow specialization by undergraduates is discouraged. In addition, he is required to elect not less than three hours of a technical subject allied to, but not included in, the field of Civil Engineering. It is felt that with this background, the graduate can augment his technical knowledge as circumstances require it, either by graduate work in the University or by independent study while in practice.

As a part of his cultural work, the student is required to elect a certain minimum number of hours in English and Modern Language. In addition, he is given a group of electives in which a very wide latitude of choice is permitted, covering subjects in Economics, Political Science, Fine Arts, Psychology, Public

Speaking, etc. The Department desires to give every possible encouragement to the development of individual capacities.

The Department does not guarantee employment to graduates, but the demand from employers usually exceeds the supply, so that graduates have little trouble in finding lucrative positions in which to obtain their early years of experience.

Graduate Work leading to advanced degrees is offered to graduates whose records indicate that they can pursue it profitably. Conditions under which such work may be undertaken are described in the General Announcement Bulletin of the Graduate School of the University.

Fellowships

Fellowships of interest to students in Civil Engineering are described in section 47.

Facilities

Transportation Library.—The Transportation Library contains 50,000 books and pamphlets dealing with every phase of transportation. It is housed in the East Engineering Building. In this library are many rare books and pamphlets relating to the origin, history and development of our various transportation systems. It also contains very complete files of the various technical engineering associations; the modern and current periodicals dealing with railways, highways, waterways and other engineering subjects; state and national, public utility, highway and special commission reports; annual reports of railways and other transportation companies; proceedings of various transportation associations and the latest books on the technical and economic phases of transportation. All of these pamphlets, books and periodicals are grouped in alcoves pertaining to particular subjects. Adjacent to each alcove are tables convenient for the use of students and others engaged in transportation research.

Highway Laboratories.—Through a co-operative arrangement between the University and the State Highway Department, all of the testing of materials for the State Trunk Line and Federal Aid roads, and all County roads which receive State aid, is done at the University. The work of the State is done in rooms immediately adjoining those used for the student work, so that the students secure the benefits to be derived from observing the work of full time trained employees of the State, as well as from their own work.

The Highway Laboratory, which has 11,000 square feet of floor space, is located in the basement of the north wing of the East Engineering Building. There are special laboratories for the

testing of the following materials: Cement, concrete, sand, gravel, broken stone and similar materials; rock and paving brick; asphalt, cements, tars and oils; bituminous mixtures; calcium chloride, metals and paints; and culvert pipe. The laboratories also contain rooms for equipment, balances, concrete curing, storage samples, lockers and showers.

The Laboratory is equipped with all the necessary apparatus for the testing of all kinds of non-bituminous and bituminous materials. Among the more important pieces of apparatus and equipment are a four-cylinder Deval abrasion machine, standard brick rattlers, ball mills, a briquette molding machine, Page impact machines, a Dorry hardness machine, diamond core drills, a 200,000 pound compression testing machine, a concrete wear testing machine, tensile testing machines, apparatus for testing cement, moist closets, Per Se and Ro-Tap sieve shakers, microscopes, Dulin Rotarex extraction machines, standard penetrometers, ductility machines, viscosimeters, constant temperature baths, Fraes and other types of electric ovens, analytical, chainomatic and torsion balances, and field testing apparatus.

Sanitary Experiment Station.—A small sanitary laboratory, with equipment for experimental work, is available for the study of problems related to public sanitation, especially those involved in the purification of water, the treatment of city sewage and industrial wastes, and the protection of streams from pollution.

Hydraulic Experimental Flume.—Facilities for experimental work in the measurement of flowing water for discharges up to 250 cubic feet per second are afforded by a flume 138 feet long, 6.5 feet wide, and 8 feet deep. The flume with accompanying equipment is located just below the Argo Dam on the Huron River.

Combined Courses have been arranged with Albion and Olivet Colleges and the College of the City of Detroit. For detailed information see sections 56-58.

Advice to Students of other colleges and universities with regard to planning their courses before coming to the University, is to be found in section 12.

Military Science.—The attention of prospective students in Civil Engineering is called to the Reserve Officers' Training Corps. Students in Civil Engineering are particularly well qualified to take the work offered in the Coast Artillery group. Those who consider taking Military Science are urged to enroll at the beginning of their course. For further details see section 74.

CURRICULUM IN CIVIL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering, Civil Engineering, are required to complete the curriculum detailed below. For the definition of an hour of credit see section 52.

a. Preparatory Courses.

English 1 and 2 and English 6	6 hours
Modern Language or Cultural Electives	16 hours
Mathematics 1, 2, 3, 4	18 hours
Physics 45, 46	10 hours
Chemistry 5	5 hours
Drawing 1, 2, 3	8 hours
Geology 31	3 hours
Shop Work 2	2 hours
	68 hours

b. Secondary and Technical Courses.

Chem. Eng. 1, Engineering Materials	3 hours
Surveying 1, 2	7 hours
Eng. Mech. 1, Statics	4 hours
Eng. Mech. 2, Strength and Elasticity	3 hours
Eng. Mech. 3, Dynamics	2 hours
Eng. Mech. 4, Hydromechanics	3 hours
Civil Eng. 2, Theory of Structures	3 hours
Civil Eng. 2a, Elementary Design of Structures	3 hours
Civil Eng. 3, Masonry	4 hours
Civil Eng. 10, Hydrology	3 hours
Civil Eng. 26, Spec. and Contracts	2 hours
Civil Eng. 30, Water Works	3 hours
Civil Eng. 32, Sewerage	2 hours
Civil Eng. 40, Highway Engineering	2 hours
Civil Eng. 50, Railroad Engineering	2 hours
Mech. Eng. 3, Heat Engines	4 hours
Elec. Eng. 2a, Electrical Apparatus I	4 hours
	54 hours

Summary:

Preparatory Courses	68 hours
Secondary and Technical Courses	54 hours
Group Option	7 hours
Electives	11 hours
	140 hours

Total

First Year

FIRST SEMESTER		SECOND SEMESTER	
*Modern Language	(§ 76) 4	*Modern Language	(§ 76) 4
Chem. 5	(§ 64) 5	Chem. 5	(§ 64) 5
or Shop 2 and	(§ 79)	or Shop 2 and	(§ 79)
Eng. 1 and 2	(§ 67) 6	Eng. 1 and 2	(§ 67) 6
Math. 1	(§ 72) 4	Math. 2	(§ 72) 4
Drawing 1	(§ 73) 3	Drawing 2	(§ 73) 3
Total hours	17 or 16	Total hours	16 or 17

Second Year

*Modern Language	(§ 76) 4	*Modern Language or	
Math. 3	(§ 72) 5	Electives	(§ 76) 4
Phys. 45	(§ 78) 5	Math. 4	(§ 72) 5
Surveying 1	(§ 86) 3	E. M. 1	(§ 66) 4
		Surveying 2	(§ 86) 4
Total hours	17	Total hours	17

Summer Session

Electives, or required work, or a combination of electives and required work, to a total of 8 hours.

Third Year

Electives	(§ 76) 2	Geology 31	(§ 70) 3
Phys. 46	(§ 78) 5	Ch. E. 1	(§ 83) 3
C. E. 40	(§ 84) 2	E. M. 3	(§ 66) 2
E. M. 2	(§ 66) 3	E. M. 4	(§ 66) 3
M. E. 3	(§ 87) 4	C. E. 2	(§ 84) 3
Drawing 3	(§ 72) 2	C. E. 2a	(§ 84) 3
Total hours	18	Total hours	17

Fourth Year

Elective or		E. E. 2a	(§ 85) 4
Group Option	(§ 84) 2	Engl. 6	(§ 67) 2
C. E. 3	(§ 84) 4	C. E. 26	(§ 84) 2
C. E. 10	(§ 84) 3	Elective or	
C. E. 30	(§ 84) 3	Group Option	(§ 84) 6
C. E. 32	(§ 84) 2		
C. E. 50	(§ 84) 2		
Total hours	16	Total hours	14

*For Modern Language requirement see section 54.

Electives for Civil Engineering Curriculum

Electives from the following list to a total of at least 11 hours are to be chosen by the student, including not less than 3 hours in each of the two Groups 1 and 2.

Group 1

Advanced courses in Modern Language.

Economics: Courses 51, 52, 53, 54, 121, 122, 123, 131, 133, 173, 175, and 181.

English (Engineering College): Courses 3, 5, 14, 23, 24, 26, 27, 28, and 29.

English (Literary College): Courses 31, 32, 40, 45, 143, 147, 148, 180, 183, and 184.

Fine Arts: Courses 101, and 128.

History: Courses 3, 4, 5, 6, 43, 44, 45, 46, 92, 145, and 146.

Philosophy: Courses 31, 38, and 139.

Political Science: Courses 31, 32, 141, 142.

Psychology: Courses 31 and 122.

Speech: Courses 31, 42, and 144.

Group 2

Astronomy: Courses 31, 32, 33, 35, 103, and 104.

Bacteriology: Courses 3E and 5E.

Botany: Courses 1, 32, 33, 35, 36, and 158.

Chemistry: Courses 15, 36, 42, 53, 57, and 67.

Engineering Mechanics: Courses 2a, 5, 6, and 9.

Forestry: Courses 2, 31, 32, 33, 34, 102, 107, and 108.

Geology: Courses 32, 105, 122, 123, 124, 131, 132, 133, and 134.

Hygiene and Public Health: Course 1.

Mathematics: Courses 51, 83, 89, 105, 107, 135, 137, 169, 170, 201, 231, 233, 234, and 253.

Military Science: Basic Group (any Corps). Advanced Group (any Corps).

Mineralogy: Courses 31, 101, 104, and 107.

Physics: Courses 105, 171, 175, and 181.

Surveying: Courses 3, 5, 7, 9, 21, and 22.

Zoology: Courses 1, 31, 32, and 42.

NOTE.—Military Science, after the freshman year, is classified as Group 2.

Group Options

Each student in Civil Engineering must choose one of the following Group Options, and elect 7 hours work from the courses listed in that Option. Two of the courses elected must be a design course and its accompanying theory.

A. STRUCTURAL ENGINEERING.

Civil Eng. 4,	Advanced Theory of Structures.....	2 hours
Civil Eng. 5,	Design of Structures	3 hours
Civil Eng. 7,	Advanced Design of Structures	
	a. Bridge Design	3 hours
	b. Reinforced Concrete	3 hours
	c. Arches	2 hours
	d. Timber Construction	1 hour
Civil Eng. 8,	Construction Methods and Equipment	2 hours
Civil Eng. 9,	Cost Analysis and Estimating.....	2 hours
Civil Eng. 27,	Public Utility Problems	2 hours
Civil Eng. 65,	Structural Engineering Research....	
Mech. Eng. 20,	Mechanical Handling of Materials... ..	2 hours
Chem. Eng. 6,	Iron and Steel	2 hours
Chem. Eng. 8,	Metallography	2 hours

Students electing Group A are required to elect Design Course 5 and Course 4, the accompanying theory course.

B. HYDRAULIC ENGINEERING.

Civil Eng. 11,	Hydraulics	2 hours
Civil Eng. 12,	Development of Water Power	3 hours
Civil Eng. 13,	Administration of Water Resources..	2 hours
Civil Eng. 14,	Irrigation and Drainage	2 hours
Civil Eng. 16,	Design of Hydraulic Structures	3 hours
Civil Eng. 18,	Rivers and Harbors	1 hour
Civil Eng. 27,	Public Utility Problems	2 hours
Civil Eng. 61,	Irrigation and Drainage, Advanced..	2 hours
Civil Eng. 62,	Hydraulic Design, Advanced	2 hours
Civil Eng. 64,	Hydraulic Engineering Research	
Mech. Eng. 4,	Hydraulic Machinery	3 hours
Mech. Eng. 16,	Water Turbines	3 hours
Mech. Eng. 20,	Mechanical Handling of Materials ..	2 hours
Elec. Eng. 3a,	Alternating Current Apparatus	4 hours
Elec. Eng. 11,	Power Plants, Transmission and Distr.	5 hours
Elec. Eng. 33,	Industrial Electrical Engineering	2 hours
Elec. Eng. 36,	Rates and Cost Analysis	2 hours

Students electing Group B are required to elect Design Course 16 and Course 12, the accompanying theory course.

C. TRANSPORTATION ENGINEERING.

Civil Eng. 18,	Rivers and Harbors	1 hour
Civil Eng. 27,	Public Utility Problems	2 hours
Civil Eng. 36,	Municipal Engineering	2 hours
Civil Eng. 41,	Highway Engineering, Theory and Economics	2 hours
Civil Eng. 42a,	Highway Materials Laboratory	2 hours
Civil Eng. 42b,	Bituminous Materials Laboratory ..	2 hours

Civil Eng. 44, Highway Transport	2 hours
Civil Eng. 45, Highway Traffic Control	2 hours
Civil Eng. 46, Highway Administration	2 hours
Civil Eng. 51, Railroad Location	2 hours
Civil Eng. 52, Railroad Maintenance	2 hours
Civil Eng. 52a, Heavy Excavation and Tunnel Work	2 hours
Civil Eng. 53, Terminal Design	3 hours
Civil Eng. 54, Railway and Highway Location Design	3 hours
Civil Eng. 55, Transportation	2 hours
Civil Eng. 55a, Transportation	2 hours
Civil Eng. 58, Inland Waterway Transportation ...	2 hours
Civil Eng. 63, Civil Engineering Research	
Civil Eng. 66, Highway Engineering and Highway Transport Research	
Civil Eng. 67, Railroad Engineering	
Mech. Eng. 29, Automobiles and Motor Trucks ...	3 hours
Elec. Eng. 8, Electric Railways	2 hours
Elec. Eng. 11, Power Plants, Transmission and Distribution	5 hours

Students electing Group C are required to elect a Design Course of this group.

D. SANITARY AND MUNICIPAL ENGINEERING.

Civil Eng. 7a, Concrete and Steel Highway Bridge Design	3 hours
Civil Eng. 11, Hydraulics	2 hours
Civil Eng. 27, Public Utility Problems	2 hours
Civil Eng. 31, Water Purification	2 hours
Civil Eng. 33, Sewage Disposal	2 hours
Civil Eng. 34, Municipal and Industrial Sanitation ..	2 hours
Civil Eng. 35, Sanitary Engineering Design	3 hours
Civil Eng. 36, Municipal Engineering	2 hours
Civil Eng. 41, Highway Engineering Theory and Economics	2 hours
Civil Eng. 42, Highway Engineering Laboratory ..	2 hours
Mech. Eng. 20, Mechanical Handling of Materials..	2 hours
Mech. Eng. 25, Heating and Ventilation	2 hours

Students electing Group D are required to elect Design Course 35 and Courses 31, 33, or 34.

E. GENERAL ENGINEERING SCIENCE.

Physics
Chemistry
Astronomy
Mathematics
Mechanics
Mineralogy
Geology

This group is arranged to permit students of high scholastic standing to take advanced work in any of the above subjects. Courses elected in this group must be in advance of the last required course in the subject chosen. Students electing seven hours work in any one of the subjects will not be required to elect a design course.

Any student electing this group shall indicate the fact not later than the beginning of his junior year and all elections in the chosen science shall be with the approval of the Head of the Science Department, or a committee chosen by him.

Graduate Students in Civil Engineering may specialize in any of the above groups. Such students will ordinarily be required to complete at least eight hours in one of these groups. Additional work sufficient to complete the requirements for the M.S. degree may be selected from cognate subjects, which must be approved by the Dean of the Graduate School.

It is recommended that fourth year students who are expecting to enter the Graduate School take at least six hours of economics before graduation. Graduate students will usually be required to elect from three to six hours of approved work in either the College of Literature, Science, and the Arts or in the School of Business Administration.

COURSES IN CIVIL ENGINEERING

The courses described below are identified by letters and course numbers. Thus, Civil Engineering, Course 2, is identified as C.E. 2. Also C.E. 65, etc., etc.

Structural Group, C.E. 2 to C.E. 9.

Hydraulic Group, C.E. 10 to C.E. 19.

Transportation Group, C.E., 40 to C.E. 58.

Sanitary and Municipal Group, C.E. 30 to C.E. 39.

Graduate Group C.E., 60 to C.E. 67.

1. Engineering Structures. Historical development of structures, materials of construction, and methods; studies of typical modern construction. Lectures, library reading. *Prerequisite:* C.E. 2. One hour credit. Each semester.

2. Theory of Structures. Analysis of stresses in simple structures under various kinds of static and moving loads. Graphical and analytical methods discussed and applied to practice problems. Lectures, text, problems. *Prerequisite:* E.M. 2. *Required of all Civil Engineering students.* Three hours credit. Each semester.

2a. Elementary Design of Structures. Design work, covering theory of beams and plate girders, mill buildings, and elements of design of simple structures. Computations, drawing work. *Prerequisite:* *Drawing 3, and preceded or accompanied by C.E. 2. Required of all Civil Engineering students.* Three hours credit. Each semester.

3. Masonry Construction. Properties of materials; analysis of stresses in plain and reinforced concrete structures; foundations for engineering structures; theory and design of concrete mixtures; laboratory work on cement and aggregates. Text, problems, laboratory. *Prerequisite:* *E.M. 2. Required of all Civil Engineering students.* Four hours credit. Each semester.

4. Advanced Theory of Structures. Analysis of stresses and deflection in special types of structures, cantilever trusses, draw spans, and arches. This is a continuation of C.E. 2. Lectures, text problems. *Prerequisite:* *C.E. 2.* Two hours credit. Each semester.

5. Design of Structures. Design work covering general design of reinforced concrete, steel, and timber structures. Computations, drawing work. *Prerequisites:* *C.E. 2a and C.E. 3.* Three hours credit. Each semester.

7. Advanced Design of Structures. A group of optional specialized courses as listed below for students desiring advanced and specialized instruction in the design of various classes of structures. Students may elect these courses simultaneously. *C.E. 7 group is open to graduate students and to qualified seniors by special permission.* Each semester.

7a. Bridge Design. Studies of waterway determination and bridge live loads; design of bridge foundations and superstructures. Computations, drawing work. *Prerequisites:* *C.E. 4, C.E. 5.* Three hours credit. Second semester.

7b. Reinforced Concrete. Structural features of reinforced concrete building construction; drafting room practice in the general design and detailing of reinforced concrete. Lectures, drawing work. *Prerequisite:* *C.E. 5.* Three hours credit. Each semester.

7c. Arches. Analysis of stresses and design of arches, specially reinforced concrete arches. Lectures, drawing work. *Prerequisite:* *C.E. 5.* Two hours credit. Second semester.

7d. Timber Construction. Physical characteristics of structural woods; selection of timber; grading rules; commercial practice; design of typical structures. Lectures, drawing work. *Prerequisite:* *C.E. 2a.* One hour credit. Each semester.

8. Construction Methods and Equipment. Deals with contractors' organizations, laws of management, plant selection and layout; catalogue studies of various types of equipment, their operating characteristics and care. Lectures, class discussion. *Prerequisite:* Open to seniors and graduate students.. Two hours credit. Each semester.

9. Cost Analysis and Estimating. Elements of cost in construction; determination of unit costs; analysis of cost records; estimates of cost; quantity surveys. Lectures, references, problems. *Prerequisite:* Open to seniors and graduate students. Two hours credit. Each semester.

10. Hydrology. A study of natural streams; measurement of stream discharge; continuous discharge records; factors affecting precipitation; evaporation from land and water surface; relation of precipitation to stream flow; estimating stream flow; storage of water; floods. Lectures, recitations, problems. *Prerequisite:* E.M. 4. Open to seniors and graduate students. Three hours credit. Each semester.

11. Hydraulics. Fundamental considerations; application of experimental data to hydraulic problems; orifices, weirs, pipes and open channels; analysis of empirical formulas; transportation of sediment. Lectures, problems. *Prerequisite:* E.M. 4. Two hours credit. Each semester.

12. Water Power. History of science; hydraulic and hydrological studies; power output of streams; hydraulics of turbines; selection of turbines, power plant layout and equipment; general study of dams; economic considerations; engineering reports on water power developments. Lectures, recitations, problems. *Prerequisite:* E.M. 4. Open only to seniors and graduate students. Three hours credit. Second semester.

13. Administration of Water Resources. Progress made by India, Egypt, Italy, France and Spain; development of common law doctrines relating to waters and their introduction into the United States; a few leading decisions; the abrogation of the common law rule in the Arid Region; an engineering administration, based on principles, contrasted with court government under the common law doctrine; examples of water administrations in western states. Lectures, assigned reading, reports. *Prerequisite:* E.M. 4. Open only to seniors and graduate students. Two hours credit. Second semester.

14. Irrigation and Drainage. History of the development of both sciences; demand for them in the United States; principles underlying the use of water from streams; laws relating to irrigation and drainage; engineering principles; water supply; water

available and required; diversion works; conveyance system; distribution systems; structures; maintenance; economic considerations. Lectures, assigned reading. *Prerequisite: E.M. 4. Open only to seniors and graduate students.* Two hours credit. Second semester.

16. Hydraulic Engineering Design. Description of hydraulic structures; hydraulic and structural computations; design of two or more hydraulic structures; water conveyance structures; dams; power houses; head gates; wasteways; regulating works. Lectures, computations, design. *Prerequisite: C.E. 3, preceded or accompanied by C.E. 12.* Three hours credit. Second semester.

18. Rivers and Harbors. Classification and description of harbors; wave action and littoral drift; design and construction of artificial harbors; entrance to harbors; breakwaters; wharves; quays; dredging; description of various American and foreign harbors; maintenance of river channels. Lectures, assigned reading, reports. *Prerequisite: E.M. 4.* One hour credit. Second semester.

26. Specifications, Contracts, and Engineering Relations. Engineering relations; ethics; the engineer as a witness; contracts; bids and bidders; public lettings; methods of payment for contract and extra work; specifications. Lectures, reading, discussion. *Prerequisite: Open to junior, senior and graduate students in Engineering and in Business Administration. Required of all Civil Engineering students.* Two hours credit. Each semester.

27. Public Utility Problems. Relation of public service corporations to the public; organization; ownership; valuation; depreciation; accounting; regulation; taxation; rates; problems of different utilities. Lectures, library reading. *Prerequisite: Open to fourth and fifth year students.* Two hours credit. Each semester.

30. Water Works. A general study of municipal water supply. Quantity required and quality necessary for various purposes; public health relationships; sources of supply; impounding reservoirs; wells, intakes; aqueducts and pipe lines; purification works; distribution; fire protection. Lectures, problems. *Prerequisite: E.M. 4. Open to seniors and graduates.* Three hours credit. Each semester.

31. Water Purification. Relates to engineering methods and devices for improving the sanitary quality and economic value of municipal water supplies; processes of sedimentation; use of coagulants; filtration; softening; iron removal; sterilization; devices and structures for accomplishing these. Lectures,

library reading, and visits to municipal water purification plants. *Prerequisite*: C.E. 30. *Open to seniors and graduates*. Two hours credit. Second semester.

