UNIVERSITY OF MICHIGAN
OFFICIAL PUBLICATION
VOL. XXXII, NO. 42 FEBRUARY 14, 1931

# Colleges of Engineering and Architecture

## Announcement
## 1931-1932

Entered as second-class matter at the Post Office at Ann Arbor, Michigan.
Issued by the University of Michigan semi-weekly from March to August, inclusive, and weekly from September to February, inclusive.

# UNIVERSITY OF MICHIGAN

ALEXANDER GRANT RUTHVEN, Ph.D., LL.D., *President*

**College of Literature, Science, and the Arts,** JOHN R. EFFINGER, *Dean*

(Admission officers: The Dean, for advanced standing; Registrar Ira M. Smith, for freshmen.)

General literary and scientific courses; special programs in ancient and modern languages, astronomy, mathematics, landscape design, library science, journalism, physics, chemistry, biology, geology, municipal administration, and social service; preprofessional programs; combined curricula with business administration, dentistry, forestry, law, medicine, and nursing.

**Colleges of Engineering and Architecture,** HERBERT C. SADLER, *Dean*

(Admission officers: Assistant Dean Alfred H. Lovell, for advanced standing in Engineering; Professor Emil Lorch, for advanced standing in Architecture; Registrar Ira M. Smith, for freshmen in Engineering and Architecture.)

Four-year and five-year curricula in civil, mechanical, electrical, chemical, marine, and aeronautical engineering, geodesy and surveying, mathematics, physics, astronomy, engineering mechanics, transportation, architecture, and architectural engineering, and a two-year program for special students in architecture. Broad training in fundamentals. Opportunities for specialization in all departments. Practical instruction in laboratories, shops, and the field, under teachers of professional experience. Combined curricula of mechanical, chemical, and electrical engineering with business administration; combined curriculum in engineering and law; co-operative curricula in civil (highway), electrical, and chemical engineering.

**Medical School**

(Admission officers: The Executive Committee of the Medical School, for Medical School; Registrar Ira M. Smith, for curricula in Nursing.)

Ninety hours of collegiate preparation with one and one-half points required. Four-year graded professional curriculum. Modern laboratories. Ample clinical facilities in hospitals under University control. Three-year and five-year curricula in nursing.

**Law School,** HENRY M. BATES, *Dean*

(Admission officer: The Dean.)

Requirements for admission: (1) an A.B. degree (or its equivalent); or (2) the satisfactory completion of three years' study, (a) on the combined curriculum in letters and law, in the College of Literature, Science, and the Arts; or (b) on the combined curriculum in engineering and law, in the College of Engineering. Three-year curriculum, with graduate year. Instruction in all branches of our system of law, and in international law, Roman law, and jurisprudence. Library of approximately 82,000 volumes.

**College of Pharmacy,** EDWARD H. KRAUS, *Dean*

(Admission officers: Professor Clifford C. Glover, for advanced standing; Registrar Ira M. Smith, for freshmen.)

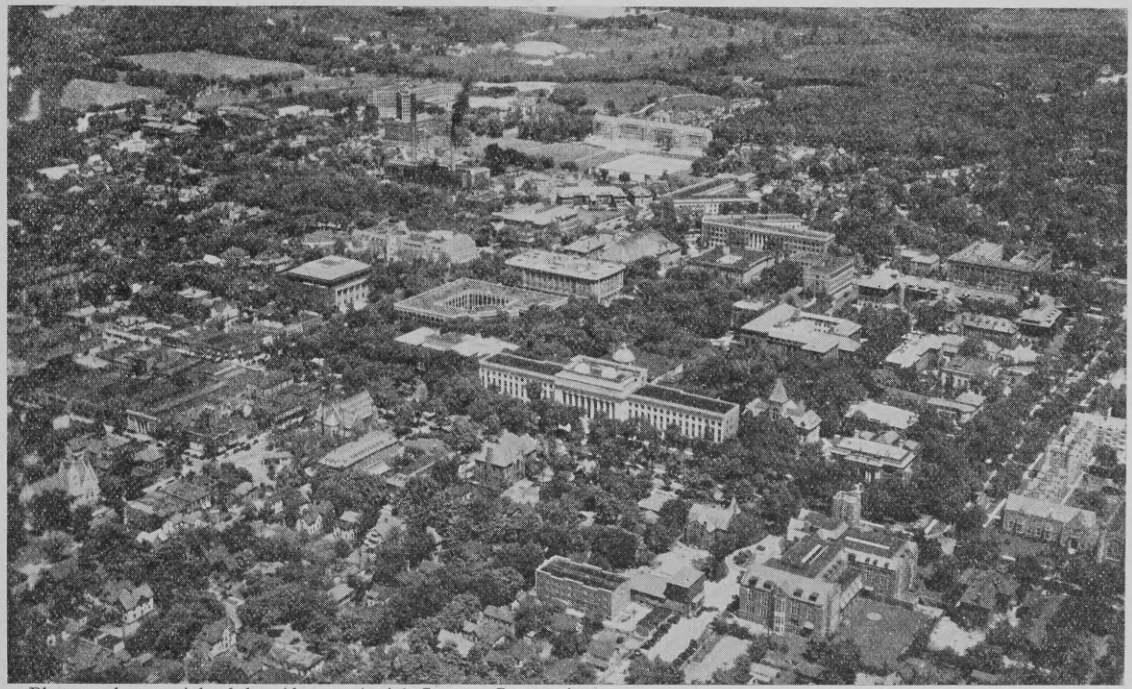
Four-year curricula leading to the degree of Bachelor of Science in Pharmacy. Fully equipped laboratories. Pharmacy experience in Health Service and hospitals. Training for prescription service, manufacturing pharmacy, food and drug inspection, analysis, laboratory and clinical technology, pharmaceutical administration. Combined curriculum in pharmacy and medicine.

*(Continued on inside page of back cover)*

# Colleges of Engineering and Architecture

Announcement
1931-1932


Save this Announcement and bring it with you. It will be needed for reference throughout the year.



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AIRPLANE VIEW OF THE CAMPUS

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

# UNIVERSITY CALENDAR

1931
April 10, Friday, evening.....Spring vacation begins
April 20, Monday, morning.....Classes resume
May 30, Saturday.....Memorial Day, holiday
June 6, Saturday.....Semester examinations begin
June 22, Monday.....COMMENCEMENT

**Summer Session, 1931**

June 23, Tuesday—September 3, Thursday....In the Law School
June 29, Monday—August 7, Friday.....In the Medical School
June 29, Monday—August 21, Friday.....In all other divisions

**Academic Year, 1931-1932**

September 21-25, Monday-Friday.....Examinations for admission
September 22-26, Tuesday-Saturday.....Orientation Period
September 25 and 26, Friday and Saturday.....
.....Classification of all students
September 28, Monday, morning.....FIRST SEMESTER BEGINS
November 26, Thursday.....Thanksgiving Day, holiday
December 18, Friday, evening.....Holiday vacation begins
1932
January 4, Monday, morning.....Classes resume
January 30, Saturday.....Semester examinations begin
February 11-13, Thursday-Saturday...Examinations for admission
February 5, Friday, evening...First semester closes in Law School
February 8, Monday, morning.....
.....Second semester opens in Law School
February 12, Friday, evening.....
.....In all divisions except Law, FIRST SEMESTER CLOSES
February 12 and 13, Friday and Saturday.....
.....Classification for second semester
February 15, Monday, morning.....
.....In all divisions except Law, SECOND SEMESTER BEGINS
February 22, Monday.....Washington's Birthday, holiday
April 8, Friday, evening.....Spring vacation begins
April 18, Monday, morning.....Classes resume
May 30, Monday.....Memorial Day, holiday
June 20, Monday.....COMMENCEMENT

**Summer Session, 1932**

June 21, Tuesday—September 1, Thursday....In the Law School
June 27, Monday—August 5, Friday.....In the Medical School
June 27, Monday—August 19, Friday.....In all other divisions

**Academic Year, 1932-1933**

September 26, Monday, morning.....FIRST SEMESTER BEGINS

West Engineering Building

# Part I

# OFFICERS AND FACULTY, 1930-1931

## BOARD OF REGENTS

### Elected Members

Hon. JUNIUS E. BEAL, Ann Arbor.....Dec. 31, 1931
Hon. RALPH STONE, Detroit.....Dec. 31, 1931
Hon. WILLIAM L. CLEMENTS, Bay City.....Dec. 31, 1933
Hon. JAMES O. MURFIN, Detroit.....Dec. 31, 1933
Hon. ESTHER M. CRAM, Ann Arbor.....Dec. 31, 1935
Hon. LUCIUS L. HUBBARD, Houghton.....Dec. 31, 1935
Hon. WALTER H. SAWYER, Hillsdale.....Dec. 31, 1937
Hon. R. PERRY SHORTS, Saginaw.....Dec. 31, 1937

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ALEXANDER GRANT RUTHVEN, *President of the University*

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SHIRLEY W. SMITH, *Secretary*
ROBERT A. CAMPBELL, *Treasurer*

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WILLIAM HENRY BUTTS, Ph.D., *Professor Emeritus of Mathematics* 1122 Hill Street
WILLIAM HENRY WAIT, Ph.D., *Professor Emeritus of Modern Languages* 332 East William Street
FRED NEWTON SCOTT, Ph.D., *Professor Emeritus of Rhetoric* Tucson, Arizona

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WALTER LUCIUS BADGER, M.S., *Professor of Chemical Engineering* 917 Church Street
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ERNEST FRANKLIN BARKER, Ph.D., *Associate Professor of Physics* 18 Ridgeway
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WELLS IRA BENNETT, M.S., *Associate Professor of Architecture* 500 Highland Road
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WILLIAM WARNER BISHOP, A.M., Litt.D., LL.D., *Librarian* 733 Oakland Avenue
ORLAN WILLIAM BOSTON, M.S.E., M.E., *Professor of Shop Practice, and Director of Engineering Shops* 2021 Vinewood Boulevard
HARRY BOUCHARD, B.C.E., *Associate Professor of Surveying* 1111 Woodlawn Avenue
‡JOHN WILLIAM BRADSHAW, Ph.D., *Professor of Mathematics* 1304 Cambridge Road
EDWARD MILTON BRAGG, S.B., *Professor of Marine Engineering and Naval Architecture* 1056 Ferdon Road
JOHN CROWE BRIER, M.S., *Professor of Chemical Engineering* 2301 Vinewood Boulevard

*Died January 25, 1930.
†In this list are included the names of certain instructors in other Colleges offering courses of interest to students in engineering and architecture.
‡On leave of absence, 1930-1931.

HUGH BRODIE, C.E., *Associate Professor of Surveying*
611 Forest Avenue
GEORGE GRANGER BROWN, Ph.D., Ch.E., *Professor of Chemical Engineering* 2037 Geddes Avenue
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JAMES HARLAN CISSEL, B.S.(C.E.), *Professor of Structural Engineering* 2022 Hill Street
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1619 South University Avenue
*JAMES WATERMAN GLOVER, Ph.D., *Professor of Mathematics and Insurance* 620 Oxford Road

*On leave of absence.

MOSES GOMBERG, Sc.D., *Professor of Organic Chemistry* 712 Onondaga Street

SAMUEL ABRAHAM GOUDSMIT, Ph.D., *Associate Professor of Physics* 216 South Ingalls Street

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THEOPHIL HENRY HILDEBRANDT, Ph.D., *Professor of Mathematics* 1930 Cambridge Road

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WILLIAM HERBERT HOBBS, Ph.D., D.Eng., *Professor of Geology, and Director of the Geological Laboratory* 1705 Hill Street

LOUIS ALLEN HOPKINS, Ph.D., *Associate Professor of Mathematics, and Secretary of the Colleges of Engineering and Architecture* 1517 South University Avenue

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HORACE WILLIAMS KING, B.S.(C.E.), *Professor of Hydraulic Engineering* Hilldene Manor

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WALTER EDWIN LAY, B.M.E., *Professor of Mechanical Engineering* 101 Orchard Hill Drive

ALFRED OUGHTON LEE, M.D., *Professor of Modern Languages* 2307 Hill Street

DAVID MARTIN LICHTY, Ph.D., *Associate Professor of General and Physical Chemistry* 922 Olivia Avenue

ANDERS FREDRIK LINDBLAD, Sc.D., *Associate Professor of Naval Architecture* 1408 Wells Street

*GEORGE ALLAN LINDSAY, Ph.D., *Associate Professor of Physics* 2015 Day Street

EMIL LORCH, A.M., *Professor of Architecture, in Charge of the College of Architecture* 718 Church Street

CLYDE ELTON LOVE, Ph.D., *Professor of Mathematics* 1915 Scottwood Avenue

ALFRED HENRY LOVELL, M.S.E., *Professor of Electrical Engineering, and Assistant Dean, College of Engineering* 3000 Geddes Road

GEORGE MCDONALD MCCONKEY, B.A.E., *Professor of Architecture* R.R. 2, Washtenaw Road

FERDINAND NORTHRUP MENEFEE, C.E., *Professor of Engineering Mechanics* 6 Geddes Heights

CHARLES FERDINAND MEYER, Ph.D., *Associate Professor of Physics* 1137 Fair Oaks Parkway

HENRY WILLARD MILLER, M.E., *Professor of Mechanism and Engineering Drawing* 1809 Hill Street

ARTHUR DEARTH MOORE, M.S., *Associate Professor of Electrical Engineering* 718 Onondaga Street

ROGER LEROY MORRISON, A.M., C.E., *Professor of Highway Engineering and Highway Transport* 1928 Lorraine Place

JOSEPH RALEIGH NELSON, A.M., *Professor of English, and Editor of Publications in Engineering Research* 2145 Melrose Avenue

JOHN MINERT NICKELSEN, B.S.(M.E.), *Associate Professor of Mechanical Engineering* 511 Linden Street

JULIUS CLARK PALMER, B.S., *Associate Professor of Mechanism and Engineering Drawing* 14 Ridgeway

†GEORGE WASHINGTON PATTERSON, Ph.D., *Professor of Engineering Mechanics, and Associate Dean of the College of Engineering* 2101 Hill Street

FELIX WLADYSLAW PAWLOWSKI, M. and E.E., M.S., *Guggenheim Professor of Aeronautical Engineering* 925 Greenwood Avenue

VINCENT COLLINS POOR, Ph.D., *Associate Professor of Mathematics* 930 Packard Street

HARRISON MCALLISTER RANDALL, Ph.D., *Professor of Physics, and Director of the Physics Laboratory* 1208 Prospect Street

DANIEL LESLIE RICH, Ph.D., *Associate Professor of Physics* 720 East University Avenue

HENRY EARL RIGGS, A.B., C.E., *Honorary Professor of Civil Engineering, and Honorary Curator of the Transportation Library* Underdown Road, Barton Hills

*On leave of absence, 1930-1931.
†Died May 22, 1930.

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East Engineering Building

# Part II

# GENERAL INFORMATION

## COLLEGES OF ENGINEERING AND ARCHITECTURE

### HISTORY

1. The University of Michigan, founded in 1817, 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, and of Pharmacy, the Medical School, the Law School, the School of Dentistry, the School of Education, the School of Business Administration, the School of Forestry and Conservation, the School of Music, and the Graduate School, each of which publishes a separate annual announcement. The various Faculties include over eight hundred and fifty officers of instruction, and several hundred assistants, some of whom participate in the work of teaching. About fifteen thousand 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 of 1837, under which the University was organized in its present form, provision was made for instruction in engineering. There are few older technical schools in the United States. The first professor of civil engineering was appointed 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 subdepartment of the College of Engineering in 1906. In 1913 the College of Architecture was given control of its programs of study, and, in general, charged with the administration of its affairs.

The aim of the Colleges of Engineering and Architecture 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 provides 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 series of lectures at moderate prices in which important lecturers appear.

## PROGRAMS OF STUDY

3. The College of Engineering has four-year programs of study in aeronautical, chemical, civil (including transportation), electrical, and mechanical engineering, geodesy and surveying, naval architecture and marine engineering, astronomy, engineering mechanics, mathematics, and physics.

The work offered by the several departments is usually broader than the name of the department may indicate. For example, under Chemical Engineering will be found metallurgical, industrial, and general chemical engineering; under Civil Engineering will be found structural, hydraulic, transportation, sanitary, and municipal engineering; under Electrical Engineering will be found power, communication, and illumination engineering and electrical design; under Geodesy and Surveying will be found geodesy, topographic and boundary surveying, and courses on the legal and administrative problems involved in titles and boundaries; under Mechanical Engineering will be found steam power, internal combustion, hydromechanical, heating, ventilating and refrigerating, automobile, and industrial engineering, and machine design; under Naval Architecture and Marine Engineering will be found in addition water transportation.

Related to transportation engineering is the subject of transportation. The University of Michigan is very fortunate in having unusual facilities for the study of transportation, including a special transportation library containing 75,000 items, and departments offering instruction in aeronautical, automobile, marine, railway, highway, and electrical engineering—including the design and construction of vehicles of transportation and of electric communication (telephone, telegraph, and radio)—and in economics, business administration, and other subjects of importance to the student of transportation. The curriculum in transportation has as a foundation the courses common to the present professional curricula.