32. Sewerage and Drainage. Functions and purposes of sewerage and drainage systems; health relationships; principles of design of sanitary, storm water and combined sewers; trunk sewers, intercepting sewers, inverted siphons, and other special structures; groundwater infiltration and its effects; sewer assessments; proper treatment and final disposal of sewage. Lectures, problems. *Prerequisite*: E.M. 4. *Open to seniors and graduates*. Two hours credit. Each semester.

33. Sewage Disposal. A broad survey of the engineering, public health, legal and economic problems involved in the disposal of city sewage and industrial wastes. Sewage treatment processes and devices; adaptation to climatic and other natural conditions; operation and maintenance; costs. Lectures, library reading, and visits to near-by disposal plants. *Prerequisite*: C.E. 32. *Open to seniors and graduates*. Two hours credit. Second semester.

34. Municipal and Industrial Sanitation. The foundations upon which the practice of public sanitation rests; effect upon public health of water purification, sewage treatment, and other sanitary improvements; methods of prevention of typhoid fever, malaria, yellow fever and other diseases, through community control of the environment; industrial sanitation; governmental control of sanitation through federal and state agencies. Lectures, library reading. *Open to seniors and graduates*. Two hours credit. Second semester.

35. Sanitary Engineering Design. Computations and drawing board design of pipe lines, large conduits, typical structures in reinforced concrete related to water supply, water purification, sewerage and sewage disposal. Drawing room and visits to plants and work under construction. *Prerequisite*: C.E. 3, and accompanied or preceded by either C.E. 31, C.E. 33, or C.E. 34. *Required in election of Group D*. Three hours credit. Each semester.

36. Municipal Engineering Administration. The city department of public works; standards and records; design and construction; street cleaning methods and organization; collection, utilization and disposal of garbage and other city wastes; water works management and maintenance. Lectures, library reading. *Open to seniors and graduates*. Two hours credit. Second semester.

40. Highway Engineering. Historical development; economics, administration and legislation; preliminary investigations; design of road and street systems and the individual highway; drainage and foundations; highway materials; construction and maintenance of roads and pavements; street cleaning and snow removal; highway structures. Lectures, text. *Required of all Civil Engineering students. Open to juniors, seniors and graduate students, but not restricted to engineering students.* Two hours credit. Each semester.

41. Highway Engineering Theory and Economics. Theory and economics of design of road and street systems, the individual highway and its component parts, drainage systems, comparison of roads and pavements; highway transport surveys; traffic classification, census and investigations; estimating future traffic. Lectures, text. *Prerequisites or accompanying courses: C.E. 40 and E. M. 1.* Open to juniors, seniors and graduate students. Two hours credit. First semester.

42. Civil Engineering Laboratory. A group of optional laboratory courses, as listed below, for students desiring to study the physical properties of materials used in civil engineering construction.

42a. Highway Materials Laboratory. Physical properties of highway materials; testing of sand, gravel, rock, slag, cement, aggregates, cement-concrete, brick, wood block, stone block, and bituminous materials; proper method of reporting and interpreting results of tests. Lectures, text, laboratory. *Prerequisite or accompanying course: C.E. 40.* Open to juniors, seniors and graduate students. Two hours credit. Each semester.

42b. Bituminous Materials Laboratory. Properties of bituminous materials; testing of oils, asphalts and tars; theory and design of bituminous paving mixtures; interpretation of results of tests; specifications. Lectures, text, laboratory. *Prerequisite: C.E. 40.* Open to juniors, seniors and graduate students. Two hours credit. Each semester.

42c. Concrete Mixtures. Theory and design of concrete mixtures; analysis of aggregate grading; bulking due to moisture; strength, permeability, durability, yield, and economy. Discussions, problems, laboratory. Open to seniors. This class meets with the laboratory section of C.E. 3. The course is offered to permit election of the work by seniors outside the Civil Engineering Department. One hour credit. Each semester.

44. Highway Transport. History of highway transport development; economics and fundamentals of different methods of transportation of passengers and commodities over highways;

utilization of highway transport by railroads; legislation pertaining to operation of motor trucks, trailers, and motor busses as private and common carriers; traffic regulations; management of transportation companies; cost of operation of motor vehicles. *Open to seniors and graduate students, but not restricted to engineering students.* Two hours credit. Second semester.

45. Highway Traffic Control. Street traffic surveys; causes of congestion; causes of accidents; physical changes to increase street capacity; regulation of moving traffic; regulation of parking; regulation of pedestrians; traffic signs and signals; municipal traffic codes; traffic bureaus; treatment of offenders. Lectures, text, field work, library reading. *Open to seniors and graduate students, but not restricted to engineering students.* Two hours credit. Second semester.

46. Highway Administration. Development of highway administration and highway systems, local, county, state and national; methods of financing roads and streets; functions and organization of highway departments. Lectures, text, library reading. *Open to seniors and graduate students, but not restricted to engineering students.* Two hours credit. First semester.

50. Railroad Engineering. A general study of the railroad problem. Includes a consideration of surveys, alignment, earthwork, trestles, structures, tunnels, ballast, ties, rails, rolling stock, train resistance, block signals, train control, yards and terminals, operating expenses and organization. Lectures, text, problems. *Required of all Civil Engineering students. Open to juniors and seniors, but not restricted to engineering students.* Two hours credit. Each semester.

51. Railroad Location. Economics of reconnaissance, preliminary and location surveys, analysis of curve, grade and train resistance. Ruling grades; maximum curvature; rise and fall; and virtual profile. Study of line changes, grade reductions and elimination of grade crossings. Lectures, text, problems. *Open to junior, senior and graduate students.* Two hours credit. Both semesters.

52. Railroad Maintenance. Maintenance of roadway, track, track appliances, switches and frogs, bridges, structures, culverts and drainage, signals and interlocking plants. Lectures, text, problems. *Open to junior, senior and graduate students.* Two hours credit. First semester.

52a. Heavy Excavation and Tunnel Work. Study of the methods and machinery applicable to all types of heavy excavation. Location, design and construction of all types of tunnels. Lectures, text, problems. *Open to junior, senior and graduate students.* Two hours credit. Second semester.

53. Terminal Design. Design of freight and passenger railroad, highway and waterway terminals, joint terminals, layout of the various types of yards and traffic facilities. Occasional field inspections take the place of design periods. Text, problems, drawing room. *Open to junior, senior and graduate students.* Three hours credit. Second semester.

54. Railway and Highway Location Design. Field and office practice of location and construction. Text, field work and drawing room. *Open to junior, senior and graduate students.* Three hours credit. First semester.

55. Transportation. History of transportation; relation of highway, waterway, railway and airway transportation. Lectures, library research, seminar. *Open to junior, senior and graduate students but not restricted to engineering students.* Two hours credit. First semester.

55a. Transportation. The relation of transportation to the political and economical development of the nation. Lectures, library research, seminar. *Open to junior, senior and graduate students but not restricted to engineering students.* Two hours credit. Second semester.

58. Inland Waterway Transportation. Engineering and economic problems involved in the development of American inland waterway transportation. Lectures, library reading, recitations. *Open to junior, senior and graduate students, but not restricted to engineering students.* Two hours credit. First semester.

60. Sanitary Engineering Research. Assigned work upon some definite problem related to public sanitation; a wide range in both subject matter and method is available, covering field investigations, experimentation in the laboratory, searches in the library and among public records, and drafting room designing. By appointment. *Prerequisite: Open to graduate students only.* Credit to be arranged.

61. Irrigation and Drainage. Special advanced assigned work. Reading, research. *Prerequisite: C.E. 14. Open only to graduate students.* Two hours credit.

62. Hydraulic Engineering Design. Special advanced problem. Computations, design. Two hours credit. Each semester.

63. Civil Engineering Research. Assigned work in the fields of transportation, public utilities or engineering relations and ethics. Exact nature of work to be determined by needs of individual students. To obtain credit a thesis must be prepared which will be acceptable for publication. *Open only to graduate students.* Credit to be arranged. Each semester.

64. **Hydraulic Engineering Research.** Assigned work in hydraulic research; investigation of some problem or subject in hydraulics approved by the Professor of Hydraulic Engineering; a wide range of matter and method permissible. Reading, experiments, thesis. *Prerequisite: C.E. 12. Open only to graduate students.* Credit to be arranged. Each semester.

65. **Structural Engineering Research.** Assigned work on some approved problem in Structural Engineering, preferably experimental work with discussion of derived data. Laboratory, library research. *Prerequisite: Open to graduate students and fifth year students who have elected Group Option A in Structural Engineering.* Credit to be arranged.

66. **Highway Engineering and Highway Transport Research.** Assigned work in the fields of highway engineering, highway transport or highway traffic control. Exact nature of work to be determined by needs of individual students. To obtain credit a thesis must be prepared which would be acceptable for publication. *Open only to graduate students.* Credit to be arranged. Each semester.

67. **Railroad Engineering Research.** Assigned work in the field of railroad engineering or highway traffic control. Exact nature of work to be determined by needs of individual students. To obtain credit a thesis must be prepared which would be acceptable for publication. *Open only to graduate students.* Credit to be arranged. Each semester.

Summer Session

Courses 2, 3, 7c, 9 and 65 will be given during the Summer Session of 1928.

85. ELECTRICAL ENGINEERING

Professors BAILEY, HIGBIE, LOVELL, CANNON; Assistant Professors MOORE, ATTWOOD; Mr. STOUT, Mr. BULL, Mr. GAULT, Mr. HOLLAND, Mr. DOW.

Electrical engineers practice in a field of great breadth; any true subdivision of it is very difficult. The four main divisions of practice, and work offered by the Department in relation thereto, are as follows:

Electrical Power Engineering has to do with the theoretical and practical phases of power generation, distribution and utilization, together with the design and construction of the apparatus involved; among other specific applications it relates to electric railways, lighting, power plants, transmission, distribution, gen-

erators, motors, and the service of the public. The almost phenomenal growth of the electric public utilities and the corresponding use of electricity indicate the opportunities existing in this branch.

In Courses 11, 19, and 20, fundamental economic principles are applied to the selection and location of standard apparatus; the financial phases of design are stressed; analytic engineering judgment is cultivated through the study of the operative functions of generating and transmitting devices. Course 8 covers the main problems of electric traction; Course 33, industrial electrical engineering; and Course 36, rate and cost analysis.

Electrical Communication covers several very large fields of application of electricity to the service of man. The transmission of signals, speech, music, and the more recent transmission of pictures, involve the practice of telephony, telegraphy, electric signalling, and radio. The radio business is doubling every year, it being already one of the country's largest industries.

Courses 10, 13 and 22 in communication apply the principles developed in previous courses to new apparatus and circuits. The work prepares the student for opportunities in the communication industry, or strengthens him for work in other fields, by virtue of his broadened perspective.

Illumination Engineering is now an electrical activity because of the fact that nearly all light sources are electrical. The illumination engineer deals with the many and varied special problems arising in relation to the production and utilization of light, economically and in accordance with correct principles of physics, physiology, psychology, art and architecture.

The purpose of the work available to the undergraduate is to indicate the scope, present and prospective importance, and attractiveness of illumination as a field of professional activity, and to establish firmly by thorough drill the principles upon which progress must be founded. Courses 7 and 7a are primarily for undergraduates; Courses 15 and 71 are for graduates and competent undergraduates. Much advanced work in illumination is pursued in Courses 9 and 18.

Electrical Engineering Design.—Inasmuch as every article ever produced must first be designed, design practice intrudes upon most phases of electrical engineering. Design involves the use of fundamental theory as modified by practical considerations of cost and the properties of materials. The successful designer is generally found to be a man with pronounced and special aptitudes; such men have a wide choice of opportunities.

Courses 5, 6, and 51 are not intended to turn out finished designers. Their purpose is to clarify the student's knowledge of apparatus by means of extended calculations on machines;

and by imposing some of the limitations encountered in practical work, to insure that the student will think as an engineer rather than as a physicist.

The Courses offered by the Department are therefore designed to give every electrical student some training in each of the above classes of work; and in his selection of technical electives he may, if desired, take more advanced work in any of the groups of studies mentioned. In addition to this specific group of subjects, other courses are offered, some preparatory, some advanced.

Course 1 serves as an introduction to the engineering viewpoint of electricity and magnetism.

Courses 2, 3, and 4 form a close-knit preparatory group devoted to the principles of the more usual circuits and machines.

Course 17, of a mathematical nature, develops electromechanics.

Courses 9 and 18 are open to more able students by permission, and give opportunity for study of any worthwhile problems not excluded by the limitations of physical equipment.

The Staff of the Department of Electrical Engineering, by constant study and revision of course content and teaching method, aims to offer such work as will react to the ultimate benefit of the student rather than to his immediate gain. Throughout, the teaching of theory and its modifications by practice, the development of analytic judgment, and the acquirement of a fundamental scientific background, are emphasized. The acquisition of specific factual knowledge is left, except where necessary to sound pedagogy, to the training in actual experience through which every electrical graduate must go during his first years out of school.

Close contact is maintained with the employing industries both to enable the instructional staff to keep in touch with a fast-growing art, and to facilitate the finding of employment for the graduates.

In co-operation with the School of Business Administration a five-year course leading to the degree of B.S. in Engineering (Electrical and Industrial Engineering) is offered.

A five-year co-operative course in electrical engineering and industry is offered in co-operation with certain leading electrical industries. The student spends, in all, four semesters or eighteen months in the chosen industry and six semesters and three summer school periods, a total of thirty-three months, in the University. The work in industry will be closely supervised and proper credit will be allowed.

Graduate work is urged for every student who would benefit by taking more advanced work. The graduate courses offered are being built up from year to year. The mathematical and

physical nature of advanced electricity makes it profitable for some gifted students to spend much time in mathematics and physics; for the better students every encouragement is offered.

The individual initiative of exceptional seniors is encouraged by seminar, research, and special problem courses offered for the purpose.

Facilities

The Electrical Engineering Laboratories include a dynamo laboratory, communication laboratories, and a photometric laboratory.

The Dynamo Laboratory is fully equipped with direct and alternating current apparatus of various types and sizes, representative of the leading American and foreign manufacturers.

In all of the electrical laboratory work, special emphasis is laid upon the development of the student's ability to analyze the phenomena which he observes in the operation of electrical machinery. To this end, and with the aim of developing the personal initiative of the student, a large number of moderate sized machines have been provided in order to give each student intimate contact with the apparatus.

The laboratory is fully equipped with meters and instruments of various ranges, types, and makes. For calibration work there are standard resistances, standard cells, potentiometers, and meters of the precision type. The equipment includes a research oscillograph with all accessories and a portable oscillograph for projecting oscillograms in classrooms for group discussions.

Distribution of power in the laboratories is controlled through a plug and socket system. The system gives great flexibility and requires that all connections be made by the student himself, but provides the means by which these operations may be quickly and easily performed.

The laboratory has on exhibit electrical apparatus of very early type which is of historic interest.

The Communication Laboratories are unusually well equipped for both practical and theoretical experimental study of communication by electrical means.

Oscillators covering both the audio and radio frequency ranges, vacuum tube voltmeters and ammeters, and impedance bridges are provided for accurate measurements. Standards of inductance, capacity and resistance are available.

For telephone work an artificial open wire line, a loaded cable, and standard cable may be used for the study of the propagation of medium frequency voltages and currents. A supply of

telephone instruments, sensitive meters, transformers, telegraph instruments including repeaters, and models of manual and automatic exchanges are provided for study.

The radio laboratory is well equipped with vacuum tubes for both receiving and transmitting purposes, high voltage generators for power supply, standard wavemeters and capacities, thermo ammeters and the usual types of auxiliary apparatus. A cathode ray oscillograph is provided for study of high frequency currents.

The Photometric Laboratory is equipped with four precision bars provided with the most accurate photometer heads of equality, contrast, and flicker types, and complete accessories for standardization and investigation; eight portable photometers for making surveys of illumination; a single-mirror selector for making measurements on large light sources; a 30-inch integrating sphere for small light sources together with a Macbeth illuminometer; a part-sphere for measuring the reflection coefficient of surfaces in place, and a most convenient form of spectrophotometer. The equipment includes, besides standard lamps, a complete and modern collection of lamps and accessories including mercury, magnetite, and carbon arcs, refractors, reflectors of all varieties in glass and metal, and head-light and flood-light projectors. Special equipment has been developed for study of surface sources of light, by means of which noteworthy investigations have been made.

The University has a medium sized steam power plant of its own which is available for instructional purposes; also the University is well situated with regard to both hydraulic and steam power plants of the Detroit Edison Company. Technical inspections of these plants are made in conjunction with the classroom work in appropriate courses.

Visits of Inspection.—See section 45.

Combined Courses have been arranged with Albion and Olivet Colleges and the College of the City of Detroit. For detailed information see sections 56-68.

Advice to Students of other colleges and universities with regard to planning their courses before coming to the University, is to be found in section 12.

Military Science.—The attention of prospective students in Electrical Engineering is called to the Reserve Officers' Training Corps. Students in Electrical Engineering are particularly well qualified to take the work offered in the Signal Corps group. Those who consider taking Military Science are urged to enroll at the beginning of their course. For further details see section 74.

CURRICULUM IN ELECTRICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering, Electrical Engineering, are required to complete the curriculum detailed below. For the definition of an hour of credit see section 52.

a. Preparatory Courses.	
English 1 and 2, and choice of English 5, 6, or 14....	6 hours
Modern Language and Cultural Electives.....	16 hours
Mathematics 1, 2, 3, 4.....	18 hours
Physics 45, 46.....	10 hours
Chemistry 5.....	5 hours
Drawing 1, 2, 3.....	8 hours
Shop 2.....	2 hours
	65 hours
b. Secondary and Technical Courses.	
Physics 147, Electrical Measurements.....	4 hours
Surveying 4, Use of Instruments.....	2 hours
Eng. Mech. 1, Statics.....	4 hours
Eng. Mech. 2, Strength and Elasticity.....	3 hours
Eng. Mech. 3, Dynamics.....	2 hours
Eng. Mech. 4, Hydromechanics.....	3 hours
Civil Eng. 2, Theory of Structures.....	3 hours
Mech. Eng. 2a, Elements of Machine Design.....	3 hours
Mech. Eng. 3, Heat Engines.....	4 hours
Elec. Eng. 1, Prin. of Electricity and Magnetism....	4 hours
Elec. Eng. 2, D.C. App. and Cir.....	4 hours
Elec. Eng. 3, A.C. Circuits.....	4 hours
Elec. Eng. 4, A.C. Apparatus.....	4 hours
Elec. Eng. 5, Design of Electrical Machinery.....	4 hours
Elec. Eng. 7, Illumination and Photometry.....	2 hours
Elec. Eng. 11, Power Plants, Transmission and Distribution	5 hours
Elec. Eng. 17, Electro-mechanics.....	4 hours
Chem. Eng. 1.....	3 hours
	62 hours
Summary :	
Preparatory Courses	65 hours
Secondary and Technical Courses	62 hours
Elective	13 hours
	140 hours

First Year

FIRST SEMESTER

*Modern Language	(§ 76)	4
Chem. 5	(§ 64)	5
or Shop 2	(§ 79)	
and Eng. 1 and 2	(§ 67)	6
Math. 1	(§ 72)	4
Drawing 1	(§ 73)	3
Total hours		16 or 17

SECOND SEMESTER

*Modern Language	(§ 76)	4
Chem. 5	(§ 64)	5
or Shop 2	(§ 79)	
and Eng. 1 and 2	(§ 67)	6
Math. 2	(§ 72)	4
Drawing 2	(§ 73)	3
Total hours		16 or 17

Second Year

*Modern Language	(§ 76)	4
Math. 3	(§ 72)	5
Phys. 45	(§ 78)	5
Drawing 3	(§ 73)	2
Surveying 4	(§ 86)	2
Total hours		18

*Modern Language	(§ 76)	4
Math. 4	(§ 72)	5
Phys. 46	(§ 78)	5
E. M. 1	(§ 66)	4
Total hours		18

Summer Session

Mech. Eng. 3	(§ 87)	4
E. E. 2	(§ 85)	4
Total hours		8

Third Year

E. M. 2	(§ 66)	3
E. M. 4	(§ 66)	3
E. E. 3	(§ 85)	4
E. E. 1	(§ 85)	4
Ch. Eng. 1	(§ 83)	3
Total hours		17

E. M. 3	(§ 66)	2
E. E. 4	(§ 85)	4
M. E. 2A	(§ 87)	3
English 5, 6, or 14	(§ 67)	2
E. E. 7	(§ 85)	2
Electives		4
Total hours		17

Fourth Year

C. E. 2	(§ 84)	3
Phys. 147	(§ 78)	4
E. E. 5	(§ 85)	4
E. E. 11	(§ 85)	5
Total hours		16

E. E. 17	(§ 85)	4
Electives		9
Total hours		13

*For Modern Language requirement see section 54.

FIVE-YEAR COURSE IN ELECTRICAL AND INDUSTRIAL ENGINEERING

The five-year course given in co-operation with the School of Business Administration leading to the degree of Bachelor of Science in Electrical and Industrial Engineering is planned as follows:

	HOURS
English	6
Modern Language or Cultural Electives	16
Mathematics	18
Physics	14
Chemistry	5
Drawing	8
Shop Work	2
Engineering Mechanics	12
Mechanical Engineering	7
Chemical Engineering	3
Electrical Engineering	34
Economics and Business Administration	36
Civil Engineering	3
Surveying	2
Electives	10

Total required for degree of Bachelor of Science in Electrical and Industrial Engineering176

The schedule of work is as follows:

First Year

FIRST SEMESTER		SECOND SEMESTER	
	Hours		Hours
*Modern Language	4	*Modern Language	4
Gen. Chem. (Chem. 5) or	5	Engl. 1 and 2 and Shop 2	6
Shop 2 and Engl. 1 and 2	6	or Chem. 5	5
Math. 1	4	Math. 2	4
Drawing 1	3	Drawing 2	3
	—		—
	16 or 17		16 or 17

Second Year

	Hours		Hours
Math. 3	5	Math. 4	5
Phys. 45	5	Phys. 46	5
Draw. 3	2	E. M. 1	4
Ec. 53 (Gen'l Ec.)	3	Ec. 54 (Gen'l Ec.)	3
Surv. 4	2		
	—		—
	17		17

*For Modern Language requirement see section 54.

Summer Session

M. E. 3		4
E. E. 2		4
		8

Third Year

	Hours		Hours
E. M. 2	3	C. E. 2	3
E. M. 3	2	Ch. E. 1	3
E. E. 1	4	E. M. 4	3
E. E. 3	4	E. E. 4	4
Ec. 171 (Acct'g.)	3	Ec. 172 (Acct'g.)	3
	16		16

Fourth Year

	Hours		Hours
Physics 147	4	M. E. 2a	3
E. E. 11	5	E. E. 17	4
Engl. 5, 6, or 14	2	Bus. 101 (Bus. Org. and Exec. Cont.)	3
Bus. 131 (Prod. Mgt.)	3	Bus. 114 (Cost Acct'g.)	3
Ec. 175 (Statistics)	3	E. E. 7	2
		Elective	2
	17		17

FIVE-YEAR COURSE IN ELECTRICAL ENGINEERING AND INDUSTRY

The time required is five years, divided tentatively as follows:

Year	First Semester	Second Semester	Summer Session
1	University	University	Free
2	University	Industry	University
3	University	Industry	University
4	University	Industry	University
5	University	Industry	

The periods spent in industry, during the second to fifth years inclusive, may be taken in the first, instead of the second, semester.

Credit for the course will be as follows:

Required university work	127 hours
Elective university work	4 hours
Credit for completing the industrial work	9 hours

Total 140 hours

No credit will be given for industrial work except as arranged under the co-operative plan.

It is contemplated that the student will spend all four outside periods with one industrial concern. This, if mutually agreeable, may lead to permanent employment. During his employment the student will work in various departments of the industry and will receive pay.

The co-operative plan will be arranged with those companies only which can provide a program of value to the student.

Fifth Year

	Hours		Hours
E. E. 33	2	E. E. 5	4
Bus. 161 (Finan. Princ.)	3	E. E. 36	1
Bus. 205 (Law)	3	Bus. 206 (Law)	3
Bus. 217 (P. U. Acct'g)	3	Elective	9
Elective	7		
	<hr/>		<hr/>
	18		17

CHOICE OF ELECTIVE WORK

The Department of Electrical Engineering has no list of group options. The case of each individual student is considered and he is expected to make his elections only after consultation with the senior classifiers.

The aim of the Department is to develop well-rounded engineers rather than narrow technicians.

Without the ability to write and speak good English an engineer rarely progresses to the higher positions in the profession. Students feeling the lack of sufficient facility in the use of English are strongly urged to elect advanced courses in English.

Economic considerations enter into every phase of engineering work. Every student is therefore urged to take at least one course in economics.

In the senior year the student should in general have some idea of the branch of electrical engineering which he intends to pursue. It is expected that he will take at least one advanced course in the line of work in which he intends to specialize.

With the object of rounding out his education the student is urged to elect some courses in liberal arts and pure science. Unless he is a liberally educated man in addition to being an engineer he cannot expect to reach the positions of highest importance.

The strong student who can profit by the instruction is urgently advised to consider the desirability of at least one year of graduate work leading to the Master's degree. In such a year he

will have opportunity to take advanced work along the lines in which he expects to specialize. Such work is usually impracticable in the undergraduate years due to lack of time and adequate preparation.

COURSES IN ELECTRICAL ENGINEERING

1. Principles of Electricity and Magnetism. Mathematical and physical treatment of force actions and energy relations in electrostatic and electromagnetic fields; capacitance and inductance of systems of conductors; development of systems of electric and magnetic units; illustrations of the universality of the laws of physics, as they occur in the fields of electricity, magnetism, gravitation, heat, light, etc. Lectures, computing periods. *Prerequisites:* *Math. 4 and Physics 46.* Four hours credit. Each semester.

2. Direct Current Apparatus and Circuits. Torque, current, flux, e.m.f. and speed relations in self-regulation and control of motors and generators; electric and magnetic circuit calculations; power losses and efficiency of machines; commutation and armature reaction; parallel operation of generators; mechanical and electrical coupling of motors. Lectures and laboratory. *Prerequisites:* *Physics 45 and 46, Eng. Mechanics 1.* Four hours credit. Each semester.

2a. Direct and Alternating Current Apparatus and Circuits. Characteristics of direct and alternating current motors and generators; problem work on these and on electric circuits. A general course for non-electrical students. Lectures and laboratory. *Prerequisites:* *Open only to non-electricals, required of all of them.* Four hours credit. Each semester.

3. Alternating Current Circuits. Wave form of e.m.f.; work on simple harmonic e.m.f.'s and currents; phase differences; active, reactive and apparent power, power factor and reactive factor; resistance, inductance, and capacitance, singly and in any combination; polyphase circuits, balanced and unbalanced; power in polyphase systems; e.m.f.'s of armature windings—vector representation and calculation; transformers—construction, theory, operation; transformers—simple and complete vector diagrams, losses and constants, efficiency and regulation; instrument transformers; voltage regulators; constant current transformers. Lectures and laboratory. *Prerequisites:* *E. E. 2, and preceded or accompanied by E. E. 1.* Four hours credit. Each semester.

4. Alternating Current Machinery. Principles of the synchronous machine, the induction machine, the rotary converter, and the various types of single-phase motors. Lectures and laboratory. *Prerequisite:* *E. E. 3.* Four hours credit. Each semester.

5. Design of Electrical Machinery and Appliances. Design problems on direct current coils, windings, motors; work in heat storage, heat transfer, and heat dissipation by radiation and convection; extensive treatment of magnetic field mapping and calculation, armature reaction, air gap design, and commutation. Lectures and computing periods. *Prerequisites:* M. E. 2a, E. E. 1, E. E. 3. Four hours credit. Each semester.

6. Advanced Theory of the Induction Motor. Continuation of Course 4; advanced theory and design of the induction motor, both polyphase and single-phase. Lectures, computations. *Prerequisites:* E.E. 4, E.E. 5. Two hours credit. Second semester.

7. Illumination and Photometry. Concepts, quantities, units and relations employed in this science, such as the lumen, candle-power, foot-candle, lambert; theory and use of typical measuring devices—precision photometer and accessories, portable photometers, integrating spheres, reflectometers, calculation of illumination from point, line and surface sources of light exhibiting typical distributions of light; light output of any source having symmetrical distribution; calculations regarding light in an enclosure; utilization factor, and flux-of-light method for designing illumination of an interior; laws of vision in correct illumination; characteristics of lamps, reflectors, enclosing globes; glare and shadow; industrial and residence lighting. Lectures and laboratory. *Prerequisite:* E. E. 1. Two hours credit. Each semester.

7a. Building Illumination. Illustrations of causes of and means to avoid glare, improper shadows, poor distribution, unsteady light and other faults; means for providing proper illumination for typical interiors such as schools, offices, residences; designed to acquaint students of public health, factory administration, and architecture with criteria for determining whether the lighting is good or harmful to the eyes. Lectures, quiz. *Not open to electrical engineering students.* One hour credit. Second semester.

8. Principles of Electric Traction. Traffic studies, train schedules, speed-time and power curves, locomotive train haulage, signal systems, cars and locomotives, control systems, traction systems, electrification of trunk lines. Lectures. Two hours credit. First semester.

9. Directed Research Problems. Special problems are selected for laboratory or library investigation with the intent of developing initiative and resourcefulness. To a large degree the student's own desires will control the subjects investigated. The work differs from that offered in Course 18 in that the instructor is in close touch with the work of the student. Course 9 may be elected by seniors who have suitable preparation. Course 18

is for graduates. *Prerequisite*: E. E. 3. Credit by arrangement. Each semester.

10. Advanced Theory of Electrical Circuits. Mathematical analysis of theoretical and practical problems; electrical filters; transmission of electric waves on lines having distributed capacitance, inductance, resistance, and leakage; mechanism of reflection at terminals; electromagnetic waves in space; Maxwell's equations. The course material is fundamental to further work in telephone, telegraph and radio circuits. Lectures. *Prerequisites*: E. E. 3, and preceded or accompanied by E. E. 17. Three hours credit. Each semester.

11. Power Plants and Transmission Systems—Economics of Design. Elementary principles of corporate finance, study of economic decay and tests for obsolescence; power plant load curves as a basis for design; economic load division between units and plants, economic conductor section and distribution systems; study of plant location; selection of oil circuit breakers; economic use of power limiting reactors, relays, synchronous condensers for power factor control and phase modification; constant voltage transmission lines. Lectures, problems. *Prerequisite*: E. E. 3, or E. E. 2a. Five hours credit. Each semester.

13. Principles of Electrical Communication. Principles and applications of wire telegraph and telephone systems. Production and reception of speech and signal currents and their propagation over open wire and cable lines. Use of repeaters in telegraph and telephone work. Laboratory work includes transmission measurements on open wire lines, loaded and unloaded cables. Lectures, recitations and laboratory. *Prerequisite*: Preceded or accompanied by E. E. 17. Four hours credit. Second semester.

15. Advanced Lighting. Selection of a topic, with instructor's approval, for continuing and intensive study, which is pursued either until all sources of information in English are exhausted, or the time of the course is ended; short oral reports by each student to the class each week; written report and bibliography presented to instructor at end of course. Seminar. *Prerequisites*: E. E. 7, and preceded or accompanied by E. E. 3. Two hours credit. Second semester.

17. Electromechanics. Analysis of complex alternating current waves; average and effective values; meaning of power factor; the method of the complex variable in a-c problems; the application of differential equations to solutions of simple transients and oscillatory circuits; use of hyperbolic functions in solving the general equation of a circuit containing distributed inductance, capacitance, resistance and leakage. Lectures and problems. *Prerequisite*: E. E. 3. Four hours credit. Each semester.

18. Research Work in Electrical Engineering. Students electing the course, while working under the general supervision of a member of the Staff, are expected to plan and carry out the work themselves, and to make a report in the form of a thesis. Research. *Prerequisite: Elected by permission of Head of Department.* Credit by arrangement. Each semester.

19. Study of Design—Power Plants. Studies of modern typical generating and sub-stations; inspection of steam and hydraulic plants; outline of complete plant design, with detailed design of the bus system, switchboard, relay and exciter plant, etc. Lectures, problems. *Prerequisite: E. E. 11.* Two hours credit. Second semester.

20. Study of Design—Electric Transmission and Distribution Systems. Electrical features of efficiency, regulation, control of voltage and power factor, inductive interference, corona and surges; mechanical problems of the design of supporting structures, sags and spans, stiff and flexible towers, etc. Conferences, problems. *Prerequisites: E. E. 11 and E. E. 17.* Two hours credit. Second semester.

22. Radio Engineering. Applications of resonant, coupled and oscillatory circuits to radio problems. Transmitting and receiving circuits with especial attention to the use of vacuum tubes. Principles of electromagnetic radiation. Audio and radio frequency amplification. Carrier wave telephony. Lectures, recitations and laboratory. *Prerequisites: Physics 164, E. E. 17.* Four hours credit. Second semester.

25. Electrical Engineering Seminar. Advanced problems in electric and magnetic fields, based on the work done in E. E. 1. Method of images; dielectric flux and refraction as concerns insulator problems; high voltage phenomena; dielectric hysteresis; losses in iron with sinusoidal variation of flux; distortion of wave shape due to saturation; eddy current losses in conductors, skin effect; inductance of lines, both cable and open. Conferences, discussions, problems, reports. *Prerequisite: Elected by permission of the instructor.* Credit by arrangement. Each semester.

26. Heaviside Operators. Advanced theory of electrical engineering, as developed by the application of Heaviside operators to electric circuits. Lectures and discussions. *Prerequisite: Elected by permission of the instructor.* Two hours credit. Each semester.

33. Industrial Electrical Engineering. Individual and group drive by electric motors; selection of motors; power requirements of various kinds of machinery; electric hoists; electric welding; electric furnaces and temperature regulation; electric

braking; and other industrial problems. Lectures. *Prerequisite: Preceded or accompanied by E. E. 4.* Two hours credit: First semester.

36. Rates and Cost Analysis. Capitalization; fair return on investment; analysis of costs and value of electrical energy; customer charge, demand charges, energy charges; investigations of practical systems used in charging for electrical energy. Lectures. *Prerequisites: E. E. 11; open to seniors only.* One hour credit. Second semester.

51. Advanced Problems in Electrical Machine Design. Study of magnetic circuits of rotating machinery; commutation of the d-c machine and the synchronous converter; losses, heating, heat transfer and heat dissipation in machines; study and design of the watt-hour meter. General conduct of course: reading of assigned papers, working of problems, and discussion with the instructor. *Prerequisites: E. E. 5; elected by permission of instructor.* Two to four hours, by arrangement. Each semester.

71. Interior Illumination, Study of Design. Advanced work in illumination design for graduate students, or for specially qualified and interested seniors. Lecture and laboratory. *Prerequisite: Elected by permission of the instructor.* Two hours credit. First semester.

Summer Session

Courses 1, 2, 2as, 3, 18 will be offered for the Summer Session of 1928. Courses 5, 7, 11, 17 may be given if there is sufficient demand. Those wishing to elect any of these should, if possible, communicate with the instructor in charge of the particular course some time before the opening of the Summer School.

Meter School

The Electrical Engineering Department, with the co-operation of the public utilities of the state and of the manufacturers, holds a one-week school for electric metermen during the Spring Recess. Information will be furnished upon application to the Department. This work carries no University credit.

86. GEODESY AND SURVEYING

Professors JOHNSTON, CAREY, BRODIE; Assistant Professors BOUCHARD, MITCHELL, MCFARLAN, YOUNG; Mr. BLEEKMAN, Mr. MALDONADO.

Geodesy and Surveying, broadly speaking, are the sciences which have to do with the making, recording and reduction of observations and measurements for determining the relative positions of points on or near the earth's surface. Geodetic theory is

applied when the work is influenced by the size and shape of the earth. The practice of plane surveying is confined to small areas.

Geodesy is employed in locating the natural and artificial features of large areas of the earth's surface both on land and at sea. Field data are obtained by a combination of astronomical and terrestrial measurements. These involve precise triangulation systems, level circuits and topographic studies. The physical and mathematical sciences are relied upon, both in the making of observations and in the interpretation of data. Some of the data thus obtained are recorded in condensed form as maps, which are of great practical value in connection with military and commercial operations. While the main lines of geodetic work are in progress, much information from related fields of science is obtained. Geodetic measurements were made to determine the shape and size of the earth as early as 276 B. C. The science, as we know it today, owes much to Newton, Laplace, Legendre, Gauss and other investigators of the past few centuries. The field is now sufficiently definite and stable to offer attractive opportunities to well-trained men.

Topographic Surveying.—Extensive topographic work is performed by the United States Coast and Geodetic Survey, the United States Geological Survey, and the Corps of Engineers of the Army. Modern city plans are preceded by topographic studies which often include large areas lying beyond the existing municipal limits. Geodetic principles are often applied here.

Boundary Surveying.—The location of boundaries, the placing of monuments, and the filing of permanent records, including notes, computations, maps, etc., is probably the most universal branch of surveying. Every property owner and every political division of the nation has a direct interest in the location of property lines. With the increase in population and in land values, this phase of surveying is becoming more important. The solution of many problems in this field requires a knowledge of geodesy and land law.

Legal and Administrative.—Many problems with which the surveyor is confronted make it necessary that he concern himself with the legal and administrative principles relating to boundary surveying, the registration of land titles, land laws and riparian boundaries.

The Courses offered by the Department aim to give the student of Geodesy and Surveying a fundamental training that will enable him to enter any branch outlined above. In order that the Department may keep in touch with practice and aid graduates in securing employment, it maintains contact with organizations which specialize in surveying work.

The Diploma Department of Geodesy and Surveying was created by the Board of Regents, at the request of the Faculty of the College of Engineering, to provide such training in pure and applied science as may be necessary to interest students in geodetic work, higher surveying, astronomy, and mathematics. The Department is convinced that only by the mastery of fundamentals may students develop that proficiency which ultimately stimulates love of work. This new Department, representing one of the oldest fields of science, accepts this basic idea as its guiding rule. The aim is to help the individual acquire a foundation upon which he can continue to build in the future, rather than to develop an immediately marketable efficiency. Students of Geodesy and Surveying are therefore urged to choose their elections in such a manner as to broaden and strengthen their foundations in science, pure and applied. They are also encouraged to become interested in the humanistic sciences and philosophy. Even those of the highest scientific attainment are obliged to deal with others, and they should always appreciate their responsibilities to society. The aid of the Department is always available to those students who are in doubt as to electives which would be most helpful to them.

Equipment for Surveying.—The equipment for surveying includes transits, levels, rods, tapes, etc., in sufficient number to supply 200 students. Special equipment is provided for triangulation work. A launch and sounding apparatus is provided for the work in the summer camp. Current meters, barometers, hand levels, sextants, cameras for surveying and engineering photography, plane-tables for topographic work, and numerous other small engineering and surveying instruments are provided.

Camp Davis.—In 1908 the Regents of the University came into possession of about 1,600 acres of land, lying between Burt and Douglas Lakes, Cheboygan County, Michigan. Nearly half of this area came as a gift from Colonel Charles Bogardus and his wife, Hannah W. Bogardus. In recognition of their kindly interest, the entire area now owned by the University in this locality,—increased by purchase since 1908 to 3,300 acres,—is called the Bogardus Tract.

The camp of the Department of Geodesy and Surveying is called "Camp Davis," in memory of the late Professor Joseph Baker Davis, C.E., of the Class of 1868, who established it in 1874 and conducted it for over thirty years. Until 1909 the camp moved from place to place as Professor Davis found land he could use. Permanent improvements were impossible during its early migratory years.

Camp Davis is situated on the south shore of South Fishtail Bay, Douglas Lake, 6 miles east of Pellston on the Pennsylvania Railway, 13 miles west and slightly south of Cheboygan and 8

miles northwest of Topinabee. Douglas Lake is about $4\frac{1}{2}$ miles long, east and west, and from a mile to two miles wide, north and south. Burt Lake lies $1\frac{3}{4}$ miles south of, 118 feet below the level of Douglas Lake.

The camp consists chiefly of 50 residence buildings of galvanized sheet steel, 14 feet square, with concrete floors, arranged in a double row running parallel with the lake shore. The street, 70 feet wide between the buildings, has been improved by the application of gravel in 1916 and 1918. Concrete sidewalks, 4 feet wide, have been laid through the entire length of the camp. In addition to the residence buildings, the camp boasts of the following improvements: a concrete building used for storing supplies, erected in 1912; a harbor excavated in 1912 and remodeled with harbor building in 1921; a kitchen; dining rooms; complete sanitary system with septic tank, built in 1915; a combined ice house and refrigerator, a cube of 17 feet, erected in 1922; a water system with concrete reservoir built in 1912; an instrument room, 14 x 28 feet, erected in 1917; 2 steel office buildings erected in 1921 and 1922; a dark room 14 x 14, completed in 1923; a club house, 30 x 50 feet, for the use of students, erected in 1923. A keeper's house, and a work shop were constructed in 1924. A new well was completed and the water supply rearranged the same year.

While the camp has had since 1914 an independent power plant to operate pumps and a small generator, this is not used at the present time except when power is interrupted from the high tension line of the Cheboygan Electric Light and Power Company, connected with the camp circuit in 1921.

For transportation facilities the camp has a tractor and lumber wagon, a small truck and a light-touring car. A shelter for automobiles was built in June, 1922. A camp garage was erected during the summer of 1926.

The Bogardus Tract has a varied topography. It is an excellent laboratory for the study of problems in surveying. While most of the valuable timber was removed prior to 1908, a second growth has since sprung up. The tract has been, under University management, well protected from fire.

A small store has been maintained at the camp for some years. This includes a telephone booth, a post office, a local bank, and headquarters for the mess accountant.

Students have laid out an athletic field and horseshoe links. They maintain a diving tower and other facilities for bathing and swimming.

A physician from the University Health Service is in attendance each year.

The camp is generally reached by way of Cheboygan, which is also the address for mail (Camp Davis, Route No. 1), freight and express.

The approximate cost per student is as follows:

Summer Session Fee	\$31.00
Camp Fee	10.00
Traveling expenses (Ann Arbor to camp and return)	25.00
Board (deposited at the beginning of camp)	60.00*
Miscellaneous	5.00
	\$131.00

Combined Courses have been arranged with Albion and Olivet Colleges and the College of the City of Detroit. For detailed information see sections 56-58.

Advice to Students of other colleges and universities with regard to planning their courses before coming to the University, is to be found in section 12.

Military Science.—The attention of prospective students in Geodesy and Surveying is called to the Reserve Officers' Training Corps. Students in Geodesy and Surveying are particularly well qualified to take the work offered in the Coast Artillery group. Those who consider taking Military Science are urged to enroll at the beginning of their course. For further details see section 74.

CURRICULUM IN GEODESY AND SURVEYING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering, Geodesy and Surveying, are required to complete the curriculum detailed below. For the definition of an hour of credit see section 52.

a. Preparatory Courses.

English 1 and 2, and 5, 6, or 14 (§ 67)	6 hours
Language and Cultural Electives, (§ 76)	16 hours
Mathematics 1, 2, 3, 4, (§ 72)	18 hours
Physics 45, 46, (§ 78)	10 hours
Chemistry 5, (§ 64)	5 hours
Drawing 1, 2, 3, (§ 73)	8 hours
Shop 2, Metal Working, (§ 79)	2 hours
Total	68 hours

b. Secondary and Technical Courses.

Engineering Mechanics 1, 2, 3, 4, (§ 66)	12 hours
Chemical Engineering 1, (§ 83)	3 hours
Astronomy 31, 35 (§ 61)	5 hours

*This is the deposit. A rebate running from \$8 to \$18 is returned at the close of the session.

Geology 3I, (§ 70)	3 hours
Electrical Engineering 2a, (§ 85)	4 hours
Mechanical Engineering 3, (§ 88)	4 hours
Civil Engineering 2, 2a, 10, (§ 84)	8 hours
Forestry 34, (§ 69)	2 hours
Surveying 1, 2, 3, 5, 2I, (§ 86)	19 hours
Geodesy 1, (§ 86)	3 hours
Total	63 hours

Summary:

Preparatory Courses	68 hours
Secondary and Technical Courses	63 hours
Electives	12 hours
Total	140 hours

First Year

FIRST SEMESTER		SECOND SEMESTER	
*Modern Language (§ 76)	4	*Modern Language (§ 76)	4
Chem. 5 (§ 64)	5	Gen. Chem. 5 (§ 64)	5
or Shop 2 (§ 79)		or Shop 2 (§ 79)	
and Eng. 1 and 2 (§ 67)	6	and Eng. 1 and 2 (§ 67)	6
Math. 1 (§ 72)	4	Math. 2 (§ 72)	4
Drawing 1 (§ 73)	3	Drawing 2 (§ 73)	3
Total hours	17 or 16	Total hours	16 or 17

Second Year

*Modern Language (§ 76)	4	*Modern Language (§ 76)	4
Math. 3 (§ 72)	5	Math. 4 (§ 72)	5
Physics 45 (§ 78)	5	Physics 46 (§ 78)	5
Drawing 3 (§ 73)	2	E. M. 1 (§ 66)	4
Total hours	16	Total hours	18

Third Year

Surveying 5 (§ 86)	2	Astronomy 35 (§ 61)	2
Surveying 1 (§ 86)	3	Surveying 2 (§ 86)	4
E. M. 2 (§ 66)	3	E. M. 4 (§ 66)	2
Geology 3I (§ 70)	3	C. E. 2 (§ 84)	3
Astronomy 3I (§ 61)	3	Chem. Eng. 1 (§ 83)	3
E. M. 3 (§ 66)	3	Electives	3
Total hours	17	Total hours	17

*For Modern Language requirement see section 54.