In co-operation with the School of Business Administration the College has five-year programs in chemical and industrial engineering, electrical and industrial engineering, and mechanical and industrial engineering.

Also engineering students who have completed at least three years of prescribed work with an average grade of 2.0 may transfer to the School of Business Administration, provided they have completed not less than 90 semester hours including 18 hours of economics (not less than 6 hours in economic principles and 6 hours in accounting). On the satisfactory completion of two years of work in that School they may be granted the degree of Master of Business Administration.

The College of Engineering, in co-operation with the Law School, offers a six-year engineering-law curriculum in which a student spends three years in the College of Engineering and then enters the Law School. On the satisfactory completion of his pre-law work and that of the first year's program in the Law School, he receives the degree of Bachelor of Science in Engineering; on satisfactory completion of the law curriculum, he receives the law degree. A student who transfers to the Law School without completing the first three years of the engineering-law curriculum does not receive the degree in Engineering. For details see section 83.

The Civil Engineering Department offers a co-operative program in highway engineering in which the summer is spent with the Highway Department of the State or of an important county.

The Electrical Engineering Department offers a five-year co-operative program with industry, conforming substantially to the following principles: Co-operative relations will be established only with such industries as are able and willing to offer a definite program of graded work of educational value. The student will undertake the co-operative work during periods of an entire semester or an entire summer session. Credit for the co-operative work will be given only on completion of the entire prescribed program.

The College of Architecture offers four-year programs in architecture, architectural design, architectural engineering, and decorative design, and a two-year program for special students in architecture.

The programs in engineering are described in Part V, those in architecture in Part VI of this Announcement.

## COMBINED PROGRAMS WITH OTHER INSTITUTIONS

4. The College of Engineering has an agreement with Albion, Olivet, and Battle Creek Colleges, and the College of the City of Detroit, under which a student who has been in residence at one of these colleges for three years and has completed with a good record a prearranged program including substantially the work of the first two years of the College of Engineering may be admitted to the College of Engineering, and after two additional years be graduated in engineering.

A college under this agreement accepts the first year at the College of Engineering in lieu of its senior year, and if the student's record is satisfactory graduates him.

## ORIENTATION PERIOD

5. During Orientation Period, before the opening of school, the campus is virtually turned over to new students. Each group of twenty is placed in charge of a faculty adviser. Routine matters, such as payment of fees, medical examination, and classification, are handled in such a way that waiting in long lines is eliminated as far as possible. In addition, many special features, such as talks, sings, mixers, inspection trips, and discussion groups are included, the whole purpose being to give the student a proper introduction to the University. Further detailed information is furnished to each freshman on acceptance of his application.

## ACADEMIC YEAR AND SUMMER SESSION

6. The academic year extends from September 28, 1931, to June 20, 1932. The Summer Session, between the student's first and second, second and third, or third and fourth years, extends eight weeks, from the Monday following Commencement (June 29 to August 21, 1931).

Every student in the College of Engineering, in order to finish his program 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

7. New students expecting to take the examinations for admission to the University the first semester must present themselves September 21-25, 1931; for the second semester, February 11-13, 1932.

All freshmen are required to report on Tuesday, September 22, for registration and the activities of Orientation Period. No freshman will be excused from attendance during Orientation Period 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

8. 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. For freshmen, the record of work done in the preparatory school must be presented on a form to be obtained from the Registrar of the University; for students transferring from other colleges, the transcript of record usually includes a satisfactory statement.

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

9. All students whose native language is other than English shall, upon matriculation and registration in the Colleges of Engineering and Architecture, 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 Colleges of Engineering and Architecture 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 is considered as on trial. If at the end of the semester he passes his work, credit will 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 will be disregarded but he will 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 will 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 advanced credit will be granted foreign students until they have been in residence at the University at least one semester.

## REQUIREMENTS FOR ADMISSION

10. Requirements for admission are stated in units, a unit being defined as a course covering an academic year and including in the aggregate not less than the equivalent of one hundred and twenty sixty-minute hours of classroom work. Two to three hours of laboratory, drawing, or shop work are counted as equivalent to one of recitation.

Applicants for admission as freshmen without deficiencies* must present fifteen high school units, including the following:

*PROVISIONAL ADMISSION.—In general, an applicant for admission either on certificate or by examination who lacks not more than one and one-half of the units prescribed as shown in Groups I and II of section 10, may, if he presents fifteen acceptable units, be admitted provisionally. These deficiencies must be made up during the first year of residence, without credit toward graduation. 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.

GROUP I—TEN UNITS

For admission to the Colleges of Engineering and Architecture, all of the following must be presented:

English ..... 3 units
(Grammar, Composition, Classics, History of English Literature)
Mathematics ..... 3 units
(Algebra, through quadratics; Geometry—Plane, Solid, and Spherical)
Physics ..... 1 unit
History ..... 1 unit
Greek, Latin, German, French, or Spanish—one of these. 2 units

GROUP II—ONE AND ONE-HALF OR TWO UNITS

One and one-half or two units also in any one of the following combinations must be presented. The first combination is urgently advised.

Trigonometry .....½
Chemistry ..... 1
or
Chemistry ..... 1
Foreign Language (additional) ..... 1
or
Trigonometry .....½
Foreign Language (additional) ..... 1
or
Foreign Language (additional) ..... 2

or
Trigonometry .....½
Botany, Zoology, or History (additional)..... 1
or
Foreign Language (additional) ..... 1
Botany, Zoology, or History (additional)..... 1
or
Other combinations of the above subjects ..... 2

For students entering the College of Architecture, Free-hand Drawing and Mechanical Drawing may be substituted in Group II. In order to enter the College of Architecture under the most favorable conditions, the fifteen units offered for admission should include the following: English, 3 units; Mathematics, including plane trigonometry, 3½; Physics, 1; Chemistry, 1; History, 1 or more; Modern Languages, 2 or more; Free-hand Drawing, 1 or more; Manual Training, ½ or 1.

GROUP III—THREE AND ONE-HALF OR THREE UNITS

The remaining three or three and one-half units may be presented in any subjects for which credit toward graduation is given by the accredited school and which are taught in a manner approved by the University. But see section 11 with regard to the maximum number of credits allowed for vocational work.

NOTES ON THESE REQUIREMENTS

**English.**—Four units of English should always be presented whenever it is possible.

**Foreign Language.**—No less than two units of any language will be accepted for admission. Foreign languages other than those listed are sometimes accepted, in the case of students whose native language is other than English. These cases will be considered individually.

**Chemistry and Trigonometry.**—It is urgently advised that one unit of Chemistry and one-half unit of Trigonometry be included in the fifteen units offered for admission. The student who presents the full requirements without Chemistry and Trigonometry must take Chemistry 3 and Mathematics 8 in his first college year, which may necessitate more than the usual time to complete the graduation requirements. Chemistry and Trigonometry are offered in the Summer Session to accommodate those students who wish instruction in them before entering college.

**Science.**—In order that a half unit in science may be accepted, it must be supplemented by a second half unit in science. For this purpose the only groupings permitted are the following:

*a*) Botany and Zoology
*b*) Zoology (or Botany) and Physiology
*c*) Physiography and Geology
*d*) Physiography and Physiology

11. **Vocational Units.**—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 three hundred and sixty periods, not less than forty-five minutes each.

All applicants must send prospectuses of the 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.

DRAWING.—*Free-hand Drawing,* one-half or one 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. Pencil, charcoal, or brush may be used.

*Mechanical Drawing,* one-half or one 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, 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.

*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.—Not more than two units will be accepted. The work accepted may be:

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

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 commercial branches, 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-entry 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 textbooks on 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

12. Only those applicants are admitted on certificate who are officially recommended graduates of high schools accredited to this University* and have completed in a standard high school a full four-year curriculum covering at least fifteen units of acceptable entrance credit.

It is expected that the principal will recommend not all graduates, but only those whose character, scholarship interests and attainments, seriousness of purpose, and intellectual promise 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.

The principals of approved schools are urged to send direct to the Registrar, immediately at the close of the first semester of the senior year, upon the blank furnished by the University, the application of each prospective graduate intending to enter the

*A bulletin containing a list of the accredited schools in the State of Michigan, together with the requirements for accrediting, will be sent upon request.

freshman class at the beginning of the ensuing year. The applicant will be given a tentative report concerning his eligibility for admission, which will be confirmed when the principal's supplementary report of the final semester's work has been received by the Registrar. If the applicant's credentials are satisfactory, he will receive a certificate of admission to the University without examination, contingent only upon the passing of a medical examination at the time of registration.

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 especially satisfactory preparation in mathematics and in English. This preparation may be shown by a certificate of work done or by attendance at the Summer Session of the University of Michigan with a satisfactory record of eight hours of work, a part of which must be in mathematics.

As a general rule no advanced credit will be given for work done in the usual high school course. However, college credit may be given for languages presented in excess of the fifteen units required for admission, if the courses are deemed equivalent to similar courses in the University. Such credit will be adjusted after admission.

A student who for any reason has failed to secure a certificate of graduation and his principal's recommendation will be required to pass the regular examinations for entrance in all subjects.

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

## ADMISSION BY EXAMINATION

13. Fifteen units are required for admission. Eleven and one-half or twelve units are prescribed as shown in Groups I and II of section 10. The three and one-half or three units remaining may be presented in any of the other subjects mentioned under admission requirements in section 10. In general, applicants will not be admitted with deficiencies in more than one and one-half units of the prescribed units.*

*The conditions under which an applicant may be admitted provisionally are given on page 29.

No one is admitted partially by examination and partially on certificate. School credits are not accepted in lieu of the examination given by the University.

Candidates for admission who have passed College Board, New York State Regents, or Canadian Matriculation Examinations with satisfactory grades will be excused from further examinations in the subjects covered. All applications for examination by the College Entrance Examination Board must be addressed to the Secretary, 431 West 117th Street, New York, N. Y., and must be made on a blank form to be obtained from its Secretary on application.

Those applicants for admission who are not entitled to enter on certificate, and who wish to take the entrance examinations given by the University should make definite arrangements with the Registrar *at least one month* in advance of the dates set for the examination. Entrance examinations are held each year in September, February, and June.

The applicant may divide the examination, taking one part either a year or a semester before the date of his admission, and the second part at the time of admission. But if he fails to secure the requisite number of units within this specified time he forfeits all credits for the subjects he may have passed.

Applicants presenting themselves too late for the scheduled examinations are required to pay an examination fee of five dollars.

Students desiring to validate credits in Zoology by the examination method must present laboratory notebooks at the time of the examinations.

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

14. A student in another college or university who intends to enter the College of Engineering or of 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, mathematics, physics, chemistry, and the nontechnical 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 of the College of Engineering or the Professor of Architecture will be glad to give information concerning admission requirements or other matters of a general nature.

Students who receive on admission less than twenty-four hours of advanced credit are tentatively considered as freshmen; those presumably to be graduated within one year are considered as seniors; other entering students will be considered as sophomores until they have been in residence one semester and have satisfied the requirement for recognition as upperclassmen, for which see section 32.

*a*) Graduates of the University and of 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 a 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 Architecture in two years should also complete the equivalent of Drawing 21, 22, and 23, and Architecture 1, 4, 5, 6, and 21.

A student who has completed a regular four-year course at an approved college or other institution may be admitted to the Colleges of Engineering and Architecture as a senior provided that,

*A student enrolled in the College of Literature, Science, and the Arts, who desires to elect, in the College of Engineering or Architecture, any course which is not printed in the Literary Announcement, must obtain the written permission of the Assistant Dean of the Literary College.

in general, the course completed has covered substantially the equivalent of the required work in the first three years of the program he desires to follow at the University of Michigan. The courses to be taken during residence at the University will depend upon his 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, the student will be recommended for the degree of Bachelor of Science in Engineering or Bachelor of Science in Architecture.

*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 12.

*c*) A student who has not completed a year's college work in an approved college, but before entering 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 12 or 13.

## ADMISSION ON COMBINED PROGRAMS

15. Students who have completed the first three years of the combined programs arranged by the College of Engineering with Albion, Olivet, and Battle Creek Colleges and the College of the City of Detroit, are admitted as juniors. For the admission of other students from these colleges see the regulations in section 14.

## ADJUSTMENT OF ADVANCED CREDITS

16. All advanced credits are adjusted by the Assistant Dean of the College of Engineering or the Professor of Architecture; and, until a transcript of record at another institution or other like information is furnished, no one is authorized to say what credit may be given 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 transcript 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, Room 207, Architecture Building. It is desirable that credentials should be submitted as far in advance of registration week 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 AS GRADUATE STUDENTS

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

## ADMISSION AS SPECIAL STUDENTS

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

Persons 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 an architect's office, 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, and 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 10.

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

## FEES AND EXPENSES

19. *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.*

**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.

**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, $113; for all others, $138. 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, membership in the Michigan Union or Michigan League, as well as medical attention from the University Health Service and dispensary.

**Part-Time Fees.**—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 a total of ten hours in one academic year and not more than six hours in any one 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. The special privileges of Michigan Union or Michigan League membership, outdoor physical education, and Health Service are not included; *but these may be secured by paying the appropriate extra fees at the time of registration.*

**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.

**Fee for Special Entrance Examination.**—An applicant for admission who desires to take the entrance examination at a time other than that 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.

**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. 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.

**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).

**Other Expenses.**—There are no dormitories for men (except students in the Law School) and no commons connected with

the University. Students obtain board and lodging in private families. Room rent varies from three and a half to six dollars a week for each student. The cost of board is from seven to eight dollars a week.

**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 $860 for residents of Michigan, $900 for non-residents. By practice of strict economy it may be possible to keep these expenses close to $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 from $18 to $32, and, if well selected, will be serviceable for many years. The set should not be bought before coming to Ann Arbor.

The cost of attending the Camp Davis Summer Session is about $125. See section 78.

## REFUNDING OF FEES

20. *a*) *No student will be entitled to a refund except after surrender to the Secretary of the University of the student's original receipt from the Treasurer of the University, the athletic coupon book and all tickets issued to such student for athletic events not yet having occurred, the Michigan Union or Michigan League membership card, and the identification card. Students should scrupulously preserve all receipts, as in case of loss of the receipt* $5 *will be deducted from the refund as a penalty.*

*b*) No refund will be granted unless applied for within one year after withdrawal.

*c*) No refund of matriculation fee is made except in case of withdrawal within the first two weeks after registration.

*d*) A 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.

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

*f*) A student who withdraws more than eight weeks after the beginning and not later than the end of the semester of registration is entitled to a refund of 40 per cent of his annual fee.

*g*) The 40 per cent refund to students enrolling at the beginning of the second semester by permitting them to register for 60 per cent of the annual fee shall be included in determining any further refund to withdrawing students under (d) and (e) above.

*h*) A student who transfers at the beginning of the second semester from one School or College to another in which the annual fee is higher shall be required to pay an additional amount sufficient to bring the total fee to that in the latter School or College.

*i*) A student enrolling during the second semester in a different School or College from that in which he was enrolled during the first semester shall not be required to pay a total annual fee in excess of the higher annual fee in these two divisions of the University.

*j*) Refunds for Summer Session or short courses will be made pro rata on the basis of the foregoing rules.

## SELF-SUPPORTING STUDENTS AND STUDENT EMPLOYMENT

21. The normal number of hours that students should carry each semester is between sixteen and eighteen. Students who support themselves wholly or in part should 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.

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 recommends 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 curriculum. Each student doing outside work should notify his classifier 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

22. There are several fellowships and scholarships in the Colleges of Engineering and Architecture. For details see sections 44-45 and 115, or the bulletin on Scholarships, Prizes, and Loan Funds.

There are also appointed annually 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

23. 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.

## MICHIGAN UNION AND MICHIGAN LEAGUE

24. The University of Michigan Union was organized and incorporated under the laws of the State of Michigan in 1904 to establish a University social center, to provide a meeting place for faculty, alumni, and students of the University, to furnish a home for alumni when in Ann Arbor, and a place for wholesome relaxation for students. As a social center it encourages and stimulates activities that are for the welfare and enjoyment of the student body, thus fostering a richer, more intense University life, a product of the student's own work. In recognizing neither artificial barriers nor distinctions, the Union serves as a democratizing influence in the student body; in emphasizing the social value

of education, it complements the work of the University in its endeavor to graduate broadly educated men and good citizens. Membership in the Union is restricted to men.

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 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 fee of every male student of the University.

The Michigan League Building, erected by alumnae and friends of the University and completed in 1929, provides for the women of the University a clubhouse similar in scope to that of the Michigan Union for men. Every woman attending the University pays, in her tuition, a fee of ten dollars, which entitles her to all the privileges of the League and at the end of her four years of college automatically secures for her a life membership with no further dues.