Summer Session

Surveying 3 (§ 86) 8

Fourth Year

FIRST SEMESTER		SECOND SEMESTER	
Forestry 34	(§ 69) 2	Geodesy I	(§ 86) 3
Surveying 21	(§ 86) 2	M. E. 3	(§ 87) 4
C. E. 2a	(§ 84) 2	Electives	9
C. E. 10	(§ 84) 3		
Public Speaking	2		
E. E. 2a	(§ 85) 4		
	15		16
Total hours	15	Total hours	16

COURSES IN GEODESY AND SURVEYING

Surveying

1. **Surveying.** Fundamental theory and practice; note keeping; verniers; linear measurements; angle reading; traverse surveying; computing areas; straight line; circular curves; differential levelling; continuous levelling; profile; grade stakes; vertical curve. Lectures, text assignments, quizzes, field practice. Required for students of Geodesy and Surveying, Civil Engineering and Landscape Design. *Prerequisite: Mathematics 2.* Three hours credit. Each semester.

2. **Surveying.** Topographic field work; stadia; plane table; mapping from transit and plane table notes; theory of cross-sectioning and earthwork calculation; triangulation; adjustment, design, and care of instruments. Lectures, text assignments, quizzes, field practice, drawing. Required for students of Geodesy and Surveying, Civil Engineering and Landscape Design. *Prerequisite: Surveying 1.* Four hours credit. Each semester.

3. **Surveying.** See Summer Session courses.

4. **Surveying.** Elementary theory and practice; use of instruments; reading verniers and angles; running straight lines; traverse survey; computing areas; levelling; profile; grade stakes; note keeping. Lectures, text assignments, quizzes, field practice. Required of all engineering students except Geodesy and Surveying, Civil and Chemical Engineering. *Prerequisite: Mathematics 2.* Two hours credit. Each semester and Summer Session.

5. **Least Squares.** Theory of least squares; adjustment and comparison of data; computation of triangulation systems;

determination of empirical formulae. Lectures, text, problems, quizzes. *Prerequisite: Mathematics 4.* Two hours credit. Each semester.

7. Municipal Surveying. Surveys for street location, fixing grades, paving, sewers, property lines; subdivision planning and laying out; state laws relating to municipal surveys. Lectures, text, field, drawing. *Prerequisite: Surveying 3.* Two hours credit. Each semester.

9. Railway Surveying. Text, quizzes, field, track problems. *Prerequisite: Surveying 3.* Two hours credit. Second semester.

12. Surveying. Similar to Surveying 1 with drawing work added. Designed for Forestry students. Drawing, lectures, text, quizzes, field. *Prerequisite: Mathematics 2.* Four hours credit. First semester.

13. Surveying. Similar to Surveying 2. Designed for Forestry students. Lectures, text, quizzes, drawing, field. *Prerequisite: Surveying 12.* Four hours credit. Second semester.

21. Photography and Camera Surveying. History of photography; testing camera and lenses; exposure of plates; development of negatives; printing, enlarging, and reducing; lantern slides; color work; mapping and field sketching. Lectures, reference work, field, laboratory. *Prerequisites: Surveying 3, Physics 36 and an elementary course in chemistry.* Two hours credit. Each semester.

22. Advanced Topographic Surveying. History of the development of topographic methods and practice of foreign countries; status of such surveys in this country; purpose of topographic surveys; use of topographic maps. Lectures, reference work, quizzes, problems. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Four hours credit. First semester.

23. Map Projections and Sketching. Map projections with special reference to the polyconic system; exercises in topographic mapping and sketching. Lectures, reference work, quizzes, problems. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Three hours credit. First semester.

31. History of Administrative Departments. History and organization of national and state departments which conduct extensive surveys. Lectures, reference work. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Two hours credit. First semester.

32. **Land Law.** Legislation relating to registration of land titles and estates; acquiring of title to property; essential elements of deeds; application. Lectures, reference work. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Three hours credit. First semester.

33. **Land Law.** Law of boundaries; adverse possession; prescription and prescriptive rights; easements and rights of way. Lectures, reference work. *Prerequisite: Surveying 32. Open to fourth and fifth year students only.* Three hours credit. Second semester.

34. **Registration of Land Titles.** Legislation relating to the registration of land titles; Torrens Act of Australia and modifications as adapted to conditions of other countries. Lectures, reference work. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Three hours credit. Second semester.

35. **Boundary Surveys.** Boundary surveys from a legal standpoint; boundary surveys in this country and abroad; problems relating to the establishment of boundaries uncertain, due to obliteration of monuments, errors in surveys, inaccurate descriptions in deeds or to other causes. Lectures, reference work. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Three hours credit. Second semester.

36. **Riparian Boundaries.** Uncertainty of riparian boundaries as now defined by court decision under the Common Law; method of definite determination of riparian boundaries. Lectures, reference work. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Three hours credit. Second semester.

Geodesy

1. **Geodesy.** Introductory course; history; elements of modern practice and its application to several branches of surveying. Lectures, text, quizzes. *Prerequisite: Surveying 3. Open to fourth and fifth year students only.* Three hours credit. Second semester.

2. **Geodesy.** Methods employed and field covered by the United States Coast and Geodetic Survey. Lectures, reference work. *Prerequisite: Geodesy 1. Open to fourth and fifth year students only.* Two hours credit. Second semester.

Summer Session

3. **Surveying.** Plane table, stadia, railroad, highway, hydrographic and land surveys; triangulation; azimuth; cross-sectioning; computation of field data; making of maps and diagrams; preparation of permanent records of work performed; camp con-

struction and maintenance and many things which relate to the welfare of those who live in the open. Field problems, office work. *Prerequisites: Surveying 1 and 2, or 12 and 13. Astronomy 35.* See page 191 (relating to fees). Eight hours credit. Summer camp.

4s. Surveying. Use of instruments, same as Surveying 4; given at Ann Arbor. Lectures, text, quizzes, field. *Prerequisite: Mathematics 2.* Two hours credit. Summer session.

87. MECHANICAL ENGINEERING

Professors COOLEY, ANDERSON, BURSLEY, EMSWILER, FESSENDEN, WILSON, HAWLEY, LAY, SHERZER; Assistant Professors MICKLE, NICKELSEN, KEELER, WATSON, GORDY, HOLLIS, GOOD, KESSLER, MARIN, CALHOON.

Mechanical Engineering is that branch of engineering which broadly speaking covers the fields of heat, power, design of machinery, industrial management, and manufacturing problems. Mechanical Engineering may be divided into the following branches:

Steam Power Engineering deals with the theory, design, construction, and operation of the various forms of prime movers using steam as the motive power, and their applications in the modern power house. The problems of combustion of fuels, the application of power and steam in industrial plants, determination of power costs, and similar subjects, may be included under this heading. This branch is so closely allied with Electric Power Engineering that a knowledge of both is essential to the practicing engineer in this field.

Internal Combustion Engineering covers the design, construction and operation of the various types of engines using gas, oil, or gasoline, to generate the motive power; the different types of gas producers and the application of this form of engine to the generation of power for many purposes. Because of the present day use of the automobile, the increased cost of coal, and the development of the oil industry, the field has become very important in recent years.

Hydro-Mechanical Engineering deals with the theory, design, construction, installation, testing, and operation of water wheels, water turbines, centrifugal and reciprocating pumps. This is one of the oldest branches of Mechanical Engineering and one of the most important.

Heating, Ventilating and Refrigerating Engineering are included under one general heading because of the similarity in the

type of problem involved. Broadly speaking, this group includes the theory, design, installation and operation of heating, ventilating and refrigerating plants. Among the specific applications would be the heating and ventilating requirements of buildings for various uses. Problems relating to compressed air are also considered in this group.

Automobile Engineering.—The University of Michigan has a strategic location at the center of the automobile industry in this country, and particular attention has been directed toward the development of courses in this branch of engineering. Work in this field covers the general principles of operation, theory and design of the automobile engine and other chassis units, laboratory and road tests of the various component parts of the automobile or of the complete automobile itself.

Industrial Engineering deals largely with industrial plant operation and management, efficiency methods, production, and the business side of manufacturing. This branch of engineering, while old in principle, has not been generally recognized until recent years, but now commands an important place in the engineering field.

Machine Design.—While design is included in practically all branches of Mechanical Engineering, and is therefore a necessary adjunct to those branches, there is also the general field for the man who wishes to follow machine design either as technical designer or as manufacturer of general machinery. The very general application of automatic machinery to manufacturing methods has established a definite need for good designers.

The Department of Mechanical Engineering of this University endeavors to give the student a thorough training in the fundamental principles of the basic Mechanical Engineering subjects. Most of the time of the first two years, and a part of the third year, is spent in a study of the foundation courses such as Mathematics, English, Physics, Chemistry, Drawing, and Mechanics. In the third and fourth years, required courses in Heat Engines, Machine Design, Mechanical Laboratory, Thermodynamics, Hydraulics and Power Plants supplement the foundation courses. The Department recognizes the fact that no student can properly expect to specialize in any branch of Engineering in four years of college work. The fourth year, however, allows some opportunity, if desired, for selection of special courses in some one of the Mechanical Engineering branches. Graduate work is encouraged, and a number of advanced courses are offered for those who plan to spend more than four years, or for graduate students from this and from other universities. It has been the policy of this Department to keep in close touch with the actual needs of the graduate

student, and as far as possible to give him the training that will fit him for the immediate future. Most of our graduates are absorbed immediately by the industries and a friendly relation of mutual benefit is always maintained with these industries. Many students come to us with advanced credit, and these are urged to elect courses in other departments of the Engineering College, and also in the College of Literature, Science, and the Arts. Graduate Mechanical Engineers very rapidly rise to positions of responsibility in the industries, and a broad general course as well as a technical course is of great value to them in their advancement.

Facilities for Instruction

It is recognized by this Department that the principal benefits to be derived from a college training are dependent more upon the character of the instruction than upon physical equipment. The importance of certain apparatus for purposes of illustration, demonstration and testing is however apparent in some lines of work, and the Department aims to include a sufficient amount of laboratory instruction to properly supplement the work of the class room.

The Mechanical Engineering Laboratory is located in the West Engineering Building and has a floor space of approximately 13,000 square feet. It is devoted to experimental work in connection with the testing of engines, boilers, pumps, fans, air compressors, hydraulic machinery, and automobile engines. The very complete and modern Washington Street plant (for description see page 63) of the University is available for use, and a test of this plant constitutes a regular part of the second course in Mechanical Laboratory. Occasionally tests are made of outside plants in the vicinity of Ann Arbor.

The laboratory, as a whole, comprises all the equipment utilized for illustration of the theory involved in Mechanical Engineering and for experimental work of both standard and research nature. Separate laboratory instruction is given along the lines of hydraulic machinery and automobiles, and those parts of the equipment applying especially to these divisions are segregated as far as possible to form the Hydro-Mechanical Laboratory and the Automobile Laboratory. The general laboratory is well equipped with power machines of all kinds, which furnish the means of instruction in the principles of testing.

The Hydro-Mechanical Laboratory is equipped with a pair of 600-cubic-foot tanks on scales, a large Duplex pump, a Francis turbine, a Doble tangential water wheel, two Rees Roturbo pumps, two three-inch single-stage centrifugal pumps, one 50-h.p. Sprague electric dynamometer arranged for direct connection to centrifugal pumps, and all necessary accessories for testing.

The **Automobile Laboratory** consists of an engine testing section, a dynamometer room, and a section for the display and demonstration of automobiles, motor trucks, and their component parts. The engine testing section contains a complete equipment of engines, selected with a view to affording the student experience with various typical successful types. This section is equipped with prony brakes, water dynamometers, and one fan dynamometer. The dynamometer room contains a complete Diehl electric dynamometer and a 100-h.p. Sprague electric dynamometer, together with special fuel measuring devices, tachometers, air meters, pyrometers, gas analysis apparatus, manograph, and complete accessories necessary for instructional testing and advance research work. In the display and demonstration section are gathered together complete operating and cut-out chassis, various types of engines, cut-out transmissions, rear axles, differentials, clutches, carburetors, ignition systems, and other automobile parts and equipment. This apparatus is especially mounted to show its operation and design, and is used as demonstration study and test equipment for the regular automobile courses. It further serves as a permanent educational exhibit open to the public.

Combined Courses have been arranged with Albion and Olivet Colleges and the College of the City of Detroit. For detailed information see sections 56-58.

Advice to Students of other colleges and universities with regard to planning their courses before coming to the University, is to be found in section 12.

Military Science and Tactics.—Students who plan to take courses in Military Science are urged to enroll in the beginning of the freshman year, and in doing so should consult with the officer in charge of this department, and also with the head of the department in which he proposes to take his degree. For information regarding the work of Military Science and Tactics see section 74.

CURRICULUM IN MECHANICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering, Mechanical Engineering, are required to complete the four-year curriculum detailed on page 201.

Candidates for the degree of Bachelor of Science in Engineering, Mechanical and Industrial Engineering, are required to complete the five-year curriculum detailed on page 203.

For the definition of an hour of credit see section 52.

I. *Outline of Required Courses, Four-year Curriculum.*

a. Preparatory Courses.

English 1 and 2, and choice of English 5, 6, or 14	6 hours
Modern Languages or Cultural Electives.....	16 hours
Mathematics 1, 2, 3, 4.....	18 hours
Physics 45, 46	10 hours
Chemistry 5	5 hours
Drawing and Descriptive Geometry 1, 2, 3	8 hours
Shop 2, Metal Working and Treating	2 hours
Shop 3, Foundry	4 hours
Shop 4, Machine Shop	4 hours
Total	73 hours

b. Secondary and Technical Courses.

Surveying 4, Use of Instruments	2 hours
Eng. Mech. 1, Statics	4 hours
Eng. Mech. 2, Strength and Elasticity	3 hours
Eng. Mech. 3, Dynamics	2 hours
Eng. Mech. 4, Hydromechanics	3 hours
Mech. Eng. 2, Elements of Machine Design	3 hours
Mech. Eng. 3, Heat Engines	4 hours
Mech. Eng. 4, Hydraulic Machinery	3 hours
Mech. Eng. 5, Thermodynamics	3 hours
Mech. Eng. 6, Machine Design	4 hours
Mech. Eng. 7, Mechanical Laboratory, First Course	2 hours
Mech. Eng. 8, Mechanical Lab., Second Course ..	3 hours
Mech. Eng. 9, Power Plants	3 hours
Mech. Eng. 10, Theory of Machine Movements ..	2 hours
Civil Eng. 2, Theory of Structures	3 hours
Elec. Eng. 2a, D.C. App. and Cir.	4 hours
Chem. Eng. 1, Engineering Materials	3 hours
Chem. Eng. 10, Tech. Exam. of Gas and Fuel	1 hour
Total	52 hours

Summary :

Preparatory Courses	73 hours
Secondary and Technical Courses	52 hours
Electives	15 hours
Total	140 hours

2. *Selection of Elective Courses.*

The 15 hours of elective work is to be filled partly by "Restricted Electives" and partly by "Free Electives."

a. Restricted Electives.

The student must elect one 3-hour design course from the following list: M.E., 9a, 11a, 12a, 15a, 16a, 17a, 20a, 25a, 30a, 31a. Course 15a must be preceded or accompanied by 15. Courses 30a and 31a must be preceded by the corresponding classroom course and by M.E. 29.

Students electing design courses other than M.E. 15a, 30a, or 31a, must also offer credit for graduation in some additional mechanical engineering course from the following list:

M.E. 11, 12, 13, 15, 16, 17, 19, 20, 25, 30, 31, 35.

b. Free Electives.

The remaining elective hours may be filled by courses offered by any department in the Engineering College or by any College or School in the University to which the student is eligible, subject to the approval of the Head of the Mechanical Engineering Department.

In the selection of his elective hours the student is urged to broaden his training by making elections in other departments of work, and in so doing should consult freely with the members of the Mechanical Engineering staff.

PROGRAM IN MECHANICAL ENGINEERING

First Year

FIRST SEMESTER		SECOND SEMESTER	
*Modern Language	(§ 76) 4	*Modern Language	(§ 76) 4
Chemistry 5	(§ 64) 5	Engl. 1 and 2	(§ 67)
or Shop 2	(§ 79)	and Shop 2	(§ 79) 6
and Engl. 1 and 2	(§ 67) 6	or Chemistry 5	(§ 64) 5
Mathematics 1	(§ 72) 4	Mathematics 2	(§ 72) 4
Drawing 1	(§ 73) 3	Drawing 2	(§ 73) 3
	—		—
Total hours	16 or 17	Total hours	16 or 17

*For Modern Language requirements see section 54.

Second Year

FIRST SEMESTER		SECOND SEMESTER	
*Language	(§ 76) 4	*Language	(§ 76) 4
Mathematics 3	(§ 72) 5	Mathematics 4	(§ 72) 5
Physics 45	(§ 78) 5	Physics 46	(§ 78) 5
Chem. Eng. I	(§ 83) 3	Eng. Mech. I	(§ 66) 4
Drawing 3	(§ 73) 2		
	19		18
Total hours		Total hours	

Summer Session

Elec. Eng. 2a	(§ 85) 4
Shop 3	(§ 79) 4
	8
Total hours	

Third Year

Eng. Mech. 2	(§ 66) 3	Shop 4	(§ 79) 4
Eng. Mech. 3	(§ 66) 2	Eng. Mech. 4	(§ 66) 3
Mech. Eng. 2	(§ 87) 3	Mech. Eng. 5	(§ 87) 3
Mech. Eng. 3	(§ 87) 4	(a) Mech. Eng. 6,	(§ 87) 4
(a) Mech. Eng. 7	(§ 87)	or	
and		(b) Mech. Eng. 4, 8	(§ 87) 6
Chem. Eng. 10	(§ 83) 3	(a) Mech. Eng. 7	(§ 87)
(b) Mech. Eng. 10	(§ 87) 2	and	
		Chem. Eng. 10	(§ 83) 3
		(b) Mech. Eng. 10	(§ 87) 2
	17		18 or 19
Total hours		Total hours	

Fourth Year

(a) Mech. Eng. 4, 8	(§ 87) 6	Mech. Eng. 9	(§ 87) 3
or		Mech. Eng. 9a, 11a, 12a,	
(b) Mech. Eng. 6	(§ 87) 4	15a, 16a, 17a, 20a, 21a,	
Surv. 4	(§ 86) 2	25a, 30a, or 31a	(§ 87) 3
Mech. Eng. 11, 12, 13, 15,		Other Electives	8 or 7
16, 17, 19, 20, 25, 30, 31,			
32 or 35	(§ 87) 2 or 3		
Engl. 5, 6, or 14	(§ 67) 2		
Civil Eng. 2	(§ 84) 3		
Other Electives	2		
	16, 17, or 18		13 or 14
Total hours		Total hours	

*For Modern Language requirement see section 54.

FIVE-YEAR CURRICULUM IN MECHANICAL AND INDUSTRIAL ENGINEERING

The five-year course in co-operation with the School of Business Administration leading to the degree of Bachelor of Science in Engineering, Mechanical and Industrial Engineering, is planned as follows:

<i>Subjects</i>	<i>Hours</i>
English	6
Physics	10
Modern Languages (or Cultural Electives)	16
Mathematics	18
Chemistry	5
Drawing and Descriptive Geometry	8
Shop Work	10
Engineering Mechanics	12
Mechanical Engineering	24
Chemical Engineering	4
Electrical Engineering	4
Civil Engineering	3
Economics and Business Administration	36
Shop Management and Shop Transportation	8
Electives	12
	176

Total hours
The schedule of work is as follows:

First Year

FIRST SEMESTER		SECOND SEMESTER	
*Modern Language	(§ 76) 4	*Modern Language	(§ 76) 4
Chemistry	(§ 64) 5	English 1, 2	(§ 67)
or English 1, 2	(§ 67)	and Shop 2	(§ 79) 6
and Shop 2	(§ 79) 6	or Chem. 5	(§ 64) 5
Mathematics 1	(§ 72) 4	Mathematics 2	(§ 72) 4
Drawing 1	(§ 73) 3	Drawing 2	(§ 73) 3
	16 or 17		16 or 17

Second Year

*Modern Language	(§ 76) 4	*Modern Language	(§ 76) 4
Mathematics 3	(§ 72) 5	Mathematics 4	(§ 72) 5
Chem. Eng. 1	(§ 83) 3	Physics 45	(§ 78) 5
Drawing 3	(§ 73) 2	Economics 54	(§ 65) 3
Economics 53	(§ 65) 3		
	17		17

*For Modern Language requirement see section 54.

Summer Session

Shop 3	(§ 79)	4
Shop 4	(§ 79)	4
Total hours		8

Third Year

FIRST SEMESTER			SECOND SEMESTER		
Eng. Mech. 1	(§ 66)	4	Eng. Mech. 2	(§ 66)	3
Physics 46	(§ 78)	5	Mech. Eng. 3	(§ 87)	4
Economics 121	(§ 65)	3	Economics 177	(§ 65)	3
Economics 171	(§ 65)	3	†Economics 172	(§ 65)	3
Elective		3	Elective		3
Total hours		18	Total hours		16

Fourth Year

Eng. Mech. 3	(§ 66)	2	Mech. Eng. 6	(§ 87)	4
Mech. Eng. 2	(§ 87)	3	Mech. Eng. 5	(§ 87)	3
Mech. Eng. 7	(§ 87)	2	Mech. Eng. 8	(§ 87)	3
Chem. Eng. 10	(§ 83)	1	Bus. Admin. 114	(§ 63)	3
Bus. Admin. 101	(§ 63)	3	Bus. Admin. 102	(§ 63)	3
or			Elective		2
Mech. Eng. 35	(§ 87)	3			
Eng. Mech. 4	(§ 66)	3			
Elective		4			
Total hours		18	Total hours		18

Fifth Year

Mech. Eng. 10	(§ 87)	2	Mech. Eng. 42	(§ 87)	3
Mech. Eng. 9	(§ 87)	3	English	(§ 67)	2
Elec. Eng. 2a	(§ 85)	4	Bus. Admin. 202	(§ 63)	3
Bus. Admin. 161	(§ 63)	3	Bus. Admin. 162	(§ 63)	3
Mech. Eng. 36	(§ 87)	3	Mech. Eng. 43	(§ 87)	3
Civil Eng. 2	(§ 84)	3			
Total hours		18	Total hours		14

†Students classified in this group should consult the Head of the Mechanical Engineering Department before electing Economics 172.

COURSES IN MECHANICAL ENGINEERING

2. Elements of Machine Design. Practical application of theory to elementary machine design including riveted joints, keys and cotters, screw fastenings, power screws, shafts, permanent couplings, journals and bearings, and spur gearing. Recitations, problems, drawing. *Prerequisites: Drawing 3, and preceded or accompanied by E.M. 2.* Three hours credit. Each semester.

2a. Elements of Machine Design. Same as Course 2; includes in addition, belts, ropes, chains, brakes and clutches. Recitations, problems, drawing. *Prerequisites: Drawing 3 and E.M. 2. Not open to Mechanical Engineering students.* Three hours credit. Each semester.

3. Heat Engines. General principles involved in the action of the various forms of heat engines, including the steam engine and boiler, the steam turbine, and the internal combustion engine with special attention given to the different types in use; the general problem of a modern power plant is considered for the benefit of those who do not devote further time to the subject. Required of all engineering students. Lectures, recitations. *Prerequisites: Physics 45 and 46, Math. 3.* Four hours credit. Each semester.

4. Hydraulic Machinery. General considerations of theory, construction, and operation of principal types of hydraulic machinery. Lectures, problems and written recitations. *Prerequisite: Preceded or accompanied by E.M. 4.* Three hours credit. Each semester.

5. Thermodynamics. Principles governing action of steam, hot air, gas and compressed air engines, steam turbines, air compressors, and refrigerating apparatus. Lectures, recitations. *Prerequisite: M.E. 3.* Three hours credit. Each semester.

6. Theory of Machine Design. Continuation of Course 2; more advanced in character; analysis of loads and forces; design of parts, considering wear, dynamic and static forces including critical speeds, application of the theory of elasticity. Lectures, recitations, problems, drawing. *Prerequisites: M.E. 2 and preceded or accompanied by M.E. 10.* Four hours credit. Each semester.

7. Mechanical Laboratory. First Course. Elementary tests of a steam engine, steam turbine, gas or oil engine, power pump, and steam boiler; use and calibration of instruments used in mechanical engineering work exemplified in connection with these tests and in the calculation of the results. Laboratory, computa-

tions, reports. *Prerequisites: E.M. 1, preceded or accompanied by M.E. 3, and accompanied by Ch.E. 10.* Two hours credit. Each semester.

8. Mechanical Laboratory. Second Course. Experimental study of a steam turbo-generator, oil engine, fan, steam injector, air compressor, refrigerating machine, steam power plant, and several forms of hydraulic machinery. Laboratory, computations, reports. *Prerequisites: M.E. 7 and preceded or accompanied by M.E. 5.* Three hours credit. Each semester.

9. Power Plants. Design, operation, and economics of power plants. Lectures, recitations and problems. *Prerequisites: M.E. 3, and preceded or accompanied by E.M. 4.* Open only to seniors and graduates. Three hours credit. Each semester.

9a. Design of Power Plants. Students given usual data furnished the engineer; selects the proper machinery to meet the needs of a power house; makes the general design of the power house, including setting and piping plans for all the principal machines to be installed. Computations and drawing. *Prerequisites: M.E. 9 and E.M. 4.* Three hours credit. Second semester.

10. Theory of Machine Movements. Gear trains, linkages, cams, intermittent motions, instantaneous centers, periodic centers, and acceleration. Lectures, recitations, drawing. *Prerequisite: E.M. 3 and M.E. 2.* Two hours credit. Each semester.

11. Steam Boilers. Commercial types of boilers, stokers and superheaters; principles of boiler economy and operation; combustion of fuels; theory of heat transference; purchase of coal by specifications; storage of coal; feed water treatment; problems of design. Lectures, recitations, problems. *Prerequisite: M.E. 3.* Three hours credit. First semester.

11a. Design of Steam Boilers. Complete design of boilers of different types, including calculations and drawing of important details. Drawing, problems. *Prerequisite: M.E. 6.* Three hours credit. Second semester.

12. Steam Reciprocating Engines. A study of the general theory and thermodynamics of the steam engine; the various commercial types, and problems on design. Lectures, recitations, problems. *Prerequisite: M.E. 5.* Two hours credit. Second semester.

12a. Design of Reciprocating Steam Engines. Complete design of a steam engine; including the calculation and drawing of important details. Drawing, problems. *Prerequisite: M.E. 6.* Three hours credit. Second semester.

13. **Steam Turbines.** Advanced study of the flow of fluids, kinetic effects, thermodynamics; steam turbine used as concrete example; field of application; influence of vacuum, pressure, superheat, preheating, stage heating of feed water and condensing operation. Lectures, recitations, problems. *Prerequisite:* M.E. 5. Three hours credit. Each semester.

15. **Internal Combustion Engines.** Underlying theory; thermodynamics; fuels and combustion; different commercial types; carburetion; ignition; injection; cooling; regulating devices; testing; computations for principal dimensions; details of construction. Lectures, recitations, problems. *Prerequisites:* M.E. 5 and preceded or accompanied by M.E. 6. Three hours credit. Each semester.

15a. **Design of Internal Combustion Engines.** Complete layout of standard types of internal combustion engines, calculation and design of important details. Drawing, problems. *Prerequisites:* M.E. 6 and preceded or accompanied by M.E. 15. Three hours credit. Second semester.

16. **Water Turbines.** Hydrodynamic theory of the operation of the various types; computation of important dimensions; considerable portion devoted to analysis of test data and selection of turbines for various operating conditions. Lectures, recitations, problems. *Prerequisite:* preceded or accompanied by M.E. 4. Three hours credit. First semester.

16a. **Design of Water Turbines.** General problem of turbine design. Calculations and drawings made for runners, guide vanes, draft tubes, etc., with special attention given to the layout of runners. *Prerequisite:* M.E. 6. Three hours credit. Second semester.

17. **Pumping Machinery.** Advanced course covering the theory and operation of reciprocating and centrifugal pumps; application of pumps to definite pumping problems; economic considerations; graphical methods. Lectures, recitations, problems. *Prerequisite:* M.E. 4. Three hours credit. Second semester.

17a. **Design of Pumping Machinery.** Complete design including calculations and drawings made for a centrifugal or reciprocating pump, with special attention to runners, casings and valves. *Prerequisites:* M.E. 4 and M.E. 6. Preferably accompanied by M.E. 17. Three hours credit. Second semester.

18. **Heating and Ventilation.** Elementary theory; design and construction of hot air, direct and indirect steam, hot water and fan heating systems. Lectures, recitations. *For Architects only.* Two hours credit. First semester.

19. Refrigeration and Compressed Air. Application of theories of thermodynamics to refrigeration and compressed air; study of constructive details of refrigerating plants and compressed air systems; operation. Lectures, recitations, problems. *Prerequisite: M.E. 5.* Three hours credit. Second semester.

20. Mechanical Handling of Materials. Features of design and installation; application to various classes of plants, processes and materials; subjects considered; cranes and derricks, hand and electric travelers, inclined and vertical hoisting, haulage systems, aerial and surface cableways, conveyors of all classes. Lectures, recitations, problems, reports, and inspection of systems in use. *Prerequisites: M.E. 2 and E.M. 2.* Two hours credit. Each semester.

20a. Design of Hoisting and Conveying Machinery. Calculations and layout work on hoists, cranes and conveyors. Drawing, reports. *Prerequisite: M.E. 6.* Three hours credit. Each semester.

21a. Design of Machine Tools. Complete layout of modern machine tool; magnitude and direction of forces acting on cutting tools calculated, and all parts of machine proportioned to resist these forces. Investigations of special metal-working processes and machinery may be undertaken. Drawing, problems. *Prerequisite: M.E. 6.* Three hours credit. Second semester.

22. Research in the Mechanical Laboratory. Opportunity for advanced experimental study along any line of work in which student may be specializing; consists of investigations for securing data on more difficult problems of mechanical engineering; students left largely to own resources in planning and carrying out work. Laboratory. *Prerequisite: M.E. 8.* Two or three hours credit. Each semester.

23. Hydraulic Machinery. Opportunity for advanced experimental study along any line of work in which student may be specializing; consists of investigations for securing data on more difficult problems of hydro-mechanical engineering; students left largely to own resources in planning and carrying out work. Laboratory. *Prerequisite: M.E. 4.* Two or three hours credit. Each semester.

25. Heating and Ventilation. Theory, design and installation of hot air, direct and indirect steam, hot water, and fan heating systems; central heating; air conditioning. Lectures, recitations. *Prerequisite: M.E. 3.* Two hours credit. Second semester.

25a. Design of Heating and Ventilating Systems. Student given the usual data furnished the heating and ventilating engineer; expected to select system to meet requirements; makes layout of piping, ducts, auxiliary apparatus and computations for size of principal parts. Computations and drawing. *Prerequisite: M.E. 3.* Three hours credit. Second semester.

29. Automobile and Motor Trucks. Fundamental principles of construction, operation; application in current practice; engine cycle, details of construction, cooling, lubrication, carburetion, electrical systems, clutch, transmission, axle, differential, steering, springs, brakes; engine and car testing, performance curves, operation and control. Lectures, recitations, laboratory demonstrations. *Not open to freshmen.* Three hours credit. Each semester.

30. Automobile and Truck Engines. Student selects type of car or truck; makes expectancy curves for engine performance; then computes and sketches principal parts. Lectures, problems, drawing. *Prerequisites: M.E. 6 and 29.* Three hours credit. First semester.

30a. Design of Automobile and Motor Truck Engines. Continuation of Course 30. Lectures, assembly drawing, and details. *Prerequisite: M.E. 30.* Three hours credit. Second semester.

31. Design of Automobile and Motor Truck Chassis. Student selects type of engine for assumed conditions, then computes and sketches the principal parts of the chassis. Lectures, problems, drawing. *Prerequisites: M.E. 6 and 29.* Three hours credit. First semester.

31a. Design of Automobile and Motor Truck Chassis. Continuation of Course 31. Lectures, assembly drawings, and details. *Prerequisite: M.E. 31.* Three hours credit. Second semester.

32. Automobile and Motor Truck Testing. Experimental study of engine construction, horsepower, fuel economy, thermal efficiency, mechanical efficiency, heat balance, indicator cards, carburetion and electrical systems. Road tests of car performance includes speed range, acceleration, braking and fuel mileage. Laboratory, reports. *Prerequisites: M.E. 7 and M.E. 29.* Two hours credit. Each semester.

33. Advanced Automobile Testing and Research. Opportunity for advanced experimental and research work; students left largely to own resources in planning apparatus and in carrying

out work. Laboratory, reports. *Prerequisite: M.E. 32.* Two or three hours credit. Each semester.

34. Advanced Automobile Design and Research. Special problems in the design of some automobile or truck unit. Drawing. *Prerequisites: M.E. 30 and 31.* Credit and hours to be arranged. Each semester.

35. Factory Management. A study of the application of the scientific method to the operation of the shop and other departments of a factory; including organization methods and problems, job analysis, wages, production control, personnel, costs, inventory control, etc. Lectures, recitations, reports, field trips. *Not open to freshmen or sophomores.* Three hours credit. Each semester.

36. Factory Management. Field Work. Lectures and problems presented by prominent men in industrial field; topics include store room and tool room operation, factory buildings, costs, planning and routing; field trips give opportunity of observing how these various ideas are worked out in the factory. Lectures, problems, field trips. *Prerequisite: M.E. 35.* Two hours credit. Each semester.

37. Special Topics on the Internal Combustion Engine. Course designed to bring students in touch with latest developments in theory, design and construction. Reading, reports. *Prerequisite: M.E. 15.* Two hours credit. Each semester.

38. Internal Combustion Engineering. Research work on internal combustion engines. Laboratory. *Prerequisites: M.E. 8 and 15.* Credit and hours to be arranged. Each semester.

39. Internal Combustion Engineering. Research design of parts or units requiring special study. Drawing. *Prerequisite: M.E. 15a.* Credit and hours to be arranged. Each semester.

41. Automobile Engineering Seminar. Student prepares a paper on current topics of the automobile industry and one covering an investigation of some special subject; class discussion of papers. Reading, preparation of papers. One hour credit. Each semester.

42. Factory Management—Advanced. Special problems for study and investigation. Problems, reports. *Prerequisite: M.E. 35.* Two or three hours credit. Each semester.

43. Factory Internal Transportation. Various systems; includes initial, operating and upkeep costs for different types of handling equipment; detailed study of typical installations. Lectures, recitations, reports. *Open to seniors and graduates only.* Three hours credit. Each semester.

44. **Automotive Electrical Equipment.** Storage batteries, ignition, starting and lighting equipment for gasoline automobiles; storage battery equipment, charging apparatus, motors and control equipment for electrically propelled vehicles. Lectures, recitations, laboratory. *Prerequisites: Physics 46 and M.E. 29.* Three hours credit. Each semester.

45. **Studies in Natural Ventilation.** Theory of air movement through buildings by wind and temperature difference. Deductions from test data at hand. Some experimental work of an illustrative nature, and possibly something of a research nature. *Prerequisite: M.E. 8.* Two hours credit. Second semester.

50. **Gyroscopic Action and Critical Speeds.** Fundamental principles and applications of gyroscopic action; synchronous action in general; mathematical study of critical speeds; empirical treatment of complex cases. Lectures, recitations. *Prerequisites: E.M. 3.* Two hours credit. Each semester.

Summer Session

Courses 2, 3, 4, 6, 7, 8, 17s, and 20s, or similar courses will be given during the Summer Session of 1928.

88. NAVAL ARCHITECTURE AND MARINE ENGINEERING

Professors SADLER, BRAGG; Assistant Professor LINDBLAD.

The work in this Department has for its object the training of men in connection with the design and construction of ships and their machinery, and also of those who may wish to enter the field of water transportation. The three main divisions are as follows:

Naval Architecture, which embraces all questions relating to the design and construction of ships, and includes such topics as the displacement and buoyancy, strength, resistance, propulsion and stability; and methods of solving the general problem of ship design.

Marine Engineering, which includes those subjects which deal more particularly with the design and construction of the various types of machinery, such as steam reciprocating, turbine and oil engines, boilers of different types, and auxiliaries.

Water Transportation, which deals more specifically with those problems which enter into the selection of types of vessels suitable for various trades and conditions of operation, and which in addition to a general knowledge of the design and construction of vessels, also includes certain studies in Economics, Finance and Trade.

The Courses offered in the Department are therefore designed to give a student a thorough training in the fundamental problems relating to the marine field, with certain of them open to elective work which may give him a more specific training in the particular line of work which he may wish to follow, in any group.

The Department of Marine Engineering in planning out its course of study has had in mind the fact that the basic work is similar to that in Mechanical Engineering, with the slight differentiation largely in the fourth year. As a ship represents a floating power plant, fundamental courses in Civil, Electrical and Chemical Engineering are also included. While recognizing the fact that, in the shipbuilding and shipping industry, men are eventually segregated into the above groups, it has been thought advisable to devote more time to the essentials of the subject, rather than to undue specialization in any one, and to give the student as broad a background as possible. If, however, further specialization is desired, it is recommended that the student return for a fifth year and enter the Graduate School. Facilities for research work are provided in the Naval Tank, or Marine Laboratory, which is unique in this institution.

The Department is in constant touch with all the shipbuilding and shipping establishments, not only in this district, but throughout the country, so as to enable its graduates to obtain positions in the various lines mentioned above.

Marine Engineering Laboratory.—On the first floor of the West Engineering Building the east wing contains the experimental tank. This tank is 300 feet long, 22 feet wide, with a depth of water of 10 feet. At the south end is a model room and work shop for the purpose of making models of vessels.

The models used in the tank for testing purposes are from 10 to 12 feet, and are made of paraffin wax. A clay mould is first made approximately to the shape desired, and a core inserted. The paraffin is then poured into the mould, and, after cooling, the rough model is taken to the model cutting machine. This machine consists essentially of two moving tables or platforms, upon one of which is placed the model and upon the other the drawing which it is desired to reproduce. The model moves under a pair of rotating cutters, which are made to follow the lines of the drawing. After cutting, it is brought to its final shape by hand, then carefully weighed, and sufficient ballast added to bring it to any desired draft and displacement.

The tank is spanned by a traveling truck which is driven by a motor and can be run at any desired speed. Upon this truck are mounted the dynamometers for measuring the resistance of the models of various forms at different speeds.

Combined Courses have been arranged with Albion and Olivet Colleges and the College of the City of Detroit. For detailed information see sections 56-58.

Advice to Students of other colleges and universities with regard to planning their courses before coming to the University, is to be found in section 12.

Military Science.—The attention of prospective students in Naval Architecture and Marine Engineering is called to the Reserve Officers' Training Corps. Those who consider taking Military Science are urged to enroll at the beginning of their course. For further details see section 74.

CURRICULUM IN NAVAL ARCHITECTURE AND MARINE ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering, Naval Architecture and Marine Engineering, are required to complete the curriculum detailed below. For the definition of an hour of credit see section 52.

1. *Outline of Required Courses.*

a. Preparatory Courses.

English 1 and 2, and choice of English 5, 6, or 14	6 hours
Modern Language and Cultural Electives	16 hours
Mathematics 1, 2, 3, 4	18 hours
Physics 45, 46	10 hours
Chemistry 5	5 hours
Drawing 1, 2, 3	8 hours
Shop 2, Metal Working and Treating	2 hours
Total	65 hours

b. Secondary and Technical Courses.

Surveying 4, Use of Instruments	2 hours
E. M. 1, Statics	4 hours
E. M. 2, Strength and Elasticity	3 hours
E. M. 3, Dynamics	2 hours
E. M. 4, Hydromechanics	3 hours
M. E. 2, Elements of Machine Design	3 hours
M. E. 3, Heat Engines	4 hours
M. E. 4, Hydraulic Machinery	3 hours
M. E. 6, Machine Design	4 hours
M. E. 7, Mechanical Laboratory	2 hours

M. E. 8, Mechanical Laboratory	2 hours
Elec. Eng. 2a, Elec. App. and Circ.	4 hours
Chem. Eng. 1, Engineering Materials	3 hours
N. A. 1, Structural Design	1 hour
N. A. 2, Ship Calculations	3 hours
N. A. 4, Resistance and Propulsion of Ships	3 hours
N. A. 5, Structural Drawing	2 hours
Mar. Eng. 8, Marine Boilers	1 hour
Mar. Eng. 9, Marine Engines	2 hours
*Mar. Eng. 10, Marine Boiler Design	3 hours
*C. E. 2, Theory of Structures	3 hours
Total	57 hours

Summary:

Preparatory Courses	65 hours
Secondary and Technical Courses	57 hours
Group Options	18 hours
Total	140 hours

Group Options.—Three groups of studies may be followed in this department, viz:

Group A, which is arranged for those who wish to devote the principal part of their studies to the design and construction of ships; and,

Group B, for those who wish to specialize more in the design of propelling machinery and other machinery connected with ships.

Group C, for those who wish to fit themselves for Water Transportation work.

A. NAVAL ARCHITECTURE.

N. A. 3, Stability, etc.	3 hours
N. A. 6, Ship Drawing and Design	3 hours
N. A. 7, Ship Drawing and Design	3 hours
N. A. 12, Experimental Tank Work	2 hours
N. A. 13, Ship and Engine Specifications	1 hour
Electives	6 hours
Total	18 hours

*Students electing Group C, Water Transportation, for their group options, will substitute Economics 51 and 52 in place of Mar. Eng. 10 and C.E. 2.

B. MARINE ENGINEERING.

M. E. 5, Thermodynamics	3 hours
M. E. 13, Steam Turbines	3 hours
M. E. 15, Gas Engines	3 hours
Mar. E. 11, Marine Engine Design	3 hours
Electives	6 hours
<hr/>	
Total	18 hours

C. WATER TRANSPORTATION.

Econ. 133, Transportation	3 hours
Econ. 173, Accounting	3 hours
Nav. Arch. 13, Specifications	1 hour
Civ. Eng. 22, Transportation	2 hours
Electives	9 hours
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Total	18 hours

In this group students will substitute Econ. 51 and 52 for Mar. Eng. 10 and Civ. Eng. 2 in the regular schedule.

PROGRAM

First Year

FIRST SEMESTER		SECOND SEMESTER	
*Modern Language (§ 76)	4	*Modern Language (§ 76)	4
Chemistry 5	(§ 64) 5	Chemistry 5	(§ 64) 5
or Shop 2	(§ 79)	or Shop 2	(§ 79)
and Engl. 1 and 2	(§ 67) 6	and Engl. 1 and 2	(§ 67) 6
Mathematics 1	(§ 72) 4	Mathematics 2	(§ 72) 4
Drawing 1	(§ 73) 3	Drawing 2	(§ 73) 3
<hr/>		<hr/>	
Total hours	16 or 17	Total hours	16 or 17

Second Year

*Modern Language (§ 76)	4	*Modern Language (§ 76)	4
Mathematics 3	(§ 72) 5	Mathematics 4	(§ 72) 5
Physics 45	(§ 78) 5	Physics 46	(§ 78) 5
Surveying 4	(§ 86) 2	Eng. Mech. 1	(§ 66) 4
Drawing 3	(§ 73) 2		
<hr/>		<hr/>	
Total hours	18	Total hours	18

*For Modern Language requirements see section 54.

Summer Session

Elec. Eng 2a	(§ 85)	4
Elective		4
Total hours		<u>8</u>

Third Year

FIRST SEMESTER			SECOND SEMESTER		
Eng. Mech. 2	(§ 66)	3	Eng. Mech. 4	(§ 66)	3
Eng. Mech. 3	(§ 66)	2	Mech. Eng. 5	(§ 87)	
Mech. Eng. 2	(§ 87)	3	or Naval Arch. 6	(§ 88)	3
Mech. Eng. 3	(§ 87)	4	Mech. Eng. 6	(§ 87)	4
Naval Arch. 1	(§ 88)	1	Mech. Eng. 7	(§ 87)	2
Naval Arch. 5	(§ 88)	2	Chem. Eng. 1	(§ 83)	3
			Naval Arch. 2	(§ 88)	3
Total hours		<u>15</u>	Total hours		<u>18</u>

Fourth Year

Mech. Eng. 4	(§ 87)	3	English 5, 6, or 14	(§ 67)	2
Mech. Eng. 8	(§ 87)	2	Naval Arch. 4	(§ 88)	3
Mech. Eng. 15	(§ 87)		Mar. Eng. 9	(§ 88)	2
or Naval Arch. 3	(§ 88)	3	Group Options		8
Mar. Eng. 8	(§ 88)	1			
Mar. Eng. 10	(§ 88)	3			
Civil Eng. 2	(§ 84)	3			
Total hours		<u>15</u>	Total hours		<u>15</u>

COURSES IN NAVAL ARCHITECTURE AND MARINE ENGINEERING

1. **Structural Design.** This course comprises a discussion of the principal features of construction of all types of ships; classification societies' rules; preparation of working plans. Lectures and recitations. One hour credit. First semester.

2. **Ship Calculations.** The following are the topics discussed; methods of determining areas, volumes, centers of gravity of ship-shaped bodies, displacement, centers of buoyancy, metacenters, and trim; free board and tonnage; launching; calculation of bending moments and stresses in vessels under various conditions. Lectures and recitations. Three hours credit. Second semester.

3. **Stability of Ships and Preliminary Design.** This course includes investigations of the stability of vessels and means of determining the same; discussion upon the rolling and seagoing qualities of ships; and methods of reducing rolling. The latter part of the course is devoted to estimates and calculations involved in the design of ships. *Prerequisite: Course 2.* Three hours credit. First semester.

4. **Resistance and Propulsion.** In this course all items affecting the resistance and propulsion of various ships' forms; investigation of the theory and practice involved in the design of propellers; methods of conducting trial trips, etc., are discussed. *Prerequisite: Course 2.* Three hours credit. Second semester.