## UNIVERSITY HEALTH SERVICE

25. The University Health Service, which is located on North University Avenue, concerns itself with many factors that are important in preventive medicine, as well as with curative measures, in its efforts to conserve the health of students. These activities are supported by a portion of the annual fee. The Health Service provides for practically all medical attention the student needs during the school year, and is open also to students of the Summer Session and to students remaining during the regular vacations.

The Health Service Dispensary, where students may receive any office medical attention, including special examinations and the usual medicines, is open regularly during class hours. A student may consult any physician of the Health Service at choice.

If a student receives attention from a Health Service physician at his room, a charge of one dollar for a day call and two dollars for a night call is made. The corps of physicians in the Medical School co-operates with the Health Service whenever students need the attention of such specialists. Health Service attention is extended to full-time students and to part-time students who pay the Health Service fee at the time of enrollment.

Provision is made for the care of sick students requiring bed care. If the care of such a student is previously approved by the Health Service, thirty days' service may be obtained.

## FACILITIES FOR PHYSICAL EDUCATION

26. The University is provided with excellent gymnasiums, Waterman Gymnasium for men, and Barbour Gymnasium for women. The main floor of 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 classwork 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 classwork is arranged to overcome this condition. Both athletic and gymnastic work is given, however, in order to produce variety and enthusiasm for

exercise. Men qualifying for freshman football, cross-country running, hockey, track, basketball, swimming, boxing, fencing, and wrestling teams are given credit in physical education, 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, the offices of the Dean 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 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 new field house for women on Palmer Field provides bowling alleys, indoor golf school, indoor archery range, rifle range, lockers, and showers.

The facilities of the Gymnasium, including physical examination and instruction, are free for all students, the only charge being a rental of $2 a year for a locker. For men, 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, and in the School of Music. Classes begin Monday of the third week of the first semester. Students electing Military Science are excused from the work in Physical Education. During the year six hygiene lectures are given in connection with the physical training practice. All freshmen including those electing Military Science are required to attend these lectures.

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. The University eighteen-hole golf course is located southwest of Ferry Field. 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, an indoor play-

ground known as Yost Field House, and the Intramural Sports Building.

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, indoor golf, and wrestling.

The Intramural Sports Building, similar in design and construction to Yost Field House, contains 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. This building forms the north side of a quadrangle which includes the Administration Building, concrete stand for track and field athletics, west tennis court unit, and Yost Field House.

The field house and the sports building give a complete athletic plant that functions the year around.

## ASSEMBLY AND MENTOR SYSTEM

27. Each engineering class has its separate assembly. The freshman class is brought together once a week, other classes about four times a year. Attendance at freshman assembly is required; unexcused absences subject the absentee to discipline. In freshman assemblies, faculty members and visiting engineers address the students, and the regular business of the class is assured of attention by the class as a whole.

Closely connected with these assemblies is the Mentor System. When Orientation Period ends, the Mentor System begins; the faculty Adviser continues with his group as Mentor for the group. Both socially and in an advisory capacity 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 about six weeks after the beginning of the semester, and about four weeks before the final examinations; 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.

## HONOR SYSTEM

28. 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

29. All undergraduate women of the University must make arrangements for their rooms, through the office of the Dean of Women, from the list 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 Dean of Women.

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

## RULES GOVERNING ELECTION OF STUDIES

30. *a*) No student shall be permitted to elect less than 12 hours, and no student whose grade average for the preceding semester is less than 3 shall be permitted to elect more than 18 hours a semester (exclusive of Military Science), except by permission of the Hours 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 classification, no study can be taken up or dropped without special permission of the classifier. The time for dropping any course without record is limited to six weeks from the opening of the semester. A course may be dropped only with the permission of the classifier after conference with the instructor in the course. Only in special cases, and then only for good and valid reasons, will permission to drop a course be given after this time. Such permission is granted by the Assistant Dean after conference with the classifier in charge of the group and the instructor in the course.

*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

31. 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.

Unexcused absences from Assembly during the freshman year are considered by the Discipline Committee as acts of insubordination. After two absences unexcused by the Head Freshman Mentor, the student is warned by the Discipline Committee. After two more unexcused absences, the Discipline Committee places the student upon probation for insubordination, the probationary period to last for the remainder of the freshman year. Two more unexcused absences will subject the student to the penalty of suspension in the usual manner for the remainder of the school year.

## UPPERCLASSMEN

32. 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 program 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.

*For the definition of upperclassmen see section 32.

## EXAMINATIONS AND ENTRANCE DEFICIENCES

33. Examinations for admission are held before the beginning of each semester. See section 13.

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 classifier 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

34. 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 with a qualifying grade may be given 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 examina-

tion 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 eighth week 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

35. *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. A supplementary grade removing an incomplete shall be used in computing averages when that grade is different from the original semester grade qualifying the report of incomplete. It is permissible for a student to repeat a subject in order to raise his grade average.

*d*) No student whose general average grade is below 2.0 may be graduated.

*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 of work a semester or 6 hours a summer session.

*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.

## REGENTS' RULE GOVERNING OPERATION OF MOTOR VEHICLES BY STUDENTS

36. "No student in attendance at the University shall operate any motor vehicle. In exceptional and extraordinary cases at the discretion of the Dean of Students this rule may be relaxed."

## WITHDRAWAL FROM THE COLLEGES

37. 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

38. 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 Department of Civil Engineering.

The other Departments, some of which are outgrowths of civil engineering and others of different origin, are Engineering Me-

chanics, Geodesy and Surveying, Mechanical Engineering, Electrical Engineering, Naval Architecture and Marine Engineering, Chemical Engineering, and Aeronautical Engineering, all degree-conferring departments.

The Departments of Astronomy, Mathematics, and Physics, which serve the whole University, co-operate with the College of Engineering in its programs leading to the degree of Bachelor of Science in Engineering with specialization in Astronomy, Mathematics, or Physics.

In addition to the degree-conferring departments, the College of Engineering has departments of instruction in Mechanism and Engineering Drawing and in Shop Practice; and it uses, with the rest of the University, the Departments of English, Modern Languages, Chemistry, 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. This 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

39. 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 also shares

with the rest of the University in the use of the Library, the East and the West Physics Buildings, the Chemistry Building, the Astronomical Observatory, the Gymnasiums, etc. The summer work in surveying is carried on at Camp Davis. See section 78.

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, and Marine Engineering, Geodesy and Surveying, Mechanism and Engineering Drawing, Engineering Mechanics, and Mathematics.

The East Engineering Building, completed in 1923, with a gross floor area of 160,000 square feet, contains laboratories, classrooms, shops, drawing rooms, libraries, and offices, and houses the Chemical Engineering Department, the Engineering Shops, the Department of Engineering Research, the Division of Transportation Engineering, the State Highway Laboratories, and the Department of Aeronautical Engineering.

The West Engineering Annex provides additional space for Mechanical Engineering (automobile engineering), Engineering Mechanics, 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 for the nontechnical subjects.

A new building has recently been completed for the College of Architecture.

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.

40. **The Libraries.**—A large modern library building, erected at a cost of $615,000, was opened in January, 1920. This building has general and special reading rooms accommodating a thousand students at a time, and is equipped with modern appliances for the housing and serving of books.

The University Libraries contain at present about 765,000 volumes, of which many are of importance to engineers and architects. The periodicals regularly received number over 5,100.

THE WEST ENGINEERING LIBRARY, comprising over 17,600 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.

THE EAST ENGINEERING LIBRARY, opened in 1924, is housed on the third floor of the East Engineering Building. It is provided with 7,000 books, and 160 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.

TRANSPORTATION LIBRARY.—The Transportation Library contains 100,000 items 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.

THE ARCHITECTURE LIBRARY in the new building for the College of Architecture contains a collection of books of value to architectural students. For additional information see section 112.

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

THE WILLIAM L. CLEMENTS LIBRARY of American History, completed in 1923, the gift of Hon. William L. Clements, B.S., '82, 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, pamphlets, and

manuscripts dealing with our early colonial history and the period of the American Revolution. It numbers 23,859 volumes.

41. **University Power Plant.**—The University Power Plant is an example of modern power plant construction and is used for purposes of instruction as well as to furnish heat, power, and light to the university buildings. The boiler room equipment consists of fourteen boilers totaling 8200 rated horsepower with all necessary auxiliaries and a complete coal and ash handling system. Coal is brought directly from the Michigan Central Railroad to the plant over an electrically-operated road. The generating equipment has a total capacity of 4350 kw. in turbo-alternator units. Tunnels are provided for the underground distribution of steam, hot water, and electrical energy. There is available alternating current at 2,300 volts, 230 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. The station operates in parallel with the system of the Detroit Edison Company.

42. **Visits of Inspection.**—The University is well situated for excursions to engineering industries. In Ann Arbor there is a modern machine-switching telephone exchange. 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 latest engineering practice in hydraulic and electrical design.

At Detroit there is much of interest to students of 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 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 each year about forty industrial plants illustrating the transition from 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 to inspect the various types of aircraft and port equipment both for water and air transportation.

## SOCIETIES

**43. The Engineering Council.**—The Engineering Council of the University of Michigan, formed under a constitution in 1927, is an organization of students representing all departments of the College of Engineering. Its members are the presiding officers of the student branches of the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the American Society of Mechanical Engineers, the American Society of Civil Engineers, and the Society of Industrial Engineers; of the Quarterdeck, Aero and Transportation Clubs; the presidents of the freshman, sophomore, junior, and senior classes, together with one special representative from the sophomore class to serve for three years, and two representatives from the junior class to serve for two years; and the editor of the *Michigan Technic.* The Council aims to co-ordinate the activities of the various technical societies and clubs, to assure continuity in policy for the classes, and to develop co-operation between the student body and the Faculty.

**The Michigan Technic.**—The students publish monthly for eight months of the school year a magazine called the *Michigan Technic,* which contains articles contributed by alumni, faculty, and students on technical topics and other matters of interest in the College.

**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 by 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 the Journal of the A. I. E. E., which is 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 clubroom in the East Engineering Building.

**Society of Industrial Engineers.**—This is a student branch of the national society of the same name. Membership is open to all engineering students interested primarily in the science of efficient industrial management and production. The branch holds monthly meetings throughout the school year, at which industrial executives speak informally. The society, in conjunction with the other technical societies, sponsors weekly motion-picture shows of various industrial organizations and processes. All members receive the monthly bulletin published by the parent organization, and, upon graduation from college, membership is transferable directly to the parent society.

**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 of 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 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.

**The Stump Speakers' Society of Sigma Rho Tau.**—This is a branch of the intercollegiate engineering speakers' society founded at the University of Michigan to develop ability in public discussion and debate. The major object of the organization is to insure a closer bond of understanding between the applied scientist and the general public through the development of speech activities among colleges of architecture, engineering, and technology. The society has a package library and clipping service in its library reference room in the West Engineering Building. It debates national engineering problems with local societies and adjacent branches.

**Phi Eta Sigma,** a national honorary society for freshman men, elects members each year on the basis of high scholarship.

**Phi Kappa Phi,** a national scholastic honor society, elects its members each year from the senior classes of all Schools and Colleges on the basis of scholarship, personality, and service to the University.

## FELLOWSHIPS

**44. American Gas Association Fellowship in Metallurgy.**—In 1928, this fellowship was established for the study of the utilization of gas in heat-treating steel.

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

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

**Detroit Edison Company Fellowship in Chemical Engineering.**—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.

**Detroit Edison Company Fellowship in Highway Engineering.**—A fellowship is offered for the investigation of approved subjects relating to moderate-cost country roads. This fellowship pays the sum of $500.

**Lawton Fellowship in Astronomy and Mathematics.**—The stipend varies from two to four hundred dollars. Preference is given to Astronomy if there is a suitable candidate.

**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.

**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.

**Engineering Research Fellowship in Physics.**—This fellowship for the year 1930-1931 has a stipend of $900.

## SCHOLARSHIPS, PRIZES, AND STUDENT AIDS

**45. 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 obtains the highest average for the last two years of the curriculum, in the regularly prescribed courses.

**Cornelius Donovan Scholarships.**—These scholarships were established in 1922 by a bequest of Cornelius Donovan, C.E., '72, Eng.D.(hon.), '12, for award to meritorious senior students in engineering who are working their way through college. These scholarships are awarded in the amount of $400 each. To be eligible students must be American citizens, partially or entirely self-supporting, and must have completed a minimum of 60 hours of work applicable for the degree. They must have been in residence at the University of Michigan for at least one year. Applications must be filed in the office of the Assistant Dean of Engineering before April 1. The awards are published in May and are paid in the amounts of $200 each when the recipients have enrolled for the first and second semesters of the following school year.

**Robert Campbell Gemmell Memorial Scholarship.**—This scholarship fund in memory of her brother, Robert Campbell Gemmell, B.S.(C.E.), '84, C.E., '95, M.Eng.(hon.), '13, was founded in 1926 by Mrs. Lillian Gemmell Boal (Mrs. S. H. Boal) of

Oakland, California. "This scholarship is to be available for freshman and sophomore students in the College of Engineering . . . . . of general worthiness and deserving character." These scholarships are awarded in the amount of $100 each. To be eligible, students must be American citizens, partially or entirely self-supporting, and must have completed a minimum of 15 units of work at the University of Michigan with a minimum general average of 3.00. Applications must be filed in the office of the Assistant Dean of Engineering before April 1. The awards are published in May and are paid in full in September after the recipients have enrolled for the first semester of their sophomore year.

**Simon Mandlebaum Scholarships.**—These scholarships were established in 1929 by the late Mary S. Mandlebaum (Mary S. Mandelle) of Detroit, Michigan, in memory of her father, Simon Mandlebaum. These scholarships are awarded in the amount of $500 or more, each. To be eligible students must be American citizens, partially or entirely self-supporting, and must have completed a minimum of 75 units of work applicable for the degree They must have been in residence at the University of Michigan for at least one year. Applications must be filed in the office of the Assistant Dean of Engineering before April 1. The awards are published in May, and are paid in equal amounts when the recipients have enrolled for the first and second semesters respectively of the following school year.

**Frank Sheehan Scholarship in Aeronautics.**—This scholarship was founded in 1929 by Miss Mildred Sheehan as a memorial to her brother, Frank P. Sheehan, a student in the University from 1917 to 1919 and in 1924-1925. The income on this gift of $20,000 is used as a scholarship or scholarships for students who intend to follow a career in Aeronautics or Aeronautical Engineering. It is available to students who have completed at least two years' work in the College of Engineering with a grade distinctly above the average. Usually two $500 scholarships are available each year.

**Minnie Hubbard Smith Revolving Fund.**—This fund is dispensed as gifts to juniors and seniors in civil engineering. Applications should be made to the Head of the Department of Civil Engineering.

## LOAN FUNDS

46. The following loan funds have been established especially for the use of engineering students who are in need of aid to complete their studies: Class of 1915 Engineering Loan Fund and Benjamin Sayre Tuthill Loan Fund, George H. Benzenberg Loan Fund and William J. Olcott Scholarship Loan Fund (not available

for freshmen); Class of 1914 Engineering Loan Fund (for seniors, no interest before note matures); Class of 1917 Engineering Loan Fund and the John Frank Dodge Loan Fund (for juniors and seniors); Marian Sarah Parker Memorial Fund (for women); and J. B. and Mary H. Davis Trust Fund (Geodesy and Surveying). These special loan funds, together with a number of all-University funds which are open to students in engineering and architecture, are described in the bulletin, Scholarships, Prizes, and Loan Funds, which is available on request. Applications should be made to the Dean of Students, Room 2, University Hall.

## BEQUESTS AND OTHER GIFTS

47. The University of Michigan has in recent years become more and more frequently the recipient 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. Over one-quarter of the University's permanent assets in funds, lands, buildings, and equipment have been contributed. The University has more than one hundred and fifty permanently endowed trust funds. These funds are administered with most scrupulous and precise attention to the terms and conditions laid down by the donors. The University is always desirous to widen its field of service by receiving gifts of funds to be held in trust to provide professorships, scholarships, loans, and other benefits as illustrated by the descriptions of these already existing trust funds. Correspondence on the subject of needs is solicited and will receive prompt, candid replies. Persons desiring to place property in trust permanently for the benefit of education may well remember that "The Regents of the University of Michigan" is a constitutional corporation, the highest form of body corporate known to the law.

The forms of bequest given below are not intended to take the place of the services of a competent attorney in the drafting of a will, but they may be suggestive and stimulating to the mind of a public-spirited citizen contemplating the making of a will or a gift during his or her lifetime, and they are believed to be in legal form adapted to the inclusion in a will. A form of bequest is as follows:

> I give, devise, and bequeath to The Regents of the University of Michigan .....
> (*here insert the sum or the property bequeathed*) .....
> for the following purposes .....
> (*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 to practical uselessness certain bequests, made in earlier days for

purposes then important, to various of the older educational institutions of the country. 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 original purpose of the gift should prove to be no longer a real need, it is suggested that such a benefaction the income of which is to be devoted to a specified purpose might wisely contain a clause similar in general to the following:

> In the event that, in the opinion of the said Regents, the needs to meet which this bequest is made should pass out of existence with the passage of time or not require all of the income provided, then the said Regents are hereby expressly given authority and charged with the duty to use the said income or so much of it as in their discretion may seem for the best advantage of the University, for other purposes allied to or in harmony with the spirit and purpose of this bequest as above expressed; or if such approximation of my specific purpose is in the discretion of the Regents inexpedient or impracticable then and in that event the Regents shall use the income for whatever educational or University needs they may see fit, as trustees of the University in general and of this fund in particular, since it is my purpose and intent that the income shall not lie idle and useless but shall be active and useful in contributing currently to the benefit of mankind through education.