5. **Structural Drawing.** This course includes the laying out of a vessel and the preparation of the principal working structural plans, such as midship section, deck plating, bulkheads, and stern frame. Two hours credit. Each semester.

6. **Ship Drawing and Design. I.** The lines of a vessel of an average type are drawn and all the calculations are made which are necessary for plotting curves of form, launching curves, and strength curves. Three hours credit. Each semester.

7. **Ship Drawing and Design. II.** In this course the student is given the general features of a vessel and prepares a complete design of the same, including all the general plans and calculations. Three hours credit. Each semester.

8. **Marine Boilers.** The design and construction of marine boilers and their accessories are discussed. Lectures, recitations. One hour credit. First semester.

9. **Marine Engines.** This course includes the questions relating to the design, construction, and balancing of triple and quadruple expansion engines. Condensers, air pumps, turning and reversing engines are also discussed. Each student makes all of the preliminary calculations for the design of a marine engine. Lectures, recitations. *Prerequisites: Mechanical Engineering 3, Engineering Mechanics 1.* Two hours credit. First semester.

10. **Marine Boiler Drawing and Design.** In this course a Scotch marine boiler of general type is designed. Three hours credit. Each semester.

11. **Marine Engine Drawing and Design.** The complete general plans of a triple or quadruple expansion engine are prepared, together with all calculations for the same. Three hours credit. Each semester.

12. **Naval Architecture.** Laboratory Work in Experimental Tank. Two hours credit. Each semester.

13. **Naval Architecture.** Specifications and Contracts. One hour credit. Second semester.

14. **Naval Architecture.** Shipyard Plants.

15. **Naval Architecture.** Advanced Reading and Seminary. Credit to be arranged.

16. **Naval Architecture.** Advanced Drawing and Design. Credit to be arranged.

17. **Marine Engineering.** Advanced Reading and Seminary. Credit to be arranged.

18. **Marine Engineering.** Advanced Drawing and Design. Credit to be arranged.

Part VI

COLLEGE OF ARCHITECTURE*

GENERAL STATEMENT

89. The College of Architecture aims to give the student a thorough training in the fundamentals of modern architectural practice.

The following is an effort to reply in a general way to the questions which prospective students and their parents ask regarding the profession of architecture and the courses in architecture. Once the services rendered by the architect are understood, there is a ready appreciation of the significance and value of the courses and subjects which make up the programs of study.

THE NATURE OF ARCHITECTURE

90. Architecture, the oldest of the constructive sciences, and since ancient times also ranked as a fine art, deals principally with the design of buildings, their accessories and surroundings, their construction, decoration, and equipment.

Architecture is born of the necessity for buildings and the desire to have them appropriate and pleasing in plan and design, as well as sound in construction. By its very nature, therefore, architecture is much more circumscribed as a medium of expression by utilitarian and technical conditions than is any other of the fine arts; unlike its sister arts of painting and sculpture, it must function at once practically and artistically, and misses its aim in failing in either.

*For admission requirements, etc., see section 7. For courses other than those on Architecture, see Parts IV and V.

SERVICES RENDERED BY THE ARCHITECT

91. The duties of the architect consist for the most part in conferences with clients and builders, in the preparation of drawings and documents required for the erection of buildings, and in the supervision of building operations. The drawings consist of several kinds: "Preliminary studies," in which the general arrangement and design of the building are fixed upon, many schemes often being made in order to reach the one most advantageous in point of arrangement, appearance, and economy.

"Working or scale drawings" are prepared after a scheme has been approved by the owner. These are larger drawings which accurately define the proportions of the design, the disposition and dimensions of all the parts, such as the walls, openings, and heights of stories, and show the distribution of the structural, enclosing, and decorative materials. In connection with these drawings all calculations are made to determine the required strength of constructive parts, such as the foundation, columns, beams, and trusses, the capacity and character of the equipment for heating, ventilation, sanitation, and illumination. The working drawings are accompanied by "specifications," which define the kind and quality of materials to be used throughout the fabric; they describe the apparatus and fixtures to be installed, the grade of workmanship that is expected, and define just what is expected of all parties concerned.

After bids have been received and the builders selected, contracts are drawn by the architect which define the obligations of the builders and owner. The larger "detail drawings" are then made for structural and decorative features, while the architect supervises the progress of the actual building operations to see that the terms of the contract are fairly carried out by the builder, his agents, and the owner.

OTHER ACTIVITIES OF ARCHITECTS

92. Architects also occasionally take part in competitions for which, if properly conducted, a carefully prepared program is given all competitors and an expert jury is retained to select the best solution presented. In such competitions the drawings are con-

fined to the preliminary study stage. Owing to the delay, expense, and uncertainties of this method of selecting an architect, it is employed for but a small proportion of the building undertakings of this country, and then primarily for important public projects. Most architects gain their opportunities through demonstrated fitness and integrity. Architects also help determine and often design the decorative features of interiors, for larger work cooperating with decorators, painters, and sculptors; they often design the grounds and approaches of buildings, and have taken an active part in the planning of cities, independently and in association with landscape designers and engineers, for, after all, buildings must form the most permanent and salient decorative features of the city.

The architect, then, is expected to meet alone or with the aid of his assistants and experts the varied artistic and practical problems related to all classes of buildings. In doing the above he must deal with public and private interests, with an exceptionally wide range of activities and human endeavor, extending from those of the laborer and artisan to those of artists and technical specialists as well as with the products of numberless industries.

TRAINING OF THE ARCHITECT

93. Those who are to exercise in so nearly equal degree the functions of an executive, an artist, and a constructor must needs receive a comprehensive training, one which will develop the kind of mental and moral fibre required for doing effective artistic and technical work and for meeting and dealing with men and affairs.

The old apprenticeship system which preceded the organization of architectural schools is rapidly disappearing, and is being replaced by the modern apprenticeship, which consists in working in an architect's office during vacations and after graduation from college, since progress is thus far more rapid, sure, and remunerative. The technically trained architect having "made good," it is now expected, most fortunately, that in addition to professional training he, like other educated men, have an insight into the larger questions underlying the affairs of the world.

Success in the architectural field depends largely on the same general conditions and personal qualities as are demanded in other professions. Those who expect to follow architecture as a profession should be imbued with an interest in building, in beautiful things, and in drawing. To a certain extent skill in design, construction, and drawing may be attained by all those who persist and have a real interest in the work. Artistic and constructive talent is valuable only if developed by serious work and supported by knowledge, while the mere assimilation of knowledge and acquirement of skilled draftsmanship are insufficient. Unremitting self-discipline and enthusiastic effort are required to attain the creative power and the ability to use knowledge effectively which mark the productive worker.

Until recently it was considered that graduation from a good high school, followed by four years in an architectural school and several years' experience in architects' offices should be the minimum preparation for independent practice, while a longer period of collegiate training, along with travel in this country and study and travel abroad, now actually forms the more extended preparation of many.

The American Institute of Architects and the Association of Collegiate Schools of Architecture now recommend that students devote at least five years to collegiate study as preparation for the baccalaureate degree in Architecture, dividing the additional year between technical and non-technical subjects with a view to attaining greater breadth and thoroughness.

In the three four-year programs in Architecture now offered at this University fully one-third of the time, approximately three semesters, is given to non-technical subjects, such as English, foreign language, economics, physics, mathematics, geology or mineralogy, fine arts and electives. By apportioning a fifth year between cultural and technical courses the student will spend approximately two full years on fundamental and general subjects and three full years on semi-professional and professional subjects. Since it is desirable to begin drawing and creative work immediately upon entering the Architectural School, the general and cultural courses should be distributed over the entire time the student is in residence rather than completed before the technical subjects.

The training requisite for the architect may be stated under three principal heads:

- a. General education.
- b. Technical or professional education.
- c. Experience in actual architectural work and business affairs.

a. GENERAL EDUCATION

The purpose of the first of these is to provide the essentials of a liberal education, that which tends to make the educated man and citizen, and helps give an understanding of the larger questions of life and thought and of the interests of others. Undoubtedly, university life and associations stimulate interest in the above.

The student should therefore while in the University receive those fundamentals of a general education which cannot be studied systematically later when he is absorbed in the exacting routine of the practical field. These studies will help him keep from becoming merely a narrowly specialized tool to be used by men of broader caliber. Moreover, the economic and social forces which shape his very opportunities must be understood if he is to interpret them with sympathy, intelligence, and artistic judgment. To this end, literature, science, business administration, economics, philosophy, and kindred subjects are invaluable and should receive attention throughout the collegiate period, since they require as great thoroughness of preparation and maturity of mind as the most advanced technical subjects.

b. PROFESSIONAL, OR TECHNICAL, EDUCATION

Technical education, the second division, provides the special knowledge expected of the architect, trains him in fundamental principles, and develops his taste and skill in solving the problems peculiar to the architectural field. A full statement regarding technical courses will be found under the "Work of the College" in this announcement.

c. EXPERIENCE

General and technical education prepare for the third division, in which the graduate, preliminary to independent practice, gains experience in an architect's office in the application of technical

knowledge and in the conduct of an office and actual building operations. This period brings home a fuller realization of the need of thorough training and of personal force to carry to completion building projects, and to cope with all the attendant conditions. The time required for this practical experience will vary according to the ability and opportunity of the individual.

HIGHER DEMANDS ON PROFESSIONAL MEN

94. Higher demands than ever before are being made today upon professional men. Hence, professional education is characterized by demand for at once higher specific training and additional general education. This is shown by the tendency to require more or less collegiate cultural preparation—indeed, in some cases the bachelor's degree—for admission to schools of medicine and law.

In some professional fields, specialization may or should come on the basis of a groundwork of general collegiate training alone; but in architecture training in drawing and design should begin with the first year of college, since development of the power of expression and creative design is facilitated by being continued over a long period rather than concentrated in a short one. This is particularly true in a country where the lack of artistic environment and of adequate preliminary training in drawing seriously handicaps architectural education, making it necessary to give, for the majority of students, all or most of the preliminary and subsequent technical training, as well as the elements of a general education, in four years.

SPECIALIZATION IN ARCHITECTURE

95. While ideally desirable that the architect be expert in all allied fields, it is manifest that such omniscience is denied to men at the end of a four-year course or an infinitely longer one. Indeed, the impossibility today of mastery in all fields of architecture by even the most accomplished practitioner has led to specialization within the architectural field. There are now, as a result, many architects who specialize in the design and construction of single classes of buildings, such as hospitals, theaters, schools, churches, office buildings, residential work, or city planning, and who in doing this work employ a corps of trained assistants.

Parallel with the increased demands made on the profession, education in architecture has developed to such an extent that four or more years may be devoted solely to technical subjects. If, however, students were permitted to pursue such an over-professionalized course without preliminary or parallel cultural training they would find, when too late, that they had lost one of the primary opportunities of their college course.

If specialization is desired within the field of architectural education it must be either in the direction of architectural design or construction. Hence, at the University of Michigan there exist three four-year programs in architecture the first of which is a general professional course, while the second and third emphasize, respectively, design and construction, in all of them a fair allowance being made for cultural studies. There is, in addition, a four-year program in decorative design.

Those who desire more advanced training are urged to plan their work in such a manner that it will include not less than five years, spreading the technical and cultural requirements over the entire period.

OUTLOOK FOR THE ARCHITECT

96. At no time in the history of the United States has there been so much interest in good architecture. Never before has there been so excellent an outlook for the trained architect. Classes of buildings which formerly were hardly considered from an artistic point of view, such as factories, warehouses, and the like, are now designed by architects. Our great corporations have come to a realization of the value of buildings which are at once adequate, attractive, and interesting. Cities, everywhere, by means of general improvement plans, are recognizing the need of good design in everything, and in this city planning development the architect is playing a most important part; even in primarily utilitarian projects our municipalities will no longer permit the erection of structures which are merely adequate, but are employing architects to assure the creation of something that will be permanently pleasing as well as useful.

The art development, of which architecture forms but a part, has barely begun in this country. So long as this country con-

tinues its marvelous growth highly trained men will be needed to give form to building projects of the most varied character. The prospect is therefore full of promise for the architect and hence for the architectural school.

FOUR-YEAR PROGRAMS OF STUDY

97. Four four-year programs are offered, Programs I and II in Architecture, Program III, in Architectural Engineering, and the Program in Decorative Design, each requiring four years of study. These should be supplemented on the part of architectural students by work with an architect during the vacation periods. Students in decorative design should spend the same time in the employ of an interior decorator. In each program provision is made for the study of theory, history, and practice of architecture, for training in language, mathematics, science, construction, design, building equipment, drawing, and electives.

The first year being practically identical in the three architectural programs, such students can, if advisable, at the end of that period change from one program to another without loss of credit. The courses in drawing, most of those in architectural design, practical building construction, and working drawings, sanitation and architectural history are common to the three architectural programs. General Physics is required in Programs I and II; Engineering Physics in Program III.

Programs I and II aim to prepare the student for general architectural practice. They differ only in that solid analytic geometry and a course in calculus is required in Program I, in place of which six hours of design and a course in landscape design are required in Program II. The advanced construction is taught on the basis of two special courses in mechanics given by the College of Architecture.

Program III, Architectural Engineering, or Construction, meets the needs of those who in association with architects or others will specialize in building construction and equipment. Hence, in addition to architectural design and practical building construction, which together prepare for intelligent and sympathetic collaboration with architects and builders, these students pursue engineering courses in structural design, heating and venti-

lation, heat engines and some work in testing materials, surveying, and the chemistry of engineering materials. In this program the architectural studies may be completed in two and one-half years. Hence, students who have completed the first year of an engineering course and wish to take up architectural engineering may yet graduate at the end of four years.

During the senior year architectural design forms the chief study in Programs I and II, while in Program III framed structures, structural design and other engineering subjects take up most of the year.

The above programs may be completed in four years by well prepared and conscientious students; those who have difficulty with a subject can either extend their period of study or make up deficiencies in the Summer Session.

A four-year program is provided for students in decorative design. For the present the emphasis is placed on interior decoration, but all of the fundamental courses are offered for those expecting later to specialize in the art associated with advertising, commonly designated "commercial art." Interior decoration requires a considerable knowledge of the surface qualities of architecture rather than the organic view of the architect in which plan, construction, and artistic form must all be considered. The architect designs and builds the building, the decorator may take a portion of the interior and give it added emphasis or interest through surface treatment and furnishing. He collaborates with the architect in carrying out the spirit of the building as a whole; he must have a good general knowledge of design, be resourceful in the use of color and pattern and in the production and use of textiles, furniture and fixtures, and he must also be well versed in the materials of which decorative equipment is made.

The training of the decorative design student comprises considerable freehand drawing and modeling, some mechanical drawing, perspective, the elementary courses in architectural design, those in architectural history and fine arts, with a liberal provision for the history of art and non-technical courses. The major requirement is in decorative design leading from introductory courses in decorative composition and color finally to a working out of entire interiors of various types.

DEGREES CONFERRED IN THE COLLEGE OF ARCHITECTURE

98. The degree conferred in Programs I, II, and III of the College is Bachelor of Science in Architecture, the diploma specifying the program which the student has completed. The program in Decorative Design leads to the degree of Bachelor of Science in Design.

GRADUATE STUDY AND DEGREE

99. Students who are able to attend an additional year for graduate work will find the time well spent. Graduate work may be done in design, construction, the history of architecture, and in general studies. Such work shall be of an advanced character, a thesis on the design and construction of a building being required in the second semester.

For graduate courses leading to the degree of Master of Science in Architecture, the student must register in the Graduate School, but will pursue his work under the supervision of the Faculty of the College of Architecture. For particulars, see the Annual Announcement of the Graduate School.

OTHER CLASSES OF STUDENTS

100. Candidates for both the Bachelor of Arts and Bachelor of Architecture degrees, in order to graduate in Architecture in two years after obtaining the Arts degree, should complete at least the first two years in the architectural courses, while candidates for the first degree. Students wishing to carry on some general college work parallel with or before beginning the work in Architecture, should consult as soon as possible with the Professor of Architecture in order to plan their work in the most advantageous manner. In general, work in drawing and design should be begun early and extend over a long period rather than be concentrated into one or two years.

Graduates of colleges with the Arts degree are able to earn the professional degree in from two to three years, according to the program pursued and the kind of preparation brought by them.

Those who expect to enter from other colleges or to transfer from other departments of this University should aim to bring as much credit as possible in free-hand drawing, as well as credits in descriptive geometry (the equivalent of Architecture 2 and Architecture 3) and the mathematics and physics of the program they intend to follow.

Students registered in other colleges may elect the courses in history of architecture, elements of design, allied arts and decorative design, and other courses for which they are qualified.

TWO-YEAR PROGRAM FOR SPECIAL STUDENTS

101. A two-year course is provided for special students in Architecture upon the completion of which there is awarded a certificate of proficiency.

Owing to the difference in the preparation of such students but part of the work is prescribed, the remainder being elective, to be arranged in consultation with the head of the College.

Special students may specialize in either design or construction.

Design, history of architecture, and free-hand drawing are studied throughout the two-year program; one year is devoted to construction, another year to building equipment.

In design such students are placed in the class indicated by their preparation. Very often the preparation of such students is sufficient to enable them to enter as regular students. It is then to their advantage to elect as much as possible of one of the four-year programs, returning later to complete the requirements of a regular program.

Special students who enter with enough preparation in mathematics can go on with Mathematics 1, then Architectural Mechanics 19 and 20, finally structural design, Architecture 22, 23, 26, and 27, thus completing part of the advanced building construction within two years of residence.

THE WORK OF THE COLLEGE

102. **Design.**—While design, owing to its comprehensive character, is of the greatest importance to the architect, it should be, and is, carried on parallel with the courses in construction, the history of architecture, science, and general studies which actually increase efficiency in design and make for breadth of view and greater ultimate success in the field of independent practice.

The aim throughout these courses is to develop the imagination, creative power, ability to work out the organism of a building, and skill in the clear and artistic presentation of the drawings.

The policy in teaching design, while insisting on fundamental principles, is to encourage freedom of expression, to make possible, where permitted by the character of the problem and the requirements of the program, a wide range of interpretation; thus to bring into relief the relative value of the various solutions of which each problem is capable. While the larger aspects of the composition are of chief importance, careful consideration is given to the character of the form as related to the constructive scheme and the material. Occasionally a special problem is assigned to emphasize this further. In allied arts design most of the problems deal with small objects in various materials, involving a consideration of good craftsmanship, which the architect must appreciate if he is to expect it from artisans.

The history of architecture is also of importance in this connection, for the architect must know the experience and inspiration of the past, its successes and failures, that he may better live, think, and build in terms of the present.

Emphasis is placed on modeling and perspective as a corrective and supplement of design in elevation, to develop appreciation of the third dimension and is a means of presentation in itself.

In design, as in all other drawing courses, the right is reserved to keep drawings that may be of help for purposes of illustration or instruction.

103. **Architectural Design.**—In the courses in architectural design the students work out in the drafting room, designs for a great variety of buildings, ranging from a small structure to large public buildings and groups of buildings. Lectures are given from time to time bearing on the type of building then being designed.

The problems vary from year to year, with the various classes, in order to cover as many as possible of the types of structures which make up architectural practice. Among these are the school, railroad station, library, hospital, church, theatre and auditorium, and such other public structures as the postoffice, museum, the monument, and the bridge, as well as the various kinds of busi-

ness, manufacturing, and residential buildings. Under "Housing" the entire street plan of a city is worked out: the disposition of the various sections for commercial, industrial, residential, and recreational purposes, and the actual design of typical buildings of all kinds needed in an entire city.

Problems are occasionally assigned in architectural design which must be completed the same day; usually, however, the problems require from three to five weeks for their completion. A preliminary sketch or study is made by the student without criticism from the instructor or reference to documents; then a general criticism of all these sketches is given before the class, after which the sketches are returned to the students to have the essential features developed in the drafting room under the direction and criticism of instructors. After the drawings have been completed they are hung up and a general criticism is given. Thus, while the character of the instruction is of necessity largely individual, each student may profit by the progress of the others.

The preliminary sketch, usually executed in three or four consecutive hours, compels concentration on essentials and promotes accuracy and facility. The necessity of retaining in the final design the principal characteristics of the first sketch develops a sense of responsibility and individuality, comparison of the different solutions by members of the class demonstrates the varied possibilities of a given problem. All the designs for a given problem must be handed in at a fixed time. They are then carefully examined by the instructors and graded according to degree of excellence.

Test or examination problems, some without criticism, form a part of the requirement in each course.

In the last design course required of students in Architectural Engineering problems of a special character for such students are given.

104. Advancement in Design.—Promotion in design is individual, and takes place at any time during the year whenever a student has earned the number of points required in a course. This enables students to progress in proportion to their ability, application, and actual attainment, puts a premium on good work, and stimulates helpful emulation.

While the average student is able to complete the requirements in design in the normal time allowed, students of unusual ability or those who can devote more time to the subject may complete the requirements earlier and then elect additional cultural or technical courses.

105. Allied Arts of Design.—The course in Allied Arts of Design consists of a study of the elements of decorative design; designs are made for a piece of furniture, decorative glass, metal,

and mosaic, and of other objects or features commonly used in connection with architecture.

106. Construction.—The courses in mathematics and physics are preparatory to those in structural mechanics, the strength and resistance of materials, advanced construction, or structural design, the testing of materials, and the courses in heating and ventilation, and building sanitation. The study of construction continues through two or three years, according to the program of study pursued, and is conducted by means of lectures, textbooks, conferences, visits to buildings, and the preparation of working drawings. The work is at once practical and scientific, analytical and graphical methods being employed, and most of it is completed before the advanced work in architectural design is begun. The character of building materials, their structural and artistic possibilities, and the methods of building practice are studied and problems assigned which train the student in the fundamentals of sound construction.

The drawing work of the course in construction begins with the making of working drawings of a small building. This includes the framing plans of the floors, walls, and roofs, and full-size details of some of the finished portions. This is followed by working drawings for a larger building of heavy construction, and involves soils, foundations, walls, piers, columns, floors, roofs, and details. Steel and reinforced concrete construction are next studied in the course of which girders, columns, trusses, and other structural work of fire-proof buildings are designed. There is a course in the chemistry of engineering materials and one in the testing of materials for students in Program III. The subject of specifications is taken up in connection with the work of construction and a special course is given in building details.

In these courses, which may most conveniently be grouped under Building Equipment (Heating and Ventilation, and Sanitation), the principles and applications are studied which govern the design of the apparatus, the installation of which forms a part of the architect's work.

107. History of Architecture.—Architecture, "the mother art," is an art of great and inspiring traditions, and these can be justly appreciated only through careful study of the monuments of the past, both remote and recent, in relation to the other arts and civilization of their time. Owing to the wealth of material and the possibility of illustration, the history of architecture is one of the richest and most valuable subjects in the architectural curriculum. It is at once cultural and technical in character; it helps inculcate an understanding of the true character of architecture, develops the critical power and taste of the student, and demonstrates how we may best profit by the experience and example of the past.

The development of the art of building is traced from the earliest times to the present day. The causes and influences which moulded the various modes of building or styles are analyzed and, where possible, demonstrated by means of the stereopticon. Many of the important buildings of the world are fully illustrated and critically studied, the student thus gaining a knowledge of the finest achievements of the art. Not only are the buildings studied in their larger aspects, but also in many of their details of plan, construction and form. The principles of design, the effect of construction and material on form, the value of sculpture, painting, the crafts, and landscape design in relation to architecture are discussed. Decorative sculpture, color, and ornament are considered along with the particular architecture of which they form a part, thus preserving for the student the unity of each style.

In addition to the above, all architectural students registered in Programs I and II elect one or more courses in the history of art, in order to acquaint themselves with the development and masterpieces of painting and sculpture, these courses being more intensive studies in the sculpture, painting, and decorative art of the period.

108. Drawing.—Thorough instruction is provided in descriptive geometry, shades and shadows, perspective and stereotomy. Special classes are provided for architectural students in these subjects. Here the student receives an exacting drill in projections and intersections, accurate and neat instrumental drawing, and learns those methods which are essential to skilled draftsmanship. Many of the problems assigned as illustrations are architectural in character, and thus the student, while learning principles, works out applications directly connected with his chosen field.

109. Free-Hand Drawing.—Because of the need of facility in this field considerable attention is paid to free-hand drawing. The students begin drawing from simple geometrical solids involving the accurate representation of form in line and light and shade; simple decorative, natural, and architectural forms are next drawn, after which proportions of the figure, the hand, foot, etc., are drawn from the living model. Outdoor sketching is also encouraged, and is especially recommended for the summer months, when such instruction is given in the Summer Session.

Throughout this discipline, in the observation and artistic representation of line, form, proportion, light and shade, the aim is to develop in the student the power of free artistic expression. The student is advanced as rapidly as his progress warrants. Pencil and charcoal are principally used.

110. Water Color and Rendering.—Instruction is given in painting from still life. Almost from the very beginning color is employed in rendering. The continued use of color in render-

ing is insisted on in order to cultivate as much as possible the ability to produce good color relations when dealing with the various materials used in exterior and interior design.

111. Pen and Ink.—Rendering in pen and ink is taught for advanced students.

112. General Studies.—A fair quota of general studies is provided in the four-year program, the following forming a part of the regular work: English, German, or French, the history of art, business administration, and elective hours, which permit courses in economics and philosophy, or additional courses in language.

Mathematics, physics and geology have considerable importance as liberal studies, as well as being necessary to an understanding of materials, structural mechanics, heating and ventilation, and other technical subjects. Moreover, the study of architecture has a high cultural value in addition to constituting an exacting intellectual discipline.

113. Summer Work.—In order to encourage practical experience in architects' offices during the summer vacations, four hours credit is given towards graduation for four months of such work. To the majority of students who enter college without such experience this kind of summer employment, while at first but moderately remunerative, brings home a keen realization of some of the demands of the professional field and results in more serious and better college work. It also enables students upon graduation to adapt themselves more readily to the demands of architectural office routine.

Letters should be brought from architects stating what kind of work was done by the student and how long he was employed.

114. Summer Session.—The courses offered for Architectural students and others during the summer of 1928 will include architectural design and outdoor sketching and painting.

The Summer Session will begin June 25.

A Special Announcement of the Summer Session can be had by addressing the Secretary of the University.

115. Facilities and Equipment.—The College of Architecture is housed in large and commodious quarters in its own building. The drafting rooms are well lighted, provided with drafting tables of special design, and hung with valuable original competition and measured drawings. The free-hand drawing rooms are situated on the top floor at the north side of the building. They have an area of about 5400 square feet, are lighted by means of large north windows, and are fully equipped for the instruction in

free-hand drawing, pen and ink, water color, and drawing from life. There is also a room for modeling. A comprehensive collection of plaster casts, of sculpture, of decorative and architectural form, pottery and textiles for painting from still life, and a number of original drawings in pencil, color and pencil, pen and ink, form part of the equipment.

In addition to the above, there are in the Alumni Memorial building a number of casts from the antique, among which are the Victory of Samothrace, the Hermes of Praxiteles, and some of the remarkable decorative figure sculpture from the Arch of Trajan at Beneventum. Here are also a number of paintings and other objects of artistic and archaeological value.

116. Exhibitions.—Each year a number of art exhibitions are held under the auspices of the Ann Arbor Art Association in the main gallery of the Alumni Memorial Hall and also in the Architectural Building.

Exhibitions of student work are held from time to time in the corridor and in class rooms. Work by students of the school was shown at the First International Congress on Architectural Education in London, at a number of English architectural schools and at the exhibitions of the Detroit and Chicago Architectural clubs.

Many lectures are given each year under the auspices of the University, its colleges and schools, and local organizations, and among these are always a number of especial interest to architectural students.

117. The Library.—No private and few public collections can be as complete as the library of a well-equipped architectural school. These books record the world's experience and achievements in architectural and allied fields and give an opportunity to study critically the finest work of all periods. The architect must have a fair knowledge of the literature bearing on his art, and since he may never possess many of these valuable works, and perhaps rarely again see them, the library forms a valued privilege during the student period.

The Architectural library is conveniently housed in a room 40 x 90 on the second floor. It comprises 3,188 bound volumes and folios of plates, including, besides the standard books of reference, many important early works and an unusual number of recent publications, many photographs, and about 14,000 lantern slides. With the works available in the General library, it constitutes an exceptional collection for the study of construction, architectural design, decorative design, and architectural history. It is especially strong in works on modern architecture and on the allied arts of ceramics, glass, metal work, textiles, and furniture. The leading American and foreign architectural journals are received, and bound volumes are kept on file.

Among the notable works available a few items which call for special mention are, in ancient literature, the Newton and Marino edition of Vitruvius, Palladio's *Fabbriche Antiche*, the works of Stuart and Revett, Desgodetz, Cressy and Taylor, Koldey and Puchstein, the *Restaurations des Monuments Antiques*, D'Espouy's *Monuments Antiques and Fragments d'Architecture Antique* and monographs on a number of Greek and Roman sites and buildings; in mediæval architecture, the works of Dehio and von Bezold, Britton, Pugin, Viollet-le-Duc, the *Archives de la Commission des Monuments Historiques*; in Renaissance architecture, the works of Geymüller, Raschdorff, Cicognara, Blondel, Gotch, Belcher and McCartney, and a very full collection of special works on the buildings of the Renaissance in France.

Every reasonable facility is accorded the student. A librarian is always in attendance, the library being open until ten o'clock at night.

The General library also contains an excellent collection of reference material on painting, sculpture, and archæology, a large number of photographs of Greek and Roman sculpture, and a collection of nearly five thousand prints, mostly art subject materials.

118. Materials.—The College supplies drawing tables and lockers. The student provides himself with all other materials. A good set of instruments and small drawing boards must be purchased. Water colors should not be purchased until after arrival here, when a list of required colors may be had.

FELLOWSHIPS

119. The George G. Booth Travelling Fellowship in Architecture.—The fellowship will be awarded annually, the stipend for the year being \$1200. To be eligible the candidate shall be a graduate of the College of Architecture of the University of Michigan or shall have substantially completed the last two years of the four-year course. The award will be made on the basis of the student's general record and a competition in design.

For further information regarding this fellowship candidates should write the College of Architecture.

Scholarship of the Detroit Chapter of the American Institute of Architects.—This organization from time to time offers a scholarship varying in amount open to experienced architectural draftsmen and to those who show decided artistic ability, primarily to encourage graduate study. Application should be made to the Professor of Architecture.

American Academy in Rome.—Graduates in Architecture are admitted to the annual competition for the fellowship in Architecture of the American Academy in Rome. This fellowship entitles the successful candidate to three years' study abroad with a stipend of \$1,000 per annum.

American Institute of Architecture.—Graduates in Architecture of the University of Michigan are received as candidates by the American Institute of Architects without examination, after they have had a certain amount of training. The Institute has also established a Junior membership, open upon graduation from this and other recognized schools of the Institute.

Medal of the American Institute of Architects.—The Institute annually awards a medal to that member of the graduating class having the highest standing during the four-year period of study in Architecture.

State Examinations for the Registration of Architects.—Students who are planning to enter the architectural profession should bear in mind that twenty-six states of the Union now have laws prescribing qualifications for architectural practice and require the passing of examinations given by a state board. In a very few years the remaining states will probably have such laws, a number of laws now being under consideration. These examinations comprise tests in the planning, design, construction, and equipment of buildings. Three or four days are usually required for such examination, distributed about as follows: planning and design, one day; reinforced concrete and steel construction, one day; building equipment and specifications, one-half day; architectural history and truss design, one-half day. Candidates may, by passing a somewhat more difficult examination, given under the National Council of Architectural Registration Boards, qualify for interstate practice.

Architects' Juries.—Again, as during the past few years, visiting architects have been invited to assist in grading the design problems.

Association of Collegiate Schools of Architecture.—The College is a charter member of this organization.

120. CREDIT HOURS REQUIRED IN THE THREE
FOUR-YEAR PROGRAMS, THE TWO-
YEAR PROGRAM FOR SPECIAL STU-
DENTS, AND THE COURSE IN
DECORATIVE DESIGN

One hour credit represents ordinarily about three hours of actual work during each week of one semester.

ARCHITECTURE:	AI	AI	AI	Sp.	Dec.
Elements of design	3	3	3	..	3
Architectural design	3I	37	17	23	7
Allied arts design	3	3	..	..	35
History of architecture	8	8	6	8	6
Office work	4	4	4	..	4
CONSTRUCTION:					
Structural mechanics	6	6	7	..	..
Roofs, girders, and framed structures..	..	..	5	..	..
Construction (elementary)	2	2	2	2	2
Advanced structural design (steel)	5	5	4	..	..
Masonry and reinforced concrete	4	4	3	..	..
Testing materials .....	..	..	2	..	..
Chemistry of materials .....	..	..	3	..	..
Surveying .....	..	..	2	..	..
BUILDING EQUIPMENT:					
Building sanitation	I	I	I	I	..
Heating and ventilation	2	2	2	2	..
Heat engines .....	..	..	4	..	..
DRAWING:					
Free-hand drawing	10	10	6	6	16
Water color painting	2	2	..	2	2
Desc. geometry and shades and shadows	3	3	3	I	..
Perspective and stereotomy	2	2	2	2	I
Mechanical drawing .....	..	..	..	..	3
SCIENCE:					
Mathematics	13	4	18	..	..
Physics	4	4	10	..	..
Acoustics	2	2	..	..	..
Chemistry .....	..	..	5	..	4
Geology or Mineralogy	3	3	3	..	..
Botany .....	..	..	..	..	4
LANGUAGE:					
English	6	6	6	..	9
French or German	12	12	12	..	12

GENERAL:

Business administration	3	3	..	..	3
History of art	3	3	..	3	8
Landscape design or city planning .....	..	3	..	..	..
Cultural and free electives	8	8	10	10	21
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
	140	140	140	60	140

121.

PROGRAM I. ARCHITECTURE

First Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
English 1 and 2	4	*Modern Language	4
Alg., Anal. Geom. (Math. 1)	4	Analytic Geom. (Math. 2)	4
Desc. Geom. (A.2)	3	Free-hand Drawing (Dr. 22)	2
Free-hand Drawing (Dr. 21)	2	Arch. Design (A.4)	3
Elements of Design (A.1)	3	Bldg. Construction (A.21)	2
		Ancient, Med. Arch. (A. 12)	3
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	16		18

Second Year

Calculus (Math. 3)	5	English	2
Mechanics, Sound and Heat (Phys. 41)	4	Perspective, Stereotomy (A. 3)	2
Free-hand Drawing (Dr. 23)	2	Mechanics (A. 19)	3
Arch. Design (A. 5)	4	Arch. Design (A. 6)	4
Gothic, Ren., Modern Arch. (A. 13)	3	Allied Arts (A. 17)	3
	<hr/>	Geol. 31 or Min. 104	3
	18		17

Third Year

*Modern Language	4	*Modern Language	4
Mechanics (A. 20)	3	Free-hand Drawing (Dr. 25)	2
Arch. Design (A. 7)	6	Steel Construction (A. 22)	3
Arch. Hist. Research (A. 14)	2	Structural Design (A. 23)	2
Water Color (Dr. 24)	2	Arch. Design (A. 8)	6
Bldg. Sanitation (A. 24)	1		
	<hr/>		<hr/>
	18		17

*For Modern Language requirements see section 54.

Fourth Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Reinforced Concrete (A. 26)	2	Hist. of Painting, Sculpture	3
Structural Design (A. 27)	2	Arch. Design (A. 10)	8
Heating and Ventilation (M.E. 18)	2	Business Admin.	3
Life Drawing (Dr. 27)	2	Acoustics (Phys. 130)	2
Electives	7	Elective	1
	15		17

122. PROGRAM II. ARCHITECTURAL DESIGN

First Year

*Modern Language	4	*Modern Language	4
English 1 and 2	4	Alg., Anal. Geom. (Math. 1)	4
Descriptive Geometry (A. 2)	3	Free-hand Drawing (Dr. 22)	2
Free-hand Drawing (Dr. 21)	2	Arch. Design (A. 4)	3
Elements of Design (A. 1)	3	Bldg. Construction (A. 21)	2
	16	Ancient, Med. Arch. (A. 12)	3
			18

Second Year

*Modern Language	4	English	2
Mechanics, Sound and Heat (Phys. 41)	4	Perspective, Stereotomy (A. 3)	2
Free-hand Drawing (Dr. 23)	2	Mechanics (A. 19)	3
Arch. Design (A. 5)	4	Arch. Design (A. 6)	4
Gothic, Ren., Modern Arch. (A. 13)	3	Allied Arts (A. 17)	3
	17	Geol. 31 or Min. 104	3
			17

Third Year

Mechanics (A. 20)	3	Hist. of Painting, Sculpture	3
Water Color (Dr. 24)	2	Free-hand Drawing (Dr. 25)	2
Arch. Design (A. 7)	6	Arch. Design (A. 8)	6
Arch. Hist. Research (A. 14)	2	Steel Construction (A. 22)	3
Bldg. Sanitation (A. 24)	1	Structural Design (A. 23)	2
Elective	3	Elective	2
	17		18

*For Modern Language requirements see section 54.

Fourth Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Heat., Vent. (M.E. 18)	2	Life Drawing (Dr. 27)	2
Arch. Design (A. 9)	6	Arch. Design (A. 10)	8
Reinforced Concrete (A. 26)	2	Business Admin.	3
Structural Design (A. 27)	2	Acoustics (Phys. 130)	2
Landscape Design 101 or City Planning	3	Elective	3
	15		18

123. PROGRAM III. ARCHITECTURAL ENGINEERING

First Year

English 1 and 2	4	*Modern Language	4
Alg., Anal. Geom. (Math. 1)	4	Analytic Geom. (Math. 2)	4
Descriptive Geom. (A. 2)	3	Free-hand Drawing (Dr. 22)	2
Free-hand Drawing (Dr. 21)	2	Arch. Design (A. 4)	3
Elements of Design (A. 1)	3	Bldg. Construction (A. 21)	2
		Ancient, Med. Arch. (A. 12)	3
	16		18

Second Year

Calculus (Math. 3)	5	Perspective, Stereotomy (A. 3)	2
Physics 45	5	Calculus (Math. 4a)	3
Free-hand Drawing (Dr. 23)	2	Physics 46	5
Arch. Design (A. 5)	4	Eng. Mechanics I	4
Gothic, Ren., Modern Arch. (A. 13)	3	Arch. Design (A.6)	4
	19		18

Third Year

*Modern Language	4	*Modern Language	4
Calculus (Math. 4b)	2	Steel Construction (A. 22a)	3
Eng. Mechanics 2	3	Structural Des. (A. 23a)	2
Chemistry 5	5	Geol. 31 or Min. 104	3
Arch. Design (A. 7a)	4	Chem. Eng. I	3
		English	2
	18		17

*For Modern Language requirements see section 54.

Fourth Year

FIRST SEMESTER	HOURS	SECOND SEMESTER	HOURS
Masonry (A. 36)	3	Building Details (A. 7b)	2
Surveying 4	2	Testing Materials (E.M. 5)	2
Heat Engines (M.E. 3)	4	Adv. Struct. Design (A. 35)	4
Bldg. Sanitation (A. 24)	1	Heat and Vent. (M.E. 25)	2
Elective	5	Elective	5
	<hr/>		<hr/>
	15		15

124. TWO-YEAR PROGRAM FOR SPECIAL STUDENTS
IN ARCHITECTURE

Special students have such varied preparation that a program of courses must practically be planned to meet the needs of each student.

Experienced draftsmen can, in two years, accomplish much in design; they cannot, however, advance far in construction without Mechanics,—Graphic Statics (A. 19) and Strength of Materials (A. 20). They are, therefore, advised to bring preparation in high school algebra and trigonometry, taking Mathematics 1E at the University, then going on with Mechanics,—Architecture 19 and 20. With this training they can elect steel and reinforced concrete construction. Those who desire to specialize in design can substitute other courses for those in mathematics, mechanics, and structural design.

The following is suggested as an outline for special students desiring a well-balanced training when but two years are available:

First Year

Shades and Shadows (A. 2)	2	Perspective and Stereotomy (A. 3)	2
Free-hand Draw. (Dr. 22 or 23)	2	Arch. Design (A. 6)	4
Arch. Design (A. 4)	3	Water Color (Dr. 24)	2
Arch. Design (A. 5)	4	Ancient, Med. Arch. (A. 12)	3
Alg., Anal. Geom. (Math. 1) or Elective	4	Mechanics (A. 19) or Elective	3
Elective	1	Bldg. Construction (A. 21)	2
	<hr/>		<hr/>
	16		16

Second Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Arch. Design (A. 7)	6	Arch. Design (A. 8)	6
Gothic, Ren., Modern Arch. (A. 13)	3	Arch. Hist. Research (A. 14)	2
Mechanics (A. 20) or Elective	3	Steel Construction (A. 22) or	3
Bldg. Sanitation (A. 24)	1	Structural Design (A. 23) or Elective	2
Free-hand Drawing (Dr. 25)	2	Water Color or Pen and Ink	2
Heat. and Vent. (M.E. 18)	2	Hist. of Painting, Sculpture	3
	<hr/>		<hr/>
	17		18

125. PROGRAM IN DECORATIVE DESIGN*

The purpose of these courses is to teach the theory and practice of the graphic and decorative arts, the arts and crafts and interior decoration. For the practice of design, a general education is essential and proficiency in drawing, color and modeling is necessary for developing and expressing ideas and presenting them to others.

The program published herewith is tentative in many respects and adjustments will be made with those interested in specific fields. Courses will be added as required.

Instruction in design for technical students begins with Course 17 (Arch. 17). Simple problems illustrating fundamental principles are worked out before studying design in specific materials and fields such as wood, clay, metal, textiles and glass; and for furniture, decorative painting and sculpture, costume design and stagecraft. Surveys will also be given of the historical development.

First Year

English 1 and 2	4	Language	4
Language	4	Chemistry 3	4
Free-hand Drawing (Dr. 21)	2	Free-hand Drawing (Dr. 22)	2
Mechanical Drawing	3	Elements of Design (A. 1)	3
Clay Modeling (Dr. 33)	2	Clay Modeling (Dr. 33a)	2
Sketch Class	1	Perspective	1
	<hr/>		<hr/>
	16		16

*NOTE.—In addition to the courses listed for this program, students will be required to earn 4 hours credit in practical or other approved work.

Second Year

FIRST SEMESTER		SECOND SEMESTER	
	HOURS		HOURS
Language	4	English	3
English	3	Botany	4
Free-hand Drawing (Dr. 23)	2	Nature and Design (A. 17 <i>b</i>)	3
Theory of Color (A. 17 <i>a</i>)	3	Water Color (Dr. 24)	2
Decorative Design (A. 17)	3	Bldg. Construction (A. 21)	2
Elective	3	Ancient, Med. Arch. (A. 12)	3
	18		17

Third Year

Free-hand Drawing (Dr. 25)	2	Pattern Design (A. 17 <i>d</i>)	4
Arch. Design (A. 4)	3	Batik Design (A. 17 <i>e</i>)	2
Gothic, Ren., Modern Arch. (A. 13)	3	Free-hand Drawing (Dr. 27)	2
Geometric Relations (A. 17 <i>c</i>)	4	Arch. Design and Interior Decoration (A. 5)	4
History of Painting, Sculpture	3	History of Painting, Sculpture	3
Elective	3	Elective	3
	18		18

Fourth Year

†Major in Decorative Design (A. 6 <i>d</i>)	8	Advanced Color	4
Museum Study—Research	2	†Major in Decorative Design	4
Economics	3	Sketch Class	1
Electives	5	Electives	6
	18		15

126. DESCRIPTION OF COURSES IN ARCHITECTURE

Professors LORCH, ROUSSEAU, WILBY, TITCOMB, MCCONKEY, BENNETT; Assistant Professors NEWMAN, MARSHALL, CHAMBERLAIN, SLUSSER; Mr. MAKIELSKI, Mr. O'DELL, Mr. FOWLER, Mr. MATHEWS, Mr. CHAPIN, Mr. VALERIO, Dr. ONDERDONK, Mr. ALDRICH, Mr. BARNUM, Mr. GAMBLE, Mr. SLOCUM, Mr. YOUNG, Mr. HOWE, Mrs. JOHNSON, Mrs. CRANE, Mr. TANNER, Mr. WOOD, Mr. BITTINGER.

†The Major in Design should be in Interior Decoration, Costume Design, or as arranged with the faculty.

1. **Elements of Design.** An introductory course to the field of artistic design, decorative and architectural. Principles of design and the possibilities in design of line, color, and form. Methods of indication, rendering, lettering. Drawing exercises, modeling and lectures. This course or its equivalent must precede all architectural design courses. It should be accompanied or preceded by Architecture 2 and 21. Three hours credit. Each semester.

2. **Architectural Drawing.** Descriptive geometry; shades and shadows; use of instruments, simple projections and their application to plans, sections and elevations, roof intersections. Three hours credit. Each semester.

2d. **Mechanical Drawing.** Use of instruments. Simple projections and their application to plans, sections and elevations. For students in Decorative Design. Three hours credit. Each semester.

3. **Architectural Drawing.** Advanced projections and stereotomy; application to arch and vaulting problems; architectural, isometric and perspective drawing. Two hours credit. Second semester.

Architectural Design

In the following courses in Architectural Design problems are assigned to be worked out in the drafting room. Lectures are given from time to time bearing on the type of building then being designed. Study of the requirements of various classes of buildings and of the artistic possibilities of building materials, training of the student in composition in plan, section, elevation, and perspective, in accurate draftsmanship and rendering in line, black-and-white, and color.

Courses 4 to 10, inclusive, constitute a progressive series of problems in architectural planning and design, advancing from the small building to the more important classes of buildings and to the group problems. The courses must be taken in the order given.