Further, modern givers of large sums have in numerous instances taken the grounds (1) that due to changes in social and economic conditions no one can foresee the future with sufficient clearness to warrant making any bequest for specific purposes in perpetuity, and (2) that if trustees are competent and worthy to be entrusted with investment of the principal and use of the income, they are competent to use the principal in the light of future social and economic conditions. Should a testator desire to give such discretion to the Regents at the end of a period of years he could do so by use of the following or a similar clause:

> If after this bequest shall have been in operation for..... years or more the Regents within their discretion as trustees shall believe that my general purpose in making this bequest, namely, the benefit of mankind through education, would be better served by the expenditure of both principal and income than by the continued expenditure of the income only, then and in that event the said Regents are expressly authorized and empowered to sell the securities or other property in which such principal shall then be invested, or to sell any part thereof, and to expend the proceeds thereof as may in their opinion at that time be as near as feasible to the purposes herein above specified for the best advantage of the University of Michigan in any phase of its then accepted and proper activities.

## DEGREES CONFERRED IN THE COLLEGE OF ENGINEERING

48. 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 that the student has pursued.

## DEGREES CONFERRED IN THE GRADUATE SCHOOL

49. Graduate courses are offered in the Graduate School leading to the degrees of Master of Science in Engineering, Doctor of Philosophy, Doctor of Science, 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 the Announcement 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

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

*a*) He must complete the required courses of his department.

*b*) 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 35.

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.

## NONTECHNICAL ELECTIVES

51. All regular students in the College of Engineering are required to complete 16 hours of nontechnical electives selected from the following list:

*Astronomy
*Botany
Economics
*English
Fine Arts
†Foreign Language
*Geography
*Geology
*History
Mathematics (Advanced)
*Military Science and Tactics (not to exceed 4 hours)
Mineralogy
Music (courses listed in Literary Announcement)
Philosophy
*Political Science
Psychology
Sociology
Speech
*Zoology

Credit is withheld in the following groups until the completion of the second course (See Announcement of the College of Literature, Science, and the Arts):

| | |
|---|---|
| Greek 1 and 2 | 8 hours |
| Latin 1 and 2 | 8 hours |
| French 1 and 2 | 8 hours |
| Spanish 1 and 2 | 8 hours |
| German 1 and 2 | 8 hours |
| Geography 1 and 2 | 8 hours |
| Geology 1 and 2 | 8 hours |

Plane Trigonometry and Chemistry 3 will be included in the list of nontechnical electives when college credit is given in these studies.

Students in the College of Architecture are required to complete Course 31 in French or German.

Students in aeronautical and chemical engineering are advised to elect German; and students in Astronomy, Mathematics, and Physics are advised to elect both French and German.

*Starred courses may be elected in the freshman year.

†Students who elect the beginning course in a language must continue with the second course.

# Part IV

# COLLEGE OF ENGINEERING

## NONPROFESSIONAL DEPARTMENTS

### STUDIES OF THE FIRST YEAR

52. 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* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| Physical Education or Military Science | 0 or 1 | Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

Physical Education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Enrollment in Military Science is for a period of four semesters.

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 the alternative requirements de-

*See section 51 for nontechnical elective requirement.

scribed in section 10. 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).

In case the admission requirements have been fully met on entrance, trigonometry and Chemistry 3 will give credit toward graduation as cultural subjects. See section 51. 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 51.

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 33.

## NONPROFESSIONAL DEPARTMENTS

53. 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. For other courses see the Announcements of the College of Literature, Science, and the Arts, the School of Business Administration, and others.

A course in another college that is 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 of the University.

### 54. BACTERIOLOGY AND WATER ANALYSIS

Associate Professor HADLEY and Assistant Professor EMERSON.

**105. Water Analysis.** Two afternoons weekly, first half of the first semester. This course is open to students of Sanitary Engineering and to others who are qualified. Two hours credit.

**113E. 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 November 19. Two hours credit.

## 55. BUSINESS ADMINISTRATION

Professors GRIFFIN, JAMISON, and BLACKETT; Associate Professors ELLIOTT and TAGGART; Assistant Professors WOLAVER, PHELPS, and WATERMAN; Dr. TIMOSHENKO 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 and Production.** This course stresses throughout the fundamental principles of organization and management of individual enterprises, using the functions of production as a basis for their application. Managerial control of labor, materials, and productive processes through the medium of modern scientific methods will be observed in representative cases of business practice. The relationship of the production function to other functional activities such as marketing, accounting, and finance will be emphasized. Three hours credit. First semester.

**102. Principles of Personnel.** This course deals with the problems of human relations in business and industry. Reasons for the present emphasis on personnel relations are first considered. The course, however, is chiefly concerned with methods of selection, training, and maintenance of personnel in business and industrial organizations. Devices used in selection and training are appraised. Systems of wage payment and methods for keeping a continuous inventory of employees are analyzed. As far as possible the "case method" is used. Three hours credit. Second semester.

**113. Cost Accounting, I.** This is an intensive course in cost accounting in the manufacturing field. Particular attention is given to the methods of allocating in direct expense to departments, processes, jobs, and classes of product. Among the special topics considered are the relation of cost reports to selling policies, the control and valuation of inventories, and the determination of the cost of idle time. The principles of costing are illustrated in a complete cost set which the student is required to work out as a laboratory exercise. In addition, numerous shorter problems are assigned. *Prerequisites*: *Economics* 171 *and* 172. Three hours credit. First semester.

**121. Elements of Statistics.** This course will consider the calculation and use of averages, measures of dispersion, correlation and regression coefficients, and index numbers. Special attention will be given to the application of time series analysis to practical business problems. Three hours credit. First semester.

**151. Marketing Principles, I.** This course, together with Course 152, deals with the transferring of goods and the ownership

of goods from producer to consumer, with emphasis upon the business problems involved in these activities. Course 151 includes a consideration of the following subjects: (1) general principles of marketing; (2) the marketing of agricultural products including grading, the use of central markets, speculation, and the organized exchanges; (3) manufacturers' buying problems; (4) manufacturers' selling problems such as the choice of channels of distribution and of methods of sale, and the use of advertising. The course is conducted by the study of concrete business problems and supplementary readings. Three hours credit. First semester.

152. **Marketing Principles, II.** This course is a continuation of Course 151 and has the same general aims. It specifically considers the following subjects: (1) price policies; (2) policies related to credit and finance; (3) standardization of products; (4) wholesalers' activities; (5) storage and the physical distribution of products; (6) retailing; (7) the State and marketing, including a discussion of "unfair competition." The method of instruction is the same as that in Course 151. *Prerequisite: Business Administration* 151 *or its equivalent.* Three hours credit. Second semester.

161. **Financial Principles, I.** This course undertakes an analysis of the financial principles underlying the promotion, organization, and management of business enterprises. A thorough study is made of the characteristics of the several types of securities with particular attention to their use in the original financing of concerns in various lines of industry. Methods of obtaining and managing working capital, as distinguished from problems of permanent capital, are considered, with special emphasis on such matters of current financial management as temporary borrowing, and the financial aspects of the purchase, production, and sale of goods. *Prerequisites: Economics* 171 *and* 172 *or equivalent.* Three hours credit. First semester.

162. **Financial Principles, II.** This course is a continuation of Course 161 and proceeds with a study of the financial problems of going concerns. Problems of administration of income receive specific attention, and an attempt is made to show the relationship of accounting to finance in this important phase of administration. The problems of expansion are next considered, raising the questions of the profitableness of expansion and means of financing such moves. Finally, this course undertakes a study of the problems involved in the financial reorganizations of businesses and an examination of procedures used in refinancing and reorganizing unprofitable or bankrupt concerns. *Prerequisite: Business Administration* 161. Three hours credit. Second semester.

202. **Business Forecasting.** This course endeavors to acquaint the student with the nature and limitations of business

forecasting. The methods followed by the leading forecasting services in the prediction of general business conditions are studied, the actual basis of prediction analyzed, and the records of these services examined to determine the measure of success thus far attained. Students are expected to follow closely the current issues of at least one service. The practicability of forecasting for individual trades and industries is considered. *Familiarity with the technique of statistical analysis is presupposed.* Three hours credit. Second semester.

205. **Business Law, I.** It is the purpose of this course to give a general survey of the fundamental principles of the law governing business transactions. The course will consider the main principles of contract; offer; acceptance, consideration, capacity of the parties; legality of object; the formal requisites of agreements under the statute of frauds; the operation of contracts in business, and their interpretation by the courts; breach of contract and damage. The law of business organization, and the nature and formation of relations in agency, partnership, and corporations will also be considered. Although this course is designed for second-year students, by special permission it may be elected by first-year students in the School. Three hours credit. First semester.

206. **Business Law, II.** This course is devoted to specialized problems in credit; modes of safeguarding credit; negotiable instruments; guaranty and suretyship; mortgages; pledges; sales and conditional sales; problems in bankruptcy and insolvency, and receiverships. Students will be given topics for reports and discussion. This course should be of special interest to students specializing in accounting, finance, and banking. Three hours credit. Second semester.

280. **Public Utility Accounting.** This course consists of an intensive comparative study of the standard systems of accounts prescribed for various utilities by the Interstate Commerce Commission and the state commissions. In the first part of the course particular attention is given to the classifications used by American railways. The latter part of the course will deal with the prescribed accounts for electric, water, gas, bus, and other utility enterprises. Some attention will be given the matter of consolidated income and financial statements in the utility field. This course is similar in content to the course formerly listed as Course 281, Public Utility Management. Three hours credit. Second semester.

282. **Public Utility Management.** This course deals with special problems of public utility management such as financing, administration of income, rate making, and inter-company relationships. While the principles involved are general, the emphasis of

the course is upon the problems of gas and electric utilities. *This course must be preceded or accompanied by Business Administration* 280. Three hours credit. Second semester.

**Summer Session**

Courses 101, 102, 112, 151, 152, 161, 162, 205, and 206, or similar courses, will be given during the Summer Session of 1931.

## 56. CHEMISTRY

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

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. Lecture and class rooms, laboratories for class instruction and individual research, a fully equipped stockroom, and the chemical library are all located in the one building. The library contains about 10,000 volumes and is especially rich in complete sets of journals; 120 journals are currently received.

**3, 6. General Inorganic Chemistry.*** A study of the descriptive chemistry of the nonmetallic elements (Course 3) and of the metallic elements (Course 6), with special emphasis upon the interpretation of chemical phenomena from the viewpoint of modern theory. Two lectures, two recitations, and two two-hour laboratory periods. *Course 3 is a prerequisite for 6.* Four hours credit each. Course 3 is given each semester; Course 6, second semester only.

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

**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 nonmetallic elements and of all the more important metallic elements is studied, special emphasis being placed on such facts as are of importance to the engineer. Two lectures, two recitations, and two three-hour 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 Course 3, credit for which will be counted as a nontechnical elective. Five hours credit. Each semester.

**15, 19. Qualitative Analysis.** A study of the distinctive properties of some common substances in water solution and the reactions used in the identification of such substances (Course 15), followed by the analysis of more difficult mixtures, including alloys, slags, phosphates, also studies in oxidation-reduction. Two recitations and two four-hour laboratory periods. *Prerequisite: Course 5E or 6. Course 15 is a prerequisite for 19.* Four hours credit each. Both courses are given 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. Students who may not elect Course 17 must elect Courses 15 and 19 before taking Course 57. Three recitations and two four-hour laboratory periods. *Prerequisite: completion of Course 5 or 6 with grade of C or better, or equivalent.* Five hours credit. Each semester.

**41. Elementary Theoretical and Physical Chemistry.** In this course special attention will be paid to the study of chemical equilibrium, rate of chemical reactions, and applications of physico-chemical theory. Three lectures or recitations. *Prerequisites: Course 17 or 19, Physics 36, and a knowledge of calculus.* Three hours credit. Each semester.

**43. Physico-Chemical Measurements.** Methods for the determination of molecular weight, viscosity, surface tension, reaction rate, solubility, etc., optical measurements with polarimeter, refractometer, spectrometer. Laboratory work. *Must be preceded or accompanied by Courses 41 and 57.* Two to 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 prob-

*See footnote on page 74.

lems is emphasized. Two recitations and three four-hour laboratory periods. *Prerequisite*: *Course* 17 *or* 19. Five hours credit. Each semester.

63. **Organic Chemistry.** This course is intended for students who desire a more elementary course than Courses 67 and 69. *Prerequisites*: *Courses* 3 *and* 6, *or Course* 15 *or* 17. Four hours credit. Each semester.

67, 69. **Organic Chemistry.** The properties and classification of carbon compounds. Two lectures, one recitation, and two four-hour laboratory periods. *Prerequisite*: *Course* 17 *or* 19. *Course* 67 *is a prerequisite for* 69. Five hours credit each. Both courses are given 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. Two lectures. *Must be preceded or accompanied by Course* 41. Two hours credit. First semester.

112. **Applied Electrochemistry.** Application of principles of electrochemistry to analytical and industrial processes. Two lectures. *Prerequisite*: *Course* 111. Two hours credit. Second semester.

113. **Electrochemistry Laboratory.** 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. *Must be preceded or accompanied by Course* 111. Two hours credit. Each semester.

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

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

131. **Physico-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 rate of chemical reactions and chemical equilibria in both homogeneous and heterogeneous systems. The work includes also a brief survey of recent advances in the field of physical chemistry. Two 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 quiz, twice a week; laboratory, two or three periods a week. *Prerequisites*: *Course* 57 *and Physics* 36. Four or five hours credit. Each semester.

147. **Special Problems in Analytical Chemistry.** 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*: *four hours of Course* 145. Hours and credit to be arranged. Each semester.

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

165. **Advanced Organic Chemistry.** Two lectures, and reading. *Prerequisite*: *Course* 69. Two hours credit. First semester.

166. **Advanced Organic Chemistry.** Two lectures, and reading. *Prerequisite*: *Course* 69. Two hours credit. Second semester.

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

### Summer Session

Courses 3, 6, 15, 17, 34, 41, 43, 57, 63, 65, 69, 111, 113, 125, 127, 131, 132, 145, 147, 163, 166, 242, as described for the regular session, or similar courses, will be given in the Summer Session of 1931.

## 57. ECONOMICS

Professors SHARFMAN, PATON, GOODRICH, and COPELAND; Associate Professors WATKINS and ELLIOTT; Assistant Professors CAVERLY, PETERSON, and ELLIS; Mr. BRIGGS and Dr. TIMOSHENKO.

Courses 53 and 54 listed below are of particular interest to those students in the College of Engineering who wish to have 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 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 Announcement of the College of Literature, Science, and the Arts.

*Courses* 53 *and* 54 *will not be accepted as prerequisites for other courses in this department. Students who plan to take further work in economics should take Courses* 51 *and* 52.

*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, with Course 52, its continuation in the second semester, furnishes a general introduction to the science of economics. It is designed for students who wish to prepare themselves for advanced work in the field of economics or who desire a thorough grounding in economic principles. Lecture and discussions. Successful completion of Courses 51 and 52 is a prerequisite to election of other courses in the Department. *Not open to freshmen.* Three hours credit. Each semester.

**52. Principles of Economics, II.** This course is a continuation of Course 51. Lecture and discussions. Successful completion of Courses 51 and 52 is a prerequisite to election of other courses in the Department. Three hours credit. Each semester.

**53. General Economics, I.** This course is designed to meet the needs of students, particularly in professional departments, whose chief work lies 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, trusts, and taxation. This course continues through the second semester as Course 54. *Courses* 53 *and* 54 *will not be accepted as prerequisites to other*

*courses in the department. No student will 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 application of principles to current economic problems of public significance. *Prerequisite*: *Course* 53. *Courses* 53 *and* 54 *will not be accepted as prerequisites to other courses in the department.* Three hours credit. Second semester.

**101. Money and Credit, I.** This course undertakes an analysis of theories of money and credit and of bank operations and their relation to production and capital supply. Attention is given to monetary and banking history in the United States, and a preliminary study is made of the organization of the Federal Reserve System. This course should be followed by Course 102. *Prerequisites*: *Courses* 51 *and* 52. Three hours credit. First semester.

**102. Money and Credit, II.** This course is a continuation of Course 101. Principles governing the circulation of money, the standard of value, and the relationship between money and prices are examined. Particular attention is given to the gold standard and the foreign exchanges. After a brief study of several foreign monetary and banking systems, more intensive study is made of the actual operations and credit problems of the Federal Reserve System under war and post-war conditions. *Prerequisite*: *Course* 101. Three hours credit. Second 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 efficiency. After an introductory account of the rise of permanent groups of wage-earners, it will discuss their lives and work in terms of such problems as wages, monotony, and insecurity; and it will discuss turnover, sabotage, strikes, and the growth of the labor movement as indications of industrial unrest. In conclusion, it will examine briefly the remedies which are attempted or proposed by employers, unions, and the government. Discussion and occasional lectures. *Prerequisites*: *Courses* 51 *and* 52. Three hours credit. First semester.

**131. Corporations and Combinations.** The forms of business association and their economic significance are first examined, with special emphasis placed on the corporate organization of industry and trade. Then comes an analysis of the combination movement, including the methods, causes, and effects of concentration of control. Finally the relation of government to monopolistic tendencies and competitive practices is studied with respect both to the problems involved and the public policies which have

developed. *Prerequisites*: *Courses* 51 *and* 52. Three hours credit. Second semester.

133. **Railroad Regulation.** This course is designed to acquaint the student with the system of public control of railroads which has been developed in the United States. It examines the legal and economic characteristics of the railroad industry, analyzes the principal railroad problems which have emerged and undertakes a detailed study of the character and development of government regulation. *Prerequisites*: *Courses* 51 *and* 52. Three hours credit. First semester.

153. **Elements of Economics.** *For senior and graduate students having time for only a semester's work 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. Lectures and quizzes. Students planning to take an extended program in economics should take Courses 51 and 52. Three hours credit. Each semester.

171. **Principles of Accounting, I.** This introductory course consists primarily in a study of the fundamentals 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. Three hours credit. Each semester.

172. **Principles of Accounting, II.** This is a continuation of Course 171. It includes practice in the construction of working sheets, a study of the principal types of income statements and balance sheets, a survey of the problems of valuation and income determination, a consideration of partnership accounting, and an introduction to corporate accounting. Three hours credit. Each semester.

173. **Elements of Accounting.** A survey of the accounting field with emphasis upon fundamental principles. 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 prerequisites. *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. Prerequisites*: *any introductory course in economics, or permission of instructor.* Three hours credit. Each semester.

**175, 176. Elementary Economic Statistics.** This course is intended to give a critical knowledge of the chief sources of American economic statistics, and a familiarity with the more common methods of analysis and presentation. The work will consist chiefly of sample problems in the use of averages, measures of dispersion, graphic presentation, analyses of time series, correlation, index numbers, and the preparation of questionnaires. *Prerequisites*: *Courses* 51 *and* 52. *Course* 175 (*or special permission of the instructor*) *is a prerequisite for* 176. Three hours credit each. Throughout the year.

**177. Elements of Statistics.** This is an attempt to present in one semester, for those who cannot give more time than that, the most important ideas and methods studied in Courses 175 and 176. *Prerequisites*: *Courses* 51 *and* 52. Three hours credit. Each semester.

**181. Public Finance.** This course undertakes a general survey of the field of public finance and taxation. After a brief analysis of the character and trend of public expenditures, the various forms of public revenue are discussed, with particular attention to the principles and problems of taxation. The systems of national, state, and local taxation in the United States are studied critically. The course concludes with an examination of the nature and effects of public indebtedness. *Prerequisites*: *Courses* 51 *and* 52. Three hours credit. First semester.

**182. Taxation.** This course offers an opportunity for a more intensive study of the principles, the incidence, and the economic effects of taxation, than is possible in Course 181. It includes an intensive study of current tax practices and problems and a discussion of proposals for tax reform. Each student is expected to undertake during the semester an individual study of some particular tax or tax system. *Prerequisites*: *Course* 181, *or special permission of the instructor.* Three hours credit. Second semester.

**Summer Session**

Courses 51, 52, 101, 102, 121, 122, 131, 133, 153, 171, 172, 174, 181, and 197 will be given during the Summer Session of 1931.

## 58. ENGLISH

Professor NELSON; Associate Professor THORNTON; Assistant Professors BRACKETT, BURKLUND, DAHLSTROM, EGLY, WALTON, and WENGER; Mr. JOHNSON and Mr. KIRSCHBAUM.

The work in English aims to prepare the student to speak and to write effectively, and to give him a genuine and intelligent interest in reading as a means of enlarging his fund of ideas and enriching his background. He is therefore afforded throughout

his four years a liberal choice of courses in composition, both written and oral, and courses in the appreciation and critical reading of literature.

**General Requirements.**—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 Courses 1 and 2 and a two-hour course in the junior or senior year which must be chosen from Group III. Students in Civil Engineering will take English 6.

In the College of Architecture the student may take, in addition to Courses 1 and 2, any two-hour English course at any time, unless he elects a course in Group III.

**Special Requirement for Foreign Students.**—All foreign students must take English 1a and 2a until they have demonstrated their ability to do the regular freshman work in English 1 and 2. In addition to the general requirement of six hours, foreign students will, at the discretion of the Committee on English for Foreign Students, be required to continue their work in English until, in the judgment of the English faculty, they have a satisfactory working knowledge of English. The maximum total assignment in English for such students is seventeen hours. For further regulations regarding foreign students, see section 9.

**Grouping of Courses.**—Group I includes courses which satisfy the freshman requirement and the special courses for foreign students. Group II offers nontechnical electives in public speaking, composition, and contemporary literature to all students who have satisfied the freshman requirement. Students of Architecture may also elect courses from this group to complete the six hours of required work in English. Group III offers courses to satisfy the upperclass requirement. Junior, senior, and graduate students may also take courses in this group as nontechnical electives.

**Library Facilities.**—In addition to the facilities of the General Library and of the various departmental libraries, the English Department has accumulated a special collection of approximately one thousand volumes, which is at present located in the Chemical Engineering Library on the third floor of the East Engineering Building.

### Group I—Freshman Requirement

Every freshman must take English 1 and 2 and must take them the same semester.

1. **Theme-Writing.** An introductory course in composition and the appreciative study of literature. Weekly prepared themes; frequent impromptus; readings in essays, prose fiction, drama and

poetry. *This course is a prerequisite for all courses in English except English 2.* Three hours credit. Each semester.

1a. **Theme-Writing for Foreign Students.** A special course in writing and reading which all foreign students must take until they have demonstrated their ability to take Course 1. Courses *1a* and *2a* are to be taken at the same time. Five hours of classwork, two hours of credit for the two courses. Each semester.

2. **Oral Exposition.** A practice course in public speaking which must be taken with Course 1. Written outlines, extempore and impromptu speaking, informal debates, and other oral exercises. Each student presents about ten five-minute speeches during the semester. Two hours of classwork. One hour credit. Each semester.

2a. **Oral Exposition for Foreign Students.** A special course in speech which all foreign students must take until they have been judged ready to take Course 2. Practice in conversation and in reading aloud; short expository speeches; dictation; correction of individual speech defects; drill on pronunciation. Each semester.

GROUP II—ELECTIVE COURSES

These courses, which may be taken at any time after a student has completed his freshman requirement, give credit as nontechnical electives. Students of Architecture may elect these courses to complete their requirement in English. *Prerequisites: Courses 1 and 2.*

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

4. **The Lecture: Scientific, Popular, and Technical.** The preparation and delivery of lectures on scientific subjects intended for scientific societies or for popular assemblies; presentation of technical reports and demonstration methods. Two hours credit. Second semester.

5. **Advanced Composition.** A course devoted exclusively to writing for those students who desire additional practice in the various forms of composition. Two hours credit. Each semester.

20. **Contemporary Literature.** Readings in contemporary prose, fiction, drama, and poetry. Two hours credit. Each semester.

21. **Contemporary Drama.** A study of modern drama from the time of Ibsen to the present day. Two hours credit. Each semester.

22. **Contemporary Novel.** A study of novels significant in their bearing on contemporary literary movements. Two hours credit. Each semester.

23. **The Short Story.** Reading and analysis of a large number of short stories. Two hours credit. Each semester.

GROUP III—UPPERCLASS REQUIREMENT

These courses, which are open to junior, senior, and graduate students only, may be taken to satisfy the junior-senior requirement in English and may also be taken as nontechnical electives. Students in Civil Engineering must take Course 6. Courses marked with an asterisk (*) may be taken for graduate credit provided that additional work be satisfactorily done. In all these courses papers are required and competency in writing is demanded. *Prerequisites*: *Courses* 1 *and* 2.

*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. *Open to seniors and graduate students only.* 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. Two hours credit. Each semester.

24. **The Engineer and His Reading.** Studies in literature in relation to philosophy and the social sciences. Two hours credit. Each semester.

*25. **The Drama.** An appreciative study of significant dramas in classical and western civilizations. Two hours credit. Each semester.

*26. **The Novel.** Reading and discussion of major works in the prose fiction of the eighteenth and nineteenth centuries. Two hours credit. Each semester.

*27. **The Literature of Science.** Review of the work of the great historic figures in the scientific field: ancient, modern, and contemporary. Two hours credit. Each semester.

28. **American Prose Literature.** Readings in the works of representative American essayists, dramatists, and writers of fiction. Two hours credit. Each semester.

*See legend under caption "Group III."

*29. **Literary Masterpieces.** Studies in the works of exceptional merit in the various literary forms. Two hours credit. Each semester.

30. **Shakespeare.** A study of eight of the principal plays. Two hours credit. Each semester.

**Summer Session**

Courses 1, 2, and 24, or similar courses, will be given during the Summer Session of 1931.

## 59. 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, Spain, and the Lowlands; American Art; and Oriental Art.

All elections in the following courses must be made in Room B, Alumni Memorial Hall, between 10 and 12 or between 2 and 4 on registration days.

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, subject to the approval of the Department.* Four hours credit. Each semester.

117. **The Renaissance in Spain and the Lowlands.** The history of architecture, sculpture, and painting in Spain and of painting in the Lowlands from the fifteenth through the eighteenth century. Illustrated lectures, required reading, note book, and written tests. *Open to sophomores, juniors, and seniors who have completed Course* 101 *with a grade of B or better.* Three hours credit. Second semester.

118. **The Architecture of the Renaissance in Italy.** A historical and critical consideration of the more important architects and monuments in Italy during the fifteenth, sixteenth, and seven-

teenth centuries. Illustrated lectures, required reading, note book, and written tests. *Open to sophomores, juniors, and seniors who have completed Course* 101 *with a grade of B or better.* Two hours credit. First semester.

119. **The Sculpture of the Renaissance in Italy.** A historical and critical consideration of the more important sculptors and monuments in Italy from the middle of the thirteenth century through the sixteenth century. Illustrated lectures, required reading, note book, and written tests. *Open to sophomores, juniors, and seniors who have completed Course* 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, note book, and written tests. *Open to juniors and seniors who have completed Course* 101 *and Course* 117 *or* 118 (*preferably* 118) *with a grade of B or better.* Three hours credit. First semester.

132. **Central Italian Renaissance Painting.** A study of the development and character of painting in Central Italy from the middle of the thirteenth century through the sixteenth century, with special attention to the Florentine School. Illustrated lectures, required reading, note book, and written tests. *Open to sophomores, juniors, and seniors who have completed Course* 101 *with a grade of B or better.* Three hours credit. First semester.

135. **North Italian Renaissance Painting.** A study of the development and character of painting in Northern Italy from the fourteenth century through the eighteenth century, with special attention to the Venetian School. Illustrated lectures, required reading, note book, and written tests. *Open to juniors and seniors who have completed Courses* 101 *and* 132 *with a grade of B or better.* Two hours credit. Second semester.

141. **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, note book, 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.* Three hours credit. Second semester.

### CREATIVE WORK IN SCULPTURE

Associate Professor FAIRBANKS

151. **The Theory and Technique of Sculpture,** with a study of the processes. *Prerequisite: permission of the instructor.* Two hours credit. First semester.

**152. The Theory and Technique of Sculpture.** Continuation of Course 151. Two hours credit. Second semester.

**153. Creative Studies in Sculpture,** with emphasis on problems in sculpture. *Prerequisites*: *Courses* 151, 152, *or equivalent, and permission of the instructor.* Two hours credit. First semester.

**154. Creative Studies in Sculpture.** Continuation of Course 153. Two hours credit. Second semester.

## 60. FORESTRY AND CONSERVATION

Professors DANA, MATTHEWS, ALLEN, GRAHAM, and RAMSDELL; Associate Professors YOUNG, KYNOCH, and CRAIG; Assistant Professors JOTTER, BAXTER, DEARBORN, WIGHT, and O'ROKE.

All forestry courses are given in the Natural Science Building and in the Wood Utilization Laboratory.

**31. Introduction to Forestry.** Economic and social importance of forestry. History of forestry in the United States and abroad. Character, distribution, and utilization of our timber resources. Factors influencing tree growth. How the forest is reproduced and cared for. Influence of forests on climate, streamflow, and erosion. Forestry as a profession. Three lectures. *Not open for credit to candidates for a degree in forestry.* Three 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 intensively managed forests and in national and state parks and wilderness. Emphasis is laid on the extent of these resources, their intelligent administration, and their relation to the public. Two lectures. Two hours credit. First semester.

**162. Logging and Milling.** Methods and costs of logging, with special reference to their applicability to different forest conditions; layout of logging operations. Sawmilling; methods and costs of manufacturing and marketing lumber and other rough forest products. Three lectures. *Prerequisite*: *Surveying* 13. Three hours credit. Each semester.

**163. Wood-Using Industries of the United States.** Wood-using industries of the United States; location and economic importance; kind, amount, and source of wood used by representative industries; methods and costs of manufacture; marketing and utilization of finished product. Three lectures. Three hours credit. First semester.

**164. Structure and Properties of Wood.** Structure of our native woods, with special reference to identification and properties; relation of properties to industrial utilization. Two lectures and two laboratory periods. *Prerequisite*: *Physics* 35. Four hours credit. Second semester.

**165. Conditioning and Preservative Treatment of Wood.** Air seasoning, kiln drying, and preservative treatment of woods. The laboratory work includes operation of a semi-commercial kiln and wood-preserving plant. Two lectures and one laboratory period. *Prerequisite*: *Forestry* 164. Three hours credit. First semester.

**167. Timber Mechanics.** Study of the mechanical properties of woods and of the methods used in obtaining data on these properties; practical application of strength data. The laboratory work includes standard strength tests on native woods in a well-equipped timber-testing laboratory. One lecture and one laboratory period. *Prerequisite*: *Forestry* 164. Two hours credit. First semester.

**168. Chemical Utilization of Wood.** Use of woods for the making of pulp and paper, artificial silk, and other cellulose products, and for distillation and miscellaneous products. Two lectures, with occasional laboratory work. *Prerequisites*: *Forestry* 164 *and Chemistry* 5 *or* 6. Two hours credit. Second semester.

**176. Forest Economics.** Forest resources of the United States and other countries. Forestry as a land problem. Economic importance of wood and other forest products. Timber trade; exports and imports. Economics of the lumber industry and other wood-using industries. Forest influences. Forestry and community development. Three lectures. *Prerequisites*: *Economics* 51, 53, *or* 153. Three hours credit. Second semester.

**187. Plantation Management in the Tropics.** Economic and administrative problems of plantation management in the tropics, with special attention to rubber production. Selection and administration of large land-holdings in the various countries of the tropics; labor and other practical problems involved. Valuation of tropical land and timber properties. Two lectures. *Open only to juniors, seniors, and graduate students.* Two hours credit. First semester.

**194. Conservation of National Resources.** Natural resources of the United States in soil, forests, minerals, and water; their contribution to the economic and social development of the country; importance and methods of conserving them. Application of the conservation philosophy to human resources, labor, industry, and commerce in general; its importance as the basis of

permanent national prosperity. Three lectures. Three hours credit. Each semester.

## 61. 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. Two lectures, one quiz, and two hours of laboratory a week. 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 31, 32, 105, 154, and 203, or similar courses, will be given during the Summer Session of 1931.

## 62. LANDSCAPE DESIGN

Professor TEALDI; Assistant Professors WHITTEMORE and CONE.

*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. It may be considered a practical introduction to city planning. Reports and quizzes. Three hours credit. Second semester.

**Summer Session**

Courses 101 and 102 will be given during the Summer Session of 1931.

## 63. MECHANISM AND ENGINEERING DRAWING

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

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, advanced mechanism, and professional drafting.

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

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 for 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 draw-

ings; 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 a 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 a 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 a 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 a week. *Prerequisite*: *Course* 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 a week. *Prerequisite*: *Course* 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 a week. *Prerequisite*: *Course* 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 a week. *Prerequisite*: *Course* 4. One hour credit. Each semester.

7. **Professional Drafting.** This course is intended to train the student further in the field of engineering drafting practice,

with emphasis placed upon subject material, methods, and procedures, as found in the drafting departments of leading industries. The assignments will be such as to indicate and represent the definite and exacting part that drafting takes in the development and representation of various machines, structures, vehicles, etc. Problems will be shaped largely to correspond to the branch of engineering in which the student is classified. One three-hour drafting-room period a week, and additional outside assignments and field work. *Prerequisite*: *Drawing* 3. Two hours credit. Each semester.