4. **Architectural Design.** A continuation of Course 1; the orders and simple problems in design. Illustrated lectures, modeling and drawing exercises. *Prerequisite: Courses 1, 2, and Drawing 21.* Three hours credit. Each semester.

5. **Architectural Design.** The small ensemble. *Prerequisite: Courses 3, 4, and 21 in Architecture and Drawing 22.* Four hours credit. Each semester.

6. **Architectural Design.** A continuation of Course 5. Four hours credit. Each semester.

6d. Architectural Design. For students in Decorative Design. *Prerequisite: Course 5.* Eight hours credit. First semester.

7. Architectural Design. Plan problems. *Prerequisite: Architecture 6.* Six hours credit. Each semester.

7a. Architectural Design. For students in Program III. Four hours credit. Each semester.

7b. Architectural Design. Building details. For students in Program III. Two hours credit. Each semester.

8. Architectural Design. Plan problems. *Prerequisite: Architecture 7.* Six hours credit. Each semester.

9. Architectural Design. Advanced plan problems. *Prerequisite: Architecture 8.* Six hours credit. Each semester.

10. Architectural Design. Advanced plan problems. *Prerequisite: Architecture 8 or 9.* Eight hours credit. Each semester.

10b. Architectural Design. Advanced plan problems and office practice. *Prerequisite: Architecture 7.* Credit to be arranged.

11. Architectural Design. Housing problems. The design of various types of residential units, single and multiple, and their relation to the city plan and public health. Lectures, reading, and drawing. *Prerequisite: Architecture 6.* Credit to be arranged.

Technical and Historical Development of Architecture and Design

For students in Architecture, Courses 12, 13, and 14 assume some knowledge of history, drawing, and design; they should be elected in the order given. The purpose of these courses is to study the historical conditions, building materials and methods, planning and design, as well as the sculptured and painted decoration and ornament of the more important and significant works of architecture. The courses are carried on by means of illustrated lectures, conferences, drawing exercises, research, and required visits to buildings in neighboring cities.

12. Ancient and Medieval Architecture. The architecture of Egypt, Assyria, Persia, Greece, and Rome, and a survey of the subsequent architectural development to Gothic architecture. *Should be preceded by Drawing 21 and accompanied by Architecture 4.* Three hours credit. Second semester.

13. Gothic, Renaissance, and Modern Architecture. The Gothic, Renaissance, and Modern architecture of European coun-

tries, and architecture in the United States. *Should be preceded by Architecture 12.* Three hours credit. First semester.

14. Architectural History Research. A study of the architectural development of some type of building and the preparation of an illustrated report or thesis. *Prerequisites: Courses 12 and 13 and two years of architectural design.* Two hours credit. Each semester.

15. General Course in the History of Architecture. The aim of this course is to give students seeking a liberal culture a survey of the development of the art of building. The temples, cathedrals, palaces, and other characteristic monuments of the ancient, mediæval, renaissance, and modern styles, their design, sculpture, and painted decorations will be studied by means of lectures illustrated by the stereopticon, and collateral reading. This course is open to all students in the University, but cannot be counted towards graduation in Architecture. For students of art and archæology desiring a more intensive study of the technical and historical development of architecture, Courses 12, 13, and 14 are recommended. Two hours credit.

Decorative Design

17. Theory of Design. A study of the principles of design. Short problems in design, and lectures. *Prerequisites: Drawing 21 and 22. Architectural students should also have completed Architecture 5 and 12 or 13.* Three hours credit.

17a. Theory of Color. The systematic and intensive study of color and its application in design. Problems in color and design worked out in the drafting room and accompanied by lectures. Three hours credit.

17b. Nature and Design. A study in free treatment of problems in design. Three hours credit. Each semester.

17c. Geometric Relations. A careful study of "Symmetry in Space Relations," and of the use of various geometric systems as aids to creative design. *Prerequisites: Architecture 17 and 17a.* Four hours credit. First semester.

17d. Pattern Design. The practical application of Course 17c; planning and executing patterns for various materials and purposes, together with lectures and research work. *Prerequisite: Architecture 17c.* Three hours credit. Second semester.

17e. Batik Design. Two hours credit.

17f. Advanced Color. Four hours credit.

Building Construction and Equipment

19. **Architectural Mechanics.** Statics, stresses in simple frames. The principles of equilibrium. Analysis of stresses in simple frames by graphic and algebraic methods. *Prerequisites: Mathematics 1 and Physics 41.* Three hours credit. Each semester.

20. **Architectural Mechanics.** Advanced problems in statics. Strength of materials. *Prerequisite: Architecture 19.* Three hours credit. Each semester.

21. **Wood Construction.** Lectures, conferences, drawing, and visits to buildings. Building materials and processes; working drawings; specifications and estimates of cost. *Prerequisite: Architecture 1 and 2.* Two hours credit.

22. **Steel and Fireproof Construction.** Lectures, problems, notes, and assigned reading on building materials, and methods of construction, with particular reference to steel and enclosing and protection materials against fire and other destructive elements. Design of columns, beams, plate girders, and trusses; specifications and estimates. *Prerequisite: Architecture 19 and 20.* Three hours credit. Second semester.

22a. **Structural Theory.** Recitations, problems, text, and occasional lectures. This course is devoted to a study of the laws of statics, moving and stationary loads, influence lines, reactions, shears, and moments in their relation to structures of various kinds. The practical design of beams and girders is given considerable attention. *Prerequisite: E. M. 1 and E. M. 2.* Three hours credit. Each semester.

23. **Structural Design: Steel.** Working drawings and details of a steel-frame building. *Must be preceded or accompanied by Architecture 22.* Two hours credit. Second semester.

23a. **Structural Design.** Lectures and drafting accompanying Architecture 22a. A course in which are considered fundamental principles underlying structural design and their relationship to structural theory. Its main object is to give the student the power to analyze such problems as arise in practice. Elementary forms in wood, cast iron, and steel are considered through the preparation of design and working drawings. Emphasis is laid on the cultivation of careful, systematic, and practical habits in computation. *Must be preceded or accompanied by Architecture 22a.* Two hours credit. Each semester.

24. **Building Sanitation.** Plumbing and drainage. A study of materials, fixtures, methods of assembling, and modes of arrangement. Lectures and drawings. *Prerequisites: Architecture 4 and 21.* One hour credit. First semester.

26. Masonry and Reinforced Concrete. Lectures, problems, text, and assigned reading on building materials and methods of construction, with particular reference to reinforced concrete. Brick, stone, terra cotta, cements, and waterproofing are also considered; specifications and estimates. *Prerequisite: Architecture 19 and 20.* Two hours credit. First semester.

27. Structural Design: Masonry. The design of foundations, columns, slabs, beams, and girders of various types, as used in buildings. *Must be accompanied by Architecture 26.* Two hours credit. First semester.

35a. Structural Theory (Advanced). Recitations, problems, text, and lectures. This is an extended course in continuation of Architecture 22a. Part I, nine weeks, treats of the computation and design of structures of wood, metal, and masonry by algebraic and graphical methods. Subjects considered are the theory of columns, trusses of various kinds, mill building bents, and portals, earth pressure, buttresses and retaining walls. Part II, six weeks, treats of the theory of least work, and higher framed structures. The object is to further train the student in the application of the principles of mechanics to the design of structures with special reference to building work. *Prerequisite: Architecture 22a and a course in reinforced concrete.* Four hours credit.

35b. Structural Design (Advanced). Lectures, occasional problems, and drafting. A course in which are prepared complete designs and working drawings of a structural frame building of steel and concrete. Great importance is placed upon the study of the details of the design. Special attention is devoted to types and methods of constructing foundations for buildings, materials of construction, and protection materials against fire and other destructive agencies. *Must be preceded by Architecture 23a, and preceded or accompanied by Architecture 35a.* Two hours credit.

36. Concrete Theory. Recitations, problems, text, and lectures covering theory and design of masonry structures, with particular reference to reinforced concrete. Foundations and flat slab construction are studied. *Must be preceded by E. M. 1 and E. M. 2 and preceded or accompanied by A. 22a.* Three hours credit.

Primarily for Graduates

30. Architectural Design. Special problems in planning and design. *Prerequisite: The equivalent of Architecture 10.*

33. Architectural History. A thesis on the architectural work of a period or on a particular monument. *Prerequisite: The equivalent of Architecture 12, 13, and 14.*

38. **Structural Design.** Special problems in building construction. *Prerequisite: The equivalent of Architecture 35.* Credit to be arranged.

Free-hand Drawing, Painting, and Modeling

The following courses are open to others as well as Architectural students. The courses are to be elected as Drawing 21, 22, etc., and in the order given.

All of the courses are offered both semesters and instruction is given in Courses 21 to 26, inclusive, every morning and every afternoon with the exception of Saturday afternoon only.

Drawing in charcoal, pencil, and wash, largely from casts and from the living model. This work may be varied somewhat to permit some sketching out-of-doors. Pen and ink should not be elected until after the student has mastered the fundamentals of representation.

For the general student Courses 21, 22, and 24 will give an elementary training in drawing and painting. Course 30 provides more advanced work in painting; Courses 25, 26, and 27 more advanced training in drawing. Course 23 is a special course in the drawing of ornament for students of architecture and decoration, while Course 35 is primarily for Architectural students, although open to others. Outdoor sketching and painting can best be studied during the Summer Session.

At present there are no classes in portrait painting, but such instruction can, under certain conditions, be arranged for groups of students who have advanced preparation. Still life painting in water color or oil cannot be studied profitably without some preliminary training in free-hand drawing (Drawing 21 and 22). For drawing from the living model some preliminary training is required from the antique (Drawing 25 and 26).

Advancement in all these courses is individual, depending on the progress made by the student and determined largely by work done without criticism. Advanced standing may be had as in other subjects on the basis of satisfactory work done elsewhere. Drawings should be brought to help determine the student's standing, also letters or certificates from the institution attended.

21. **Free-Hand Drawing.** Introductory Course. Drawing from simple forms in line, and light and shade. Free-hand perspective. Two hours credit.

22. **Free-Hand Drawing.** Drawing from simple architectural ornament in charcoal. Two hours credit.

23. **Free-Hand Drawing.** Drawing from architectural ornament in pencil. *Prerequisite: Drawing 22.* Two hours credit.

24. **Water Color Painting.** Painting from still life. *Prerequisite: Drawing 21 and 22.* Two hours credit.

25. **Free-Hand Drawing.** Drawing from antique casts of heads. Two hours credit.

26. **Free-Hand Drawing.** Drawing from antique casts of full figure. Two hours credit.

27 and 28. **Free-Hand Drawing.** Drawing from life in various media. Admission to these courses is limited to those who have satisfactorily completed the preceding courses or their equivalent. Two hours credit each.

30. **Water Color Painting.** Advanced Course. Painting in water color from still life. *Prerequisite: Drawing 24.* Two hours credit.

31. **Pastel Drawing and Painting.** Drawing and painting from still life in pastel. *Prerequisite: Drawing 21 or equivalent.* Two hours credit.

32. **Painting in Oil.** Painting from still life in oil. *Prerequisite: Drawing 24.* Two hours credit.

33. **Clay Modeling.** Two hours credit.

35. **Pen and Ink Drawing.** Elective. For regular students of Architecture this course must be preceded by Courses 21, 22, and 23 in Drawing, and Architecture 2 and 5. Students not registered in Architecture should have the equivalent of six credit hours in free-hand drawing before electing this course. One or two hours credit.

36. **Pencil Sketching.** Pencil technique, from architecture and landscape. One or two hours credit.

38. **Costume Sketch.** Drawing from the costumed model in various media. One hour credit.

38a. **Advanced Costume Sketch.** One hour credit.

Summer Session

Architectural Design. Problems to be worked out in the drafting room. Study of the requirements of various classes of buildings and of the artistic possibilities of building materials; training of the student in composition in plan, section, elevation, and perspective, in accurate draftsmanship and rendering in line, black-and-white, and color. The following courses in Architectural Design will be offered:

4. *Elementary Architectural Design*. Architectural form, drawing, and rendering. Three hours credit.

5 and 6. *Elementary Architectural Design*. A continuation of Course 4; introductory problems in architectural design. Four hours credit.

7 and 8. *Intermediate Architectural Design*. Credit to be arranged.

9 and 10. *Advanced Architectural Design*. Plan problems. Credit to be arranged.

Free-Hand Drawing. B. *Outdoor Drawing and Painting.* Drawing and painting in charcoal, pencil, pastel, water color or oil from landscape and architectural subjects. An effort is made to meet the needs of the individual student so far as possible. Especial attention is given to the medium, and to the principles of pictorial composition. Architects may substitute this course for Drawing 24. *Prerequisite: Drawing 21 or equivalent.* Two hours credit.

SUMMARY OF STUDENTS

(March 15, 1927)

1926-1927

COLLEGE OF ENGINEERING

	1st Year	2nd Year	3rd Year	4th Year	Spec- ials	To- tals
Civil Engineering		82	91	83	3	259
Mechanical Engineering		78	91	79	3	251
Electrical Engineering		90	77	82	1	250
Chemical Engineering		42	47	35	1	125
Marine Engineering		7	4	10	1	22
Aeronautical Engineering ...		25	36	18	1	80
Geodesy and Surveying			3	7		10
Unclassified, first year	294				1	295
Students who later transferred to Architecture						5
Totals	294	324	349	314	11	1297

COLLEGE OF ARCHITECTURE

Architecture I	43	31	20	14		108
Architecture II	42	41	28	26		137
Architecture III	28	22	19	18		87
Decorative Design	15	7	3			25
Special Students					6	6
Part-Time					2	2
Students who later transferred to Engineering						2
Totals	128	101	70	58	8	367
Undergraduates, College of Engineering						1297
Undergraduates, College of Architecture						367
Students in Colleges of Engineering and Architecture en- rolled in Summer Session 1926						322
Students in Engineering registered in the Graduate School						69
Students in Architecture registered in the Graduate School						1
Number of Students (not counted twice in Engineering and Architecture)						1827

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KEY TO THE MAP OF ANN ARBOR

BUILDINGS OF THE UNIVERSITY OF MICHIGAN ARE SHOWN IN BLACK, ALL OTHERS IN OUTLINE

UNIVERSITY BUILDINGS

- | | |
|---|--|
| 1. University Hall | 26. Heating and Power Plant |
| 2. James B. Angell Hall | 27. University Laundry |
| 3. Museum | 28. Nurses' Homes |
| 4. Alumni Memorial Hall | 29. Palmer Field House |
| 5. Tappan Hall | 30. Couzens' Nurses Home |
| 6. President's Residence | 31. Observatory |
| 7. The William L. Clements Library Building | 32. New University Hospital |
| 8. Physics Building | 33. The Thomas Henry Simpson Memorial Institute for Medical Research |
| 9. Engineering Shops | 34. State Psychopathic Hospital |
| 10. West Engineering Building | 35. University Hospital (Old) |
| 11. Old Power House (R. O. T. C. Headquarters) | 36. Nurses' Home (Dormitory) |
| 12. New Physics Building | 37. Contagious Disease Hospital |
| 13. Economics Building and Physiology and Pharmacology Building | 38. Animal House |
| 14. Medical Building | 39. Gauging Station |
| 15. Power Sub-Station | 40. Hydraulic Testing Flume |
| 16. Waterman and Barbour Gymnasiums | 41. Lane Hall (University S. C. A.—Men's Department) |
| 17. Chemistry and Pharmacy Building | 42. Betsy Barbour House |
| 18. Natural Science Building | 43. The Newberry Residence |
| 19. Law Building | 44. Newberry Hall (University Y. W. C. A.) |
| 20. Library | 45. Morris Hall (Museum Annex) |
| 21. Hill Auditorium | 46. Mimes Theatre |
| 22. Dental Building | 47. Michigan Union |
| 23. University Homoeopathic Hospital (South Department) | 48. The Adelia Cheever Residence Hall and Cottage |
| 24. University Health Service | 49. The Lawyers' Club |
| 25. Storehouse and Shops | 50. Martha Cook Building |

- | |
|---|
| 51. Architectural Building |
| 52. University High School |
| 53. East University Avenue Museum Annex |
| 54. East Engineering Building |
| 55. East Hall |
| 56. New Medical Building |
| 57. Alumnae House |
| 58. Yost Field House |
| 59. Ferry Field Administration Building and Stadium |
| 60. Office of Michigan Daily and other Publications |
| 61. Greenhouse at The Nichols Arboretum |
| 62. Faculty Women's Club |

PUBLIC BUILDINGS

- | |
|--|
| 70. U. S. Post Office |
| 70A. U. S. Post Office Sub-Station No. 1 |
| 70B. U. S. Post Office Sub-Station No. 2 |
| 71. Court House |
| 72. City Hall |
| 73. Armory |
| 74. Fire Department |
| 75. Carnegie Library |
| 76. City Y. M. C. A. |
| 77. City Y. W. C. A. |
| 78. Chamber of Commerce (Interurban Bus Station) |
| 79. County Jail |

- | | |
|---|---|
| 140. Boy Scouts of America Headquarters | 103. Zion Lutheran |
| 141. St. Joseph's Mercy Hospital | 104. Harris Hall |
| 142. St. Thomas Conservatory of Music | 105. Wesley Hall |
| | 106. Tucker Memorial Hall |
| | 107. Salvation Army Hall |
| | 108. Bethel African Methodist Episcopal |
| | 109. Second Baptist Church (Colored) |
| | 110. Beth Israel Center |
| | 111. First Free Methodist |
| | 112. St. Paul's Evangelical Lutheran |
| | 113. Parish Hall (Zion Lutheran) |

HOTELS

- | |
|---------------------|
| 81. Allene Hotel |
| 82. Whitney Hotel |
| 83. American House |
| 84. St. James Hotel |
| 85. Lincoln Hotel |

CHURCHES

- | |
|---|
| 90. First Baptist |
| 91. Bethlehem Lutheran |
| 92. St. Thomas Roman Catholic (St. Mary's Catholic Chapel—corner of William and Thompson Streets) |
| 93. Church of Christ (Disciples) |
| 94. Christian Science |
| 95. Congregational |
| 96. St. Andrew's Episcopal |
| 97. West Side Methodist Episcopal |
| 98. First Methodist Episcopal |
| 99. First Presbyterian |
| 100. Seventh Day Adventist |
| 101. Trinity Lutheran |
| 102. Unitarian |

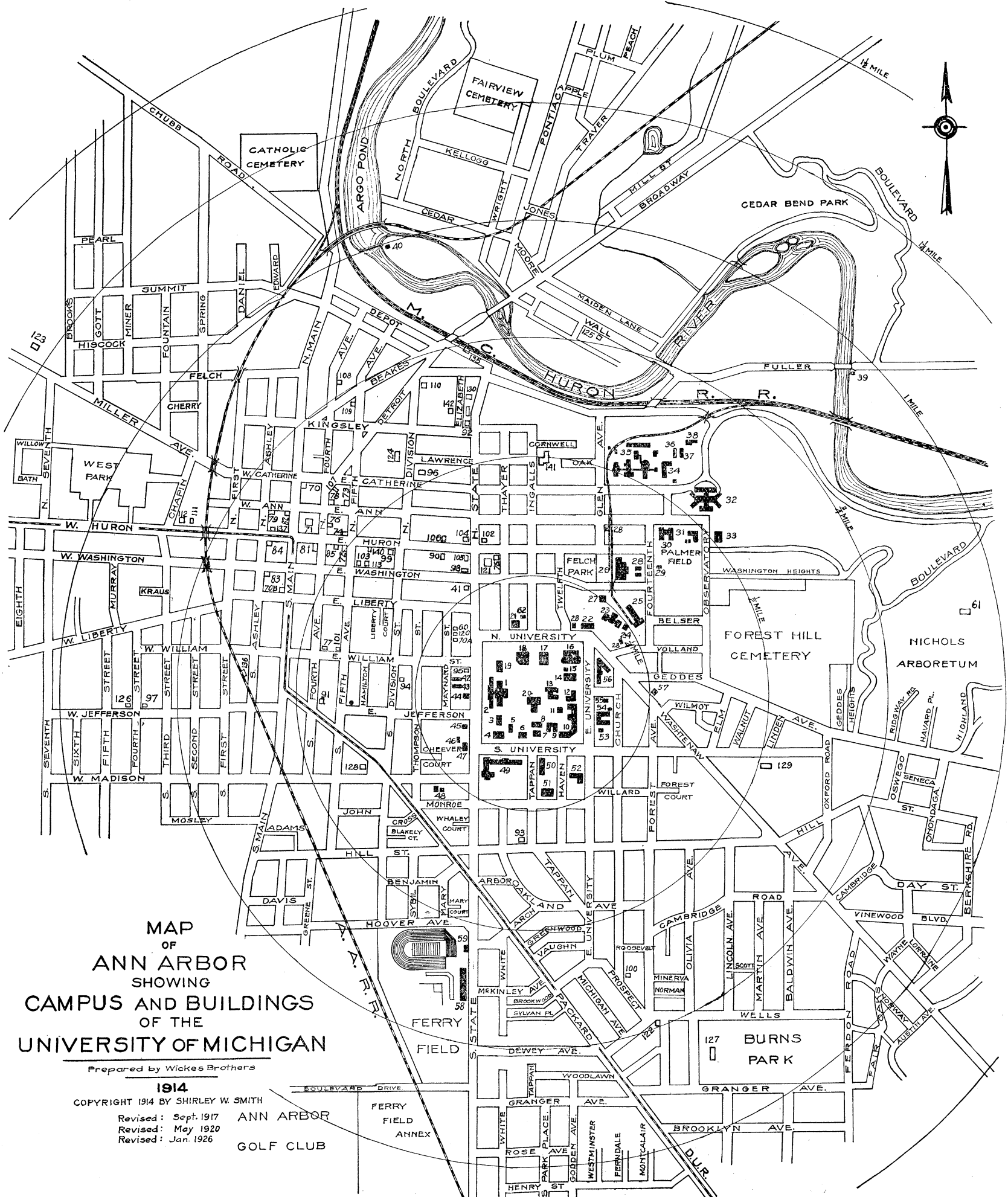
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|---|
| 103. Zion Lutheran |
| 104. Harris Hall |
| 105. Wesley Hall |
| 106. Tucker Memorial Hall |
| 107. Salvation Army Hall |
| 108. Bethel African Methodist Episcopal |
| 109. Second Baptist Church (Colored) |
| 110. Beth Israel Center |
| 111. First Free Methodist |
| 112. St. Paul's Evangelical Lutheran |
| 113. Parish Hall (Zion Lutheran) |

SCHOOLS

- | |
|---------------------------------|
| 120. University School of Music |
| 121. Ann Arbor High School |
| 122. Eberbach |
| 123. Christian Mack |
| 124. Elisha Jones |
| 125. Patrick Donovan |
| 126. Philip Bach |
| 127. Henry P. Tappan |
| 128. W. S. Perry |
| 129. James B. Angell |
| 130. St. Thomas |

RAILWAY STATIONS

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| 135. Michigan Central R. R. |
| 136. Ann Arbor R. R. |
| 137. Detroit United Railway (Electric) |



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