12. **Graphic Presentation.** 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 a week. Two hours credit. Each semester.

**Summer Session**

Courses 1, 1*d*, 2, and 3, or similar courses, will be offered during the Summer Session of 1931.

## 64. MILITARY SCIENCE AND TACTICS

Professor EDWARDS; Assistant Professors COURSEY, LORD, POWELL, and CUSTIS.

The student 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. He also enrolls at the Headquarters, Reserve Officers Training Corps, on the campus. Students electing Military Science are excused from the required gymnasium work.

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 $12.50 to cover property responsibility is required of each student.

**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 all students.

**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, and Business Administration students.

**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 and others interested in electrical communications.

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 the 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.

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.

Enrollment in an R.O.T.C. Group is not an enlistment in a 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 1, 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 lecture, one conference, and one one-hour drill period. One hour credit. Second semester.

**13. Military Telegraphy.** Recitations, lectures, and code practice. 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 lecture, one recitation, and one drill period. 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 in signal communications. Two lectures, one two-hour laboratory period, and one drill period. 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 lectures, one two-hour laboratory period, and one drill period. Two hours credit. Second semester.

**17. Communication Engineering.** Electrical engineers take Physics 165. All other engineers take E.E. 23, Elements of Radio Communication. First semester.

**18. Communication Engineering.** Electrical engineers take E.E. 10, Advanced Theory of Electrical Circuits. All other engineers take E.E. 24, Elements of Radio Communication. Second semester.

INFANTRY

BASIC GROUP

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

2. **Elementary Infantry, Continued.** Fundamental subjects in military training, to include infantry drill regulations, military hygiene and first aid, scouting and patrolling. One conference, one lecture, and one drill period. One hour credit. Second semester.

23. **Automatic Rifle; Musketry; Drill and Command.** Practical work in construction, operation, and use of the Browning automatic rifle. Lecture and practical work in the use of the combined fire of several rifles and the automatic rifle. One conference, one lecture, and one drill period. One hour credit. First semester.

24. **Combat Principles; Scouting and Patrolling; Drill and Command.** Theoretical and practical instruction in handling men, infantry organizations; training in the methods of gaining information of the enemy prior to and during combat. One conference, one lecture, and one drill period. One hour credit. Second semester.

ADVANCED GROUP

25. **Command and Leadership; Military Map Reading and Sketching; Combat Principles.** Theoretical and practical instruction in handling men; lectures and practical work in reading and making military maps. One lecture, one drill period, and one three-hour laboratory period. Two hours credit. First semester.

26. **Machine Guns; 37 mm Gun and 3″ Mortar; Drill and Command.** Lecture and practical work in machine gun, 37 mm gun, 3″ mortar, and in the exercise of command appropriate to all grades. One conference, one drill period, and one three-hour laboratory period. Two hours credit. Second semester.

27. **Minor Tactics; Field Engineering; Drill and Command.** Lecture and practical work in the offensive and defensive combat of small units, tactical employment of infantry weapons, sand-table exercises, map and terrain problems. Disposition of infantry weapons and units for defensive combat. One lecture, one conference, one drill period, and one two-hour laboratory period. Two hours credit. First semester.

28. **Military Law; Military History and Policy; Administration; Drill and Command.** Elements of common law, military law, moot court-martial, rules of land warfare, military policy, company organization and administration. Two lectures, one drill period, and one two-hour laboratory period. Two hours credit. Second semester.

ORDNANCE

ADVANCED GROUP

**35. Ammunition.** Ammunition and explosives, pressure and velocity determinations. Two lectures and one drill period. Two hours credit. First semester.

**36. Materiel.** Small arms, guns, carriages, recoil and special mechanisms, tanks, tractors, self-propelled mounts, and fire control instruments. Two lectures, one two-hour laboratory, and one drill period. Two hours credit. Second semester.

**37. Organization and Functions of the Ordnance Department.** The organization of the Army and the Ordnance Department, a study of the functions of the Field Service and Maintenance Divisions, current ordnance problems, and problems in ordnance design. Two lectures, one two-hour laboratory period, and one drill period. Two hours credit. First semester.

**38. Administration.** Military law and Officers Reserve Corps regulations; military history and policy, company administration and supply, property accountability, and industrial mobilization. Two lectures, one two-hour laboratory period, and one drill period. Two hours credit. Second semester.

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 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 1930). Ample time and facilities are allowed for recreation. All camps are of six weeks' duration and begin about June 20.

Signal Corps—Fort Sheridan, Ill.

Infantry—Camp Custer, Mich.

Ordnance—Aberdeen Proving Ground, Md.

## 65. MINERALOGY AND PETROGRAPHY

Professors KRAUS and 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. 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.

**31. Elements of Mineralogy.** This includes the elements of crystallography, and the physical and chemical properties, occurrence, uses, and determination of the more common minerals. Two lectures and two hours laboratory a week. *Prerequisite: a knowledge of elementary inorganic chemistry.* Two hours credit. Each semester.

**32. Gems and Gem Materials.** This course discusses the general properties, occurrence, determination, and history of the various minerals used as gems and gem materials. 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. Lectures. 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. Five hours laboratory work a week. Two hours credit. Each semester.

**35. Elementary Chemical and Optical Mineralogy.** Designed primarily for students of pharmacy and chemistry. The first half of the course deals with the common crystal forms and the important commercial minerals. The second half is devoted to the application of the petrographic microscope to the identification of chemical compounds. Two lectures and two hours laboratory work a week. Two hours credit. Second semester.

**104. Useful Minerals, Building and Decorative Stones.** Designed especially for students of architecture. Three lectures, and two hours laboratory work a week. 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.* 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. Two lectures and two hours laboratory work a week. 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. Two lectures and two hours laboratory work a week. *Prerequisites: Course* 31, *and Geology* 31 *or its equivalent.* Two hours credit. Second semester.

**Summer Session**

Courses 31, 32, 33, 105, and 107, or similar courses, will be offered in 1931. For other courses, see Announcement of the Summer Session.

## 66. MODERN LANGUAGES

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 object of the courses of the first two years 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 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.

FRENCH

**1. Elementary French.** Grammar, pronunciation, 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.

**9e. French Chemical Reading.** The object of this course is to familiarize the student with the technical terms used in French literature on chemistry. Equivalent to Chemistry 102. One hour credit. Second semester.

**31 (Formerly 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.

**32a (Formerly 4). Outline History of French Literature.** Survey of French literature from its origin 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.

For advanced elective courses, consult the Announcement of the College of Literature, Science, and the Arts.

**Summer Session**

Course 1*s* (for beginners, six hours credit), Course 1 (for beginners, four hours credit), and other courses will be offered during the Summer Session of 1931.

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.

**9e. German Chemical Reading.** The object of this course is to familiarize the student with the technical terms used in Ger-

man literature on chemistry. Equivalent to Chemistry 101. Two hours credit. First semester.

31 **(Formerly 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.

32 **(Formerly 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.

For advanced elective courses consult the Announcement of the College of Literature, Science, and the Arts.

**Summer Session**

Courses 1, 2, and other courses will be offered during the Summer Session of 1931.

SPANISH

1. **Elementary Spanish.** Grammar, pronunciation, 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.

31 **(Formerly 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.

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

For advanced elective courses consult the Announcement of the College of Literature, Science, and the Arts.

**Summer Session**

Courses 1, 2, and other courses will be offered during the Summer Session of 1931.

## 67. 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 of all schools and colleges of the University who are citizens of the United States and who are able to pass a satisfactory physical examination. In-

struction is given by members of the Faculty of the University and by officers of the United States Naval Reserve.

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, or 2d Lieutenant in the United States Marine Corps Reserve, and to qualification as Naval Aviator.

Flight training will be given in two periods; an elimination course of thirty days at the U. S. Naval Reserve Aviation Base, Great Lakes, Ill., and advanced training given at the U. S. Naval Air Station, Pensacola, Fla., for a period of eight months, in the same classes with officers and men of the regular Navy. During these periods all expenses are paid with additional pay as a student naval aviator. The syllabus calls for 218 flight hours.

Upon completion of the advanced training, comprising qualifications in more advanced types of airplanes, machine gunnery, bombing, photography, and scouting, the successful candidate is commissioned and designated Naval Aviator.

The course as described below must be elected at the same time and in the same manner as other elective courses in the University.

The course in Naval Aviation comprises ground school instruction in the following subjects: practical flying, aviation indoctrination, navigation, aerology, theory of flight, structure and rigging of airplanes, aviation engines, instruments, and regulations. During the school year it is intended that students be given an opportunity to take flights in airplanes of the U. S. Navy.

Seniors or graduate students only are eligible for selection for flight training. Juniors may take the course for credit. *Plane trigonometry, physics, or elementary electricity are prerequisite. To receive credit the course must be taken for the whole year.* Two two-hour evening periods a week. Four hours credit (at the rate of two hours credit a semester).

## 68. PHILOSOPHY

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

## 69. SHOP PRACTICE

Professor BOSTON; Associate Professor CAMPBELL; Assistant Professor GWIAZDOWSKI; Mr. SPINDLER, Mr. TELFER, Mr. SPEIRS, Mr. GRENNAN, Mr. KNEEBONE, Mr. BLITON, and Mr. PARKER.

The object of the courses in shop practice 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 Shop Laboratories** 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 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 separate room contains grinding, polishing, and buffing machines and auxiliary equipment. This room is connected with an air-cleaning system. Centrally located in the laboratory and under the supervision of an attendant is a well-organized tool crib, 25 by 36 feet, containing a comprehensive assortment of measuring instruments, gages, and small tools for machine and hand use. Adjoining this tool crib is a room in which material in process of manufacture 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 at the east end has been equipped recently for fine instrument work. In this shop, research apparatus for the various departments of the 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 ten oxy-acetylene welding outfits, 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, as well as the Shore scleroscope and Rockwell 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 cupola lined to 32-inch diameter, 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.

1. **Woodwork.** This course includes bench, lathe, and simple pattern work and may be varied to suit individual requirements. Two three-hour laboratory periods a week. Two hours credit. Each semester.

1d. **Shop Practice for Dental Students.** This course is designed to develop manual dexterity. The work includes metal cutting and polishing; forming and hardening tools; and the preparation of molds. The resources of the whole department are available for this purpose. One four-hour laboratory period a week. Second semester.

2. **Metal Working and Treating.** This is a study of the principles relating to the constitution and properties of wrought iron and steel. Manufacturing processes for these metals are outlined. The effects of mechanical working and heat treatment on the properties of various steels are studied and demonstrated. Attention is given to welding practice, as well as methods for pro-

tecting the ferrous metals against corrosion. One recitation and one three-hour laboratory period a 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 relating to castings of gray iron, malleable iron, steel, brass, bronze, aluminum alloys, and bearing metals. The constitution and properties of these metals, as well as the casting procedure, are studied. Some attention is given to the design, production, welding, and heat treatment of castings. Two recitations and two three-hour laboratory periods a week. *Prerequisite*: *Course* 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, measuring instruments, gages, manufacturing layouts, automatic machines, cutting fluids, die-casting, punch and die work, spinning, as well as associated subjects such as industrial organization, accounting and unit costs, stock records, standardization, time study, and routings. Two recitations and two three-hour laboratory periods a week. *Prerequisite*: *Course* 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*: *Course* 1. Two hours credit. Each semester.

**7. Jig and Fixture Design.** This course consists of a study of the principles underlying the design, construction, and application of jigs, fixtures, and special tools for different production quantities, and the cost analysis involved therein. Two classroom periods a week. *Prerequisite*: *M.E.* 6. Two hours credit. Second semester.

**8. Foundry Costs and Organization.** A study of foundry cost methods, foundry records, and standard instructions for foundry operations. Lectures and assignments. *Prerequisite: Course* 3. Two hours credit. Second semester.

**10. Aircraft, Materials of Construction.** (Also Aeronautics 17.) Designed for aeronautical engineering students, to acquaint them with the treatment of fabrics; the forming, gluing, and jointing of wooden parts; and the cutting, punching, bending, riveting, welding, brazing, heat treatment, and testing of steel tubular and duralumin parts and structures. One class and one three-hour laboratory period a week. *Prerequisite: Course 2. Open to seniors and graduate students only.* Two hours credit. Second semester.

### Summer Session

Courses 1, 2, 2*a*, 3, 3*a*, 4, and 4*a*, or similar courses, will be given during the Summer Session of 1931.

## 70. ENGINEERING RESEARCH

Professor A. E. WHITE, Director; Mr. SELLEW, Assistant Director; Professor NELSON, Editor of Publications; Professor WILLARD, Supervisor of Analytical Laboratory; Assistant Professor GOOD, Assistant to the Director; Assistant Professor WALTON, Assistant Editor of Publications; Mr. HAINES, Editor of Publicity; Mr. SMALL, Assistant to the Director; Research Engineers CHIPMAN, CLARK, FREYBERG, JOMINY, PARTRIDGE, PETTYJOHN, POWELL, SCHNEIDEWIND, WALKER; Research Physicists ABBOTT, BRASEFIELD, CASE, GEIGER, HUXFORD, SAWYER, SLEATOR, VINCENT, WOLFE; Research Associates DELP, EVERETT, HERZIG, HESSEL, HUSS, MISIEK, MONTGOMERY, OWENS, REICHARD, RICKETT, SCHULTZ, SMELLIE, SMITH, TRAPHAGEN, WARD, WILBUR, WILSON.

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.

Besides such problems several 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:

Michigan Gas Association Fellowship
American Gas Association Fellowship
Detroit Edison Fellowship in Chemical Engineering
Engineering Research Fellowship in Physics
Engineering Research Fellowship for the Study of Friction

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

# COLLEGE OF ENGINEERING

## PROFESSIONAL DEPARTMENTS

### 71. THE GROUP SYSTEM OF ELECTIVE STUDIES

The 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.

### 72. AERONAUTICAL ENGINEERING

Professors STALKER and PAWLOWSKI; Assistant Professor THOMPSON; Mr. BURKE.

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 general aerodynamics, 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 machine; 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.

From its inception the Department of Aeronautical Engineering has realized that the utilization of the air as a means of transportation, the settlement of problems confronting the designer, and the future development of this field must rest 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, in the design, research, and operative fields.

**Aeronautics Laboratory.**—The aeronautics laboratory proper comprises a large wind tunnel of the open throat type with double ducts for the return of the air flow. The cross section of the tunnel is an octagon and its minor diameter may be varied from eight feet to five feet. With the large diameter the wind velocity is one hundred miles per hour, and models of 50 inches span can be tested. The laboratory is at present equipped with a six component wire balance, and another balance incorporating a rigid model support is under development. Facilities for instruction in the testing of model propellers are now provided.

Students taking Aeronautical Engineering regularly take work in the electrical, mechanical, strength of materials, and automotive laboratories. Work may also be elected in other special laboratories such as the naval tank.

**Combined Courses** have been arranged with Albion, Battle Creek and Olivet Colleges and the College of the City of Detroit. For detailed information see section 15.

**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 14.

**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 64.

## 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 50.

| | | *Hours* |
|---|---|---|
| a) | Preparatory Courses | |
| | English 1 and 2 and a course from Group 3 | 6 |
| | Nontechnical Electives | 16 |
| | Mathematics 3, 4, 33, 34 | 18 |
| | Physics 45, 46 | 10 |
| | Chemistry 5E | 5 |
| | Drawing 1, 2, 3 | 8 |
| | Shop 2, Metal Working | 2 |
| | Total | 65 |
| b) | Secondary Courses | |
| | Shop 4, Machine Shop | 4 |
| | Surveying 4, Use of Instruments | 2 |
| | Engineering Mechanics 1, Statics | 4 |
| | E. M. 2, Strength and Elasticity | 3 |
| | E. M. 3, Dynamics | 2 |
| | E. M. 4, Hydrodynamics | 3 |
| | C. E. 2, Theory of Structures | 3 |
| | M. E. 2, Elements of Machine Design | 3 |
| | M. E. 3, Heat Engines | 4 |
| | M. E. 5, Thermodynamics | 3 |
| | M. E. 6, Theory of Machine Design | 4 |
| | M. E. 7, Mechanical Laboratory | 2 |
| | M. E. 15, Internal Combustion Engines | 3 |
| | M. E. 15*a*, Design of Internal Combustion Engines | 3 |
| | M. E. 32, Automotive Laboratory | 3 |
| | E. E. 2*a*, Electric Apparatus and Circuits | 4 |
| | Ch. E. 1, Engineering Materials | 3 |
| | Total | 53 |

| | Hours |
|---|---|
| c) Technical Courses and Electives | |
| Aero. 1, General Aeronautics | 2 |
| Aero. 2, Theory of Aviation | 2 |
| Aero. 3, Theory of Design and Propellers | 2 |
| Aero. 4, Airplane Structures | 2 |
| Aero. 5, Airplane Design | 2 |
| Aero. 6, Aerodynamic Laboratory | 1 |
| Electives | 11 |
| Total | 22 |

Summary:

| | |
|---|---|
| Preparatory Courses | 65 |
| Secondary Courses | 53 |
| Technical Courses and Electives | 22 |
| Total | 140 |

FIRST YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

SECOND YEAR

| | | | |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 | 5 | Math. 34 | 5 |
| Physics 45 | 5 | Physics 46 | 5 |
| Surveying 4 | 2 | Eng. Mech. 1 | 4 |
| Drawing 3 | 2 | | |
| | 18 | | 18 |

*For the nontechnical electives see section 51.
†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Enrollment in Military Science is for a period of four semesters.

SUMMER SESSION

| | |
|---|---|
| Shop 4 | 4 |
| Elec. Eng. 2*a* | 4 |
| | 8 |

THIRD YEAR

| | | | |
|---|---|---|---|
| Eng. Mech. 2 | 3 | Eng. Mech. 4 | 3 |
| Eng. Mech. 3 | 2 | Mech. Eng. 5 | 3 |
| Mech. Eng. 2 | 3 | Mech. Eng. 6 | 4 |
| Mech. Eng. 3 | 4 | Chem. Eng. 1 | 3 |
| Mech. Eng. 7 | 2 | Civil Eng. 2 | 3 |
| Aero. 1 | 2 | Aero. 2 | 2 |
| | 16 | | 18 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Mech. Eng. 15 | 3 | Engl. | 2 |
| Aero. 3 | 2 | Mech. Eng. 15*a* | 3 |
| Aero. 4 | 2 | Mech. Eng. 32 | 3 |
| Aero. 6 | 1 | Aero. 5 | 2 |
| Group options | 6 | Group options | 5 |
| | 14 | | 15 |

COURSES IN AERONAUTICAL ENGINEERING

1. **General Aeronautics.** Lectures and recitations. This is an introductory course giving briefly the essentials of aeronautics (balloons, dirigibles, ornithopters, helicopters, airplanes, helicoplanes, and kites), and history of flight. The fundamental aerodynamics and mechanics underlying the determination of the performance and stability of airplanes are treated largely from the experimental viewpoint. *Open to all students except freshmen.* Two hours credit. Each semester.

2. **Theory of Aviation.** Lectures and recitations. The course deals with the following: a general study of modern aerodynamical theory, and a continuation of the study of performance, maneuverability, stability, and the spin. *Prerequisites*: *Aero* 1 *and Mathematics* 34. Two hours credit. Each 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 terms. The student will design a propeller and analyze the distribution of stresses in the blades. *Must be preceded or accompanied by Aero.* 2. Two hours credit. First semester.

**4. Airplane Structures.** Lectures and recitations. This course includes the investigation of the design of the airplane from the aerodynamical and structural standpoints. The strength and design of details are discussed and a completed design prepared. *Must be preceded or accompanied by Aero.* 1 *and C. E.* 2. Two hours credit. First semester.

**5. Airplane Design.** Continuation of preceding course. Drawing only. *Prerequisites*: *Aero.* 1 *and* 4. Two hours credit. Second semester.

**6. Aerodynamic Laboratory.** An elementary course covering use of instruments, investigation of aerodynamical properties of the various combinations of bodies and aerofoils used in airplanes and airships, test of propellers. *Must be preceded or accompanied by Aero.* 2. *Open only to seniors.* One hour 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. General plans of an aerodrome are prepared. *Prerequisites*: *Aero.* 2 *and* 7. Two hours credit. First or second semester if required.

**11, 11a. 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. Study of spinning and experimental work in second semester. *Prerequisites*: *Aero.* 2 *and Math.* 39 (*Differential Equations*). *Course* 11 *is a prerequisite for* 11*a*. Two hours credit. First semester, 11; second semester, 11*a*.

**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 5, taking up some of the more complex or special problems. *Open primarily to graduates.* Credit to be arranged.

**14. Research.** Continuation of Course 6, 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. **Theoretical Aerodynamics.** A brief summary of the fundamentals of the mathematical theory of hydrodynamics, and a study of some of the recent developments in the theory of wing profiles, including the induced drag theory. Other problems such as the study of balloon hull shapes, a discussion of viscous fluid motion, and the boundary layer theory will be taken up when time permits. *Prerequisites: Aero.* 2 *and Math.* 39. A reading knowledge of German or French is desirable. Three hours credit. Each semester.

16. **Air Transportation.** Engineering and economic aspects. Two hours credit. Each semester.

17. **Aircraft, Materials of Construction.** See Shop 10.

For information on flying, see Military Science and Tactics, and Naval Aviation.

## 73. ASTRONOMY

Professor H. D. CURTIS; Associate Professor ROSSITER*; Assistant Professors RUFUS, MCLAUGHLIN, and MAXWELL; Dr. LOSH, and Mr. PETRIE.

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 spectographic 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 catalogs, 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 15-inch reflector, a 10-inch refractor, a 3-inch astronomical transit, a horizontal spectrohelioscope, 3 portable refractors, a planetarium, celestial globes, and other smaller instruments. A

*Professor Rossiter is in charge of the Lamont-Hussey Observatory of the University of Michigan, Bloemfontein, Orange Free State, South Africa.

second astronomical transit is to be added to this equipment in the future.

The Observatory maintains, through the generosity of Mr. Robert P. Lamont, '91E, a branch observing station, called the Lamont-Hussey Observatory, in Bloemfontein, South Africa. The equipment includes a 27-inch refractor and a six-inch visual and photographic telescope. The three observers at Bloemfontein are devoting their time to research in the field of visual double stars.

## CURRICULUM IN ASTRONOMY

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

Candidates for the degree of Bachelor of Science in Engineering (Astronomy) are required to complete the following program of studies:

| | | *Hours* |
|---|---|---|
| a) | Preparatory Courses | |
| | English 1 and 2, and a course from Group 3 | 6 |
| | *Nontechnical Electives | 16 |
| | Mathematics 3, 4, 33, 34 | 18 |
| | Physics 45, 46 | 10 |
| | Chemistry 5E | 5 |
| | Drawing 1, 2, 3 | 8 |
| | Shop 2 | 2 |
| | Total | 65 |
| b) | Secondary and Technical Courses | |
| | Engineering Mechanics 1, 3 | 6 |
| | Drawing 4, or C. E. 2 | 2 or 3 |
| | Geology 31 | 3 |
| | Surveying 1, 2 | 7 |
| | Surveying 5 or Astronomy 154 | 2 |
| | Astronomy 31, 32, 33, 101, 151, 152, 201 | 18 |
| | Geodesy 1 | 3 |
| | Mathematics 105, 107, or 145, 146 | 5 or 6 |
| | Physics 181, 186 | 8 |
| | Psychology 31 | 3 |
| | Total | 59 |
| Summary: | | |
| | Preparatory Courses | 65 |
| | Secondary and Technical Courses | 59 |
| | Electives | 16 |
| | Total | 140 |

*Students in this curriculum may satisfy the nontechnical elective requirement in the College of Engineering in the usual way, or they may elect twelve hours each of French and German.

COURSES IN ASTRONOMY

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.

31. **Descriptive 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. Three lectures or recitations, and one Observatory exercise. Three hours credit. Each semester.

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

33. **Observational Astronomy.** Constellation studies and telescopic examinations of the heavenly bodies. Selected problems with the celestial globe and equatorial telescope. Laboratory period of three hours. *Open to those who have had or are taking Astronomy* 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.

151. **Solar Physics.** Studies of methods and results of modern solar research. Lectures and collateral reading. *Open to those who possess a general knowledge of astronomy and physics.* Two hours credit. First semester.

152. **Astrophysics.** Studies of methods and results in physical astronomy and especially in stellar spectroscopy. Two recitations and one laboratory period each week. *Open to those who have had calculus and possess a general knowledge of astronomy and physics.* Three hours credit. Second semester.

154. **Method of 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 31, 32, 33, 101, 103, 151, 152, and 207, or similar courses, will be given during the Summer Session of 1931.

## 74. CHEMICAL ENGINEERING

Professors A. H. WHITE, A. E. WHITE, BADGER, BRIER, UPTHEGROVE, and BROWN; Associate Professors WOOD and BAKER; Assistant Professors MCCABE, PETTYJOHN, and THOMASSEN; Mr. MCCREADY.

The chemical engineer finds his principal 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 manufacturing 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. He must apply mathematics and physics in almost the same degree that he does chemistry. His relation to the chemist is very similar to that of the electrical engineer to the physicist. Like 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 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, and drying, as carried out on a commercial scale. Any manufacturing process with which the chemical engineer deals is made up of a sequence of such operations. His knowledge of these unit operations is one characteristic which distinguishes him from the chemist, and his understanding of what is actually taking place in a manufacturing process differentiates him from the mechanical engineer.

The field is so broad that more or less definite subdivisions have arisen, such as metallurgical 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 also 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.

**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, and Electro-chemical Engineering 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 carry creditably 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' study. 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 a man with a master's degree to one with a bachelor's degree on the ground that the man with postgraduate 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. During the present college year there are fifty graduate students in residence, and the size of this group makes it feasible to offer special courses not only in chemical engineering but also in mathematics and physics.

A notable development of recent years has been the call for men with the Ph.D. degree. The demand for these men has not only been greater than the supply, but the salaries and opportunities offered have been very attractive.

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.

Fifty-one graduate students are making Chemical Engineering their major subject in 1930-1931. Twenty 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 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. Some of the most important journals of pure chemistry are duplicated in this library, and there is a rich collection of journals dealing with industrial chemistry and chemical engineering. 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 distinctly with Chemical Engineering, there are many others dealing with more general engineering lines.

**Chemical Engineering Facilities.**—The Chemical Engineering Laboratories are housed in the East Engineering Building already described. The Department of Chemical Engineering is not only fortunate in having assigned to it over one-third of the 160,000 square feet of space in this new building, but is also fortunate in its neighbors. The forge shop and foundry of the Engineering College are adjacent to and co-operate closely with the metallurgical laboratories. The highway laboratories with their facilities for study of the properties of cement, brick, and asphalt are also in this building. The Department of Engineering Research with its many-sided activities has its headquarters here. Especial pains have been taken to minimize noise and vibration. Fresh air is provided by fans in the basement, and the foul air is exhausted

by fans in the attic. Ventilation of the hoods is furnished by special suction fans. Distilled water is furnished to three points on each floor. The storerooms and dispensing stands occupy a stack extending from the basement to the attic, with a freight elevator traversing the whole unit.

The Department has assigned to it over 80 rooms including laboratories, classrooms, storerooms, and offices. There are 12 single-unit and 15 double-unit laboratories available for research workers in addition to the laboratories reserved for members of the staff. There is a workshop with two mechanics who give their whole time to the departmental work, and a second shop for the use of graduate students who wish to make or repair their own apparatus.

**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 type, and a forced circulation unit. Each of these evaporators 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 crystals, and measuring condensate; and each has the greatest possible flexibility to permit adaptation to process development. Other special evaporators for research purposes are available or are constructed as needed.

There is also a full complement of equipment for work in high-temperature evaporation. This includes a gas-fired diphenyl boiler rated at 300,000 B. t. u. per hour, a small forced-circulation evaporator, and an elaborate heat-interchange apparatus, both equipped for using diphenyl heat. These pieces of equipment are provided with measuring devices of all sorts, for making complete tests. Operations can be carried out at temperatures up to 850° F.

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.—An absorption column that can be filled with various types of tower packing is available.

FILTRATION.—The present equipment consists of a 24-inch washing plate-and-frame filter press, with an assortment of special frames; a small model pressure-leaf filter of ¼ sq. ft. filtering surface; a complete Vallez pressure-leaf filter of 4 sq. ft. filtering surface; a 10-inch portable Weston centrifuge, and a 30-inch bottom discharge Tolhurst centrifuge.

CRYSTALLIZATION.—For this work there is a special 30-foot single deck Swenson-Walker continuous crystallizer with dewatering attachment, a vacuum crystallizer with a jet ejector for high vacuums, and a special vertical batch crystallizer.

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 EQUIPMENT.—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, digesters, 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 GAS AND FUEL LABORATORIES occupy two 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. A diphenyl flash boiler with a capacity of 300,000 B. t. u. per hour with air preheater is available for testing purposes.

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. The laboratory facilities are supplemented by the use of the production equipment in some one of the coal or carbureted water gas plants in Michigan when the laboratory results of the work in progress indicate that full scale plant tests are desirable.

**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 kw. transformers. A 35 KVA high frequency furnace is available for alloy studies.

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 grinding, 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, fatigue machines, 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 equipment has been selected with the aim of supplying the student with information which will enable him to take charge of the installation and control of commercial pyrometric and temperature control systems.

THE X-RAY LABORATORY has a thoroughly modern equipment, including a transformer of capacity up to 280,000 volts for the radiography of metals and another smaller X-ray outfit which is used for researches on crystal structure, grain size, inner strains, and orientation of crystals with special reference to engineering materials.

**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 other 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 high temperature work, and for testing the burning properties of clays and refractory products. The preparation room includes crushing and grinding equipment, 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. Direct current is available from a battery of 100 lead storage cells, a 5 kw. motor-generator set, and from the 110-volt line. Laboratory equipment includes a Wendt electrometric apparatus, conductivity bridges, and a complement of electrical instruments. 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.

THE PULP AND PAPER LABORATORY is equipped to make and test sheets of paper. Equipment includes a digester and an autoclave for making pulp; pulp screen, ball mill, beater, sheet-making apparatus of the latest type, and paper testing equipment. A constant temperature and humidity room houses the apparatus which requires these conditions.

**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 great 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. 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.

**Gas Engineering.**—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.

The Detroit City Gas Company, the Consumers Power Company, and the Associated Gas and Electric System join with the University in a co-operative program which permits selected students to obtain fourteen months' practical experience in a program which requires five years for its completion.

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 Professor E. S. Pettyjohn as a research engineer 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.

**Combined Courses** have been arranged with Albion, Battle Creek, and Olivet Colleges and the College of the City of Detroit. For detailed information see section 15.

**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 14. 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.

**Student Branch, American Institute of Chemical Engineers.** A student branch of this organization was established in 1922 and holds monthly meetings for discussion of topics of professional in-

terest. It has a convenient and pleasant clubroom adjoining the seminar room in the East Engineering Building.

**Reserve Officers Training Corps.**—The Colleges of Engineering and Architecture contain units of Infantry, Signal Corps, and Ordnance in the Reserve Officers Training Corps. Students completing the required work may obtain commissions as reserve officers. The Ordnance unit is especially attractive to chemical engineers, and there is sufficient flexibility in the program so that they may obtain the necessary military credits without increasing the time in residence, provided they take one summer in a military camp.

## 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 50.

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.

| *Outline of Required Courses* | *Hours* |
|---|---|
| a) Preparatory Courses | |
| English 1 and 2, and a course from Group 3 | 6 |
| Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 38 | 16 |
| Physics 45, 46 | 10 |
| Chemistry 5E, 17 | 10 |
| Drawing 1, 2, 3 | 8 |
| Shop 2, Metal Working and Treating | 2 |
| Total | 68 |
| b) Secondary and Technical Courses | |
| Chemistry 41, Theoretical Chemistry | 3 |
| Chemistry 57, Quantitative Analysis | 5 |
| Chemistry 67, Organic Chemistry | 5 |
| Chemistry 69, Organic Chemistry | 5 |
| Economics | 3 |
| Eng. Mech. 1, Statics | 4 |
| Eng. Mech. 2, Strength and Elasticity | 3 |
| Mech. Eng. 2*a*, Elements of Machine Design | 3 |
| Mech. Eng. 3, Heat Engines | 4 |
| Elec. Eng. 2*a*, Electric Apparatus and Circuits | 4 |
| Chem. Eng. 1, Engineering Materials | 3 |

| | Hours |
|---|---|
| Chem. Eng. 2, Fuels and Furnaces | 3 |
| Chem. Eng. 3, Structure and Properties of Metals | 3 |
| Chem. Eng. 4, Technology of the Inorganic Industries | 2 |
| Chem. Eng. 5, Technology of the Organic Industries | 4 |
| Chem. Eng. 9, Unit Processes | 3 |
| Chem. Eng. 12, Special Problems | 5 |
| Chem. Eng. 29, Unit Process Laboratory | 2 |
| Total | 64 |

Summary:

| | |
|---|---|
| Preparatory Courses | 68 |
| Secondary and Technical Courses | 64 |
| Electives | 8 |
| Total required for the B.S.E. degree | 140 |

Students in Chemical Engineering who wish to become candidates also in Mathematics are permitted to substitute for Astronomy 35, Eng. Mech. 3 and 4, Surveying 1, Civil Eng. 2, and such other courses as may be approved by the Department of Mathematics.

SCHEDULE FOR FOUR-YEAR PROGRAM IN CHEMICAL ENGINEERING

FIRST YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E; or Shop 2 and Engl. 1, 2 | 5 or 6 | Engl. 1 and 2 and Shop 2; or Chem. 5E | 5 or 6 |
| Alg. and Anal. Geom. (Math. 3) | 4 | Pl. and Sol. Anal. Geom. (Math. 4) | 4 |
| Elementary Draw. (Draw. 1) | 3 | Descriptive Geom. (Draw. 2) | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

*Students taking Chemical Engineering are urged to elect German. For the nontechnical elective requirement see section 51.

†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Enrollment in Military Science is for a period of four semesters.

SECOND YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | Calculus (Math. 38) | 3 |
| Calculus I (Math. 33) | 5 | Elec. and Light (Phys. 46) | 5 |
| Mech., Sound, Heat (Phys. 45) | 5 | Quant. Analysis (Chem. 57) | 5 |
| Qual. Analysis (Chem. 17) | 5 | Chem. Eng. 1 | 3 |
| | | Mech. and Sketch. (Draw. 3) | 2 |
| | 19 | | 18 |

SUMMER SESSION

| | |
|---|---|
| Theoretical Chem. (Chem. 41) | 3 |
| Chem. Eng. 2 | 3 |
| Economics 51, 53, or 153 | 3 |
| | 9 |

THIRD YEAR

| | | | |
|---|---|---|---|
| Organic Chem. (Chem. 67) | 5 | Organic Chem. (Chem. 69) | 5 |
| Statics (E.M. 1) | 4 | Strength and Elas. (E.M. 2) | 3 |
| Heat Engines (M.E. 3) | 4 | Nontechnical Elective | 4 |
| Metal. of Iron and Steel (Ch.E. 3) | 3 | Inorgan. Tech. (Ch.E. 4) | 2 |
| Chem. Eng. 9 | 3 | Unit Process Lab. (Ch.E. 29) | 2 |
| | | English | 2 |
| | 19 | | 18 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Organic Tech. (Ch.E. 5) | 4 | Elec. App. and Cir. (E.E. 2a) | 4 |
| Special Problems (Ch.E. 12) | 5 | Elective | 4 |
| Elem. Mach. Des. (M.E. 2a) | 3 | | |
| Elective | 4 | | |
| | 16 | | 8 |

*Students taking Chemical Engineering are urged to elect German. For the nontechnical elective requirement see section 51.

FIVE-YEAR PROGRAM IN CHEMICAL AND INDUSTRIAL ENGINEERING

| | *Hours* |
|---|---|
| English 1, 2, and choice of Group 3 | 6 |
| Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 38 | 16 |
| Physics 45, 46 | 10 |
| Chemistry 5, 17, 41, 57, 63, or 67 | 22 or 23* |
| Drawing 1, 2, 3 | 8 |
| Shop 2, 3 | 2 or 5* |
| Engineering Mechanics 1, 2, 2a | 7 or 8* |
| Mechanical Engineering 3, 2 or 2a, 35, 36 | 13 |
| Chemical Engineering 1, 2, 3, 4, 5, 6 or 7, 9, 12, 29 | 27 |
| Electrical Engineering 2a | 4 |
| Economics 51, 52, 171, 172, 177 | 15 |
| Business Administration 102, 113, 151 or 161 or 205, 152 or 162 or 206, 202 | 15 |
| Summer Plant Work 8 weeks | 1 |
| Electives | 8 |
| Total required for degree of Bachelor of Science in Engineering (Chemical and Industrial Engineering) | 176 |

The first-year work in the five-year program is the same as in the four-year program.

SECOND YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Calculus I (Math. 33) | 5 | Calculus (Math. 38) | 3 |
| Mech., Sound, Heat (Phys. 45) | 5 | Elec. and Light (Phys. 46) | 5 |
| Qual. Analysis (Chem. 17) | 5 | Chem. 57; or Ch.E. 1 and 2 | 5 or 6 |
| Gen. Ec. I (Ec. 51) | 3 | Gen. Ec. II (Ec. 52) | 3 |
| †Military Science | 1 | †Military Science | 1 |
| | 19 | | 17 or 18 |

THIRD YEAR

| | | | |
|---|---|---|---|
| Phys. Chem. (Chem. 41) | 3 | Statics (E.M. 1) | 4 |
| Chem. 57; or Ch.E. 1 and 2 | 5 or 6 | Statistics (Ec. 177) | 3 |
| Heat Engines (M.E. 3) | 4 | Accounting II (Ec. 172) | 3 |
| Accounting I (Ec. 171) | 3 | Unit Processes (Ch.E. 9) | 3 |
| | | Ch.E. Lab. (Ch.E. 29) | 2 |
| | 15 or 16 | | 15 |

*Options for students in Metallurgy who substitute Chem. 63 for Chem. 67; and Chem. Eng. 6 or 7, Shop 3, and Eng. Mech. 2a for Chem. 69.
†Military Science if elected in the first year must be continued throughout the second.

SUMMER SESSION

| | |
|---|---|
| Struct. of Metals (Ch.E. 3) | 3 |
| Mech. and Sketch. (Draw. 3) | 2 |
| Elective | 2 or 3 |
| | 7 or 8 |

FOURTH YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Chem. 67; or *Chem. 63 | 4 or 5 | Chem. 69; or *Shop 3, Ch.E. 6 or *7, and E.M. 2a | 5 or 7 |
| Strength of Materials (E.M. 2) | 3 | Nontechnical Elective | 4 |
| Machine Design (M.E. 2a) | 3 | Inorgan. Industries (Ch.E. 4) | 2 |
| Cost Accounting (B.A. 113) | 3 | Prin. of Personnel (B.A. 102) | 3 |
| Factory Mgt. (M.E. 35) | 3 | Factory Mgt. (M.E. 36) | 3 |
| | 16 or 17 | | 17 or 19 |

SUMMER SESSION

| | |
|---|---|
| Plant Work | 1 |

FIFTH YEAR

| | | | |
|---|---|---|---|
| Nontechnical Elective | 4 | Special Problems (Ch.E. 12) | 5 |
| Elec. App. and Cir. (E.E. 2a) | 4 | English | 2 |
| B.A. 151 or 161 or 205 | 3 | B.A. 152 or 162 or 206 | 3 |
| Organic Industries (Ch.E. 5) | 4 | Bus. Forecasting (B.A. 202) | 3 |
| Elective | 3 | Elective | 5 |
| | 18 | | 18 |

CO-OPERATIVE PROGRAM IN GAS ENGINEERING

The Detroit City Gas Company, the Consumers Power Company, and the Associated Gas and Electric System have joined with the College of Engineering to maintain a co-operative program for students interested in gas engineering. This program will require for its completion four years and ten months, of which time eight semesters and one summer session will be spent at the University. There will be one preliminary employment period of eight weeks in the summer following the freshman year and two employment periods of seven months each, the first starting at the end of the second year and the second in the middle of the fourth

*Options for students in Metallurgy who substitute Chem. 63 for Chem. 67; and Chem. Eng. 6 or 7, Shop 3, and Eng. Mech. 2a for Chem. 69.

year. There will be either one or two vacation periods of two weeks in each summer. Students in the Engineering College will be given an opportunity to learn details of the co-operative program at some time during the freshman year. Those who become interested and who are accepted will be employed by one of the companies for a preliminary period of eight weeks during the following summer. At the end of this preliminary period, students who have made a satisfactory record and are still interested, may be formally enrolled for the co-operative program. A student thus enrolled will continue his second year of study in the Department of Chemical Engineering without interruption, and will be employed at the end of that period, by the company with which he has established relations, for a practice period which will continue for seven months, commencing July 1 and ending February 1. The student will then return to the University and remain in residence for twelve months, studying for two semesters and a summer school. On February 1, he will be re-employed by the gas company for a second practice period of seven months lasting until September 1. He will then return to the University for two semesters of study and should normally graduate in the following June.

The companies agree to give the students entering upon this work a somewhat varied employment which will put them in direct contact with various aspects of gas manufacturing, distribution and accounting, and to pay them at the prevailing rate paid other workmen for the same type of work, but not less than fifty cents per hour. The company will retain the same rights to transfer, discharge, or alter the rate of pay of the student employees that it has over its regular employees.

## 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. Two lectures and two 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. Three lectures or recitations and one four-hour laboratory period. *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. Two lectures, one recitation, and one three-hour laboratory period. *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. Two recitations. *Prerequisites*: *Ch.E.* 2 *and* 9, *Chem.* 41, *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. Three lectures and two recitations. *Prerequisites*: *Ch.E.* 2 *and* 9, *Chem.* 41 *and* 67; *preceded or accompanied by Chem.* 69. Four hours credit. Each semester.

**6. Metallurgy of 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. Two lectures and one recitation. *Prerequisites*: *Ch.E.* 2 *and* 3, *or Ch.E.* 1 *and M.E.* 3. Two hours credit. First 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. Two lectures and one recitation. *Prerequisites*: *Ch.E.* 2 *and* 3, *or Ch.E.* 1 *and M.E.* 3. Two hours credit. Second semester.

**8. Advanced Physical Metallurgy.** An advanced study of the thermal, mechanical, and magnetic properties, and the macroscopic and microscopic structures of metals. One lecture, one laboratory period, reports, and discussions. *Prerequisites*: *Ch.E.* 3 *and Chem.* 41. Two hours credit. First semester.

**9. Unit Operations.** An elementary discussion of the theory of the unit operations of chemical engineering and of typical equipment for carrying out these processes. Two lectures and two 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 *and Phys.* 45; *accompanied by M.E.* 7. Not open to students in Chemical Engineering. One hour credit. Each semester.

11. **Chemical Engineering Thermodynamics.** A study of the application of the principles of the three fundamental laws of energy to chemical engineering processes. Two lectures and two recitations. Open to graduates and to seniors who receive special permission. *Prerequisites*: *Ch.E.* 2, *Chem.* 41, *and Math.* 4 *or* 4*a*. 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 work and reports. *Prerequisites*: *Ch.E.* 4 *and such other courses as are essential to a knowledge of the subject selected.* Three to eight hours credit. Each semester.

13. **Fluid Flow, Heat Flow, Evaporation, and Filtration.** An advanced study of the fundamental theory of these processes and of the equipment for their operation. Lectures and recitations. *Prerequisites*: *Ch.E.* 4 *and* 9. Two hours credit. Second semester.

14. **Crushing, Classification, Calcination, and Conveying.** An advanced study of the fundamental theory of these processes and of the equipment for their operation. Lectures and recitations. *Prerequisites*: *Ch.E.* 3 *and* 9. Two hours credit. First semester.

15. **Drying, Distillation, Extraction, and Gas Absorption.** An advanced study of the fundamental theory of these processes and of the equipment for their operation. Lectures and recitations. *Prerequisites*: *Ch.E.* 4 *and* 9. Two hours credit. Second semester.

16. **Gas Manufacture.** A study of the processes, apparatus, and operating methods used in the production of coal gas, producer gas, and carbureted water gas. Lectures and recitations. *Prerequisite*: *Ch.E.* 2. Three hours credit. First 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. One lecture, one recitation, and one laboratory period. *Prerequisites*: *Ch.E.* 2 *and* 9, *M.E.* 5. Two hours credit. Second 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. One lecture and one laboratory period. *Prerequisites*: *Ch.E.* 3 *and Chem.* 41. 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. One lecture and one laboratory period. *Prerequisites*: *Ch.E. 2 and Phys.* 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.

**21. Special Problems.** A continuation of Course 12. Laboratory work. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

**22. Applied Thermodynamics.** An advanced analytical study of chemical engineering processes from the standpoint of quantitative thermodynamics and physical chemistry. A continuation of Course 11. Two lectures and one recitation. Two hours credit. Second semester.

**23. Design of Chemical Plants.** A simple chemical process is selected, and the student proceeds to play the steps in the process and select the type of apparatus for each. *Prerequisites*: *Ch.E.* 13; *and preceded or accompanied by Ch.E.* 14 *and* 15, *and a course in Machine Design.* Three hours credit. Second semester.

**24. Testing Petroleum Products.** Laboratory work. *Prerequisite*: *Ch.E.* 2. One hour 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. *Prerequisites*: *Ch.E.* 3 *and* 8. 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.* 9 *and a course in Machine Design.* Two hours credit. Each semester.

**28. Heat and Material Balances.** Problems illustrating the application of the method of heat and material balances to chemical and manufacturing processes. Two recitations. *Prerequisite*: *Ch.E.* 4. Two hours credit. First 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. One recitation and one four-hour laboratory period. *Must be preceded or accompanied by Ch.E.* 9. Two hours credit. Each semester.

30. **Seminar in Metallurgy.** Reading and reports on metallurgical subjects. *Open to graduates, and to seniors who receive permission.* Two hours credit. Each semester.

31. **Gas Distribution.** A technical and economic study of the transportation, distribution, and utilization of manufactured and natural gas. Lectures and recitations. *Prerequisites*: *Ch.E.* 9 *and* 16. Three hours credit. Second semester.

32. **Explosives and Pyrotechnics.** A study of the processes used in the manufacture of commercial and military explosives and pyrotechnic materials; their properties and uses. Lectures and recitations. *Prerequisite*: *Ch.E.* 5. Four hours credit. Second semester.

33. **Seminar in Heat Transfer.** Conferences and problems in heat transfer. *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* 9. Three hours credit. First semester.

35. **Motor Fuel Utilization Seminar.** A discussion of engine performance as dependent upon motor fuel characteristics. *Open to graduate students who have completed Ch.E.* 11 *or are actively engaged in research in this field.* Two hours credit. First semester.

36. **Advanced Chemical Engineering Calculations.** A problem course illustrating the application of chemical engineering theory to industrial calculations. Problems involving economic balance in engineering design will be emphasized. Conferences and group calculations. *Prerequisites*: *Ch.E.* 11, 13, *and* 15. Three hours credit. Second semester.

37. **X-Ray Structures and Their Application to Engineering Materials.** Conferences and assigned work. *Prerequisites*: *advanced mathematics and physics as well as the necessary courses in Chemical Engineering.* Three hours credit. First semester.

41. **Advanced Ferrous Metallurgy.** Research work on the structures and properties of iron and steel. Laboratory work and

conferences. *Open to graduates, and to seniors who receive special permission.* Three 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 work and conferences. *Open to graduates, and to seniors who receive special permission.* Three 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 work and conferences. *Open to graduates, and to seniors who receive special permission.* Three 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 work and conferences. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

45. **Paint, Varnish, and Pyroxylin Lacquers.** Research work on problems connected with the manufacture, properties, and uses of paints, varnish, and pyroxylin lacquers. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

46. **Advanced Electrochemistry.** Research relating to electrodeposition and electrochemical processes. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

47. **Advanced Non-Ferrous Metallurgy.** Research work on structures and properties of non-ferrous metals and alloys. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

48. **Petroleum and Motor Fuels.** Research work on problems connected with the production and utilization of petroleum products. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

50. **Distillation.** Research work on the theory, design, and performance of distillation equipment. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

**51. Paper Manufacture.** Research work connected with the properties of paper pulp and paper making materials. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

**52. Refractories and Furnace Design.** Research work on the thermal and physical properties of refractory materials, combustion, and heat transfer at high temperatures. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Three to eight hours credit. Each semester.

**53. Crystallization.** Research work on the theory and practice of industrial crystallization. Laboratory work and conferences. *Open to graduates, and to seniors who receive special permission.* Five to eight hours credit. Each semester.

**54. X-Ray Studies.** Research work in the application of X-rays to the structure and properties of materials. Laboratory work and conferences. *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, 3, 4, 9, 11, 13, 15, and 34, will be given during the Summer Session of 1931, and several of the other advanced courses will be offered if there is a sufficient demand for them.

## 75. CIVIL ENGINEERING

Professors RIGGS*, GRAM, KING, HOAD, DECKER, WORLEY, CISSEL, and MORRISON; Associate Professors WISLER, SHERLOCK, EMMONS, and SADLER; Assistant Professors SWINTON, ALT and HOUSEL; Mr. BOYD, Mr. MAUGH, and Mr. JAKKULA.

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 the various 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

*Honorary Professor of Civil Engineering.

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 waterworks, 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. 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, Speech, 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 of the Graduate School of the University.

**Fellowships** of interest to students in Civil Engineering are described in section 44.

**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 laboratories for the testing of the following materials: cement, concrete, sand, gravel, rock, paving brick, and similar materials; asphalt, tars, oils, and bituminous mixtures; calcium chloride, metals and paints; culvert pipe; and soils. The laboratories also contain a freezing room where

temperatures as low as –40°F. may be obtained, and 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, mechanical shakers, microscopes, bituminous extraction machines, standard penetrometers, ductility machines, viscosimeters, constant temperature baths, electric ovens, analytical balances, field testing apparatus, and a freezing room.

**Hydraulic Experimental Equipment.**—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.

A flume in the West Engineering Building provides for inside laboratory experiments on the measurement of flowing water in quantities up to 12 cubic feet per second. The flume is 50 feet long, 2 feet wide, and 4 feet deep. Water is supplied by a 16-inch centrifugal pump driven by a 100-horsepower motor. Accurate measurement of discharge is provided by scales and weighing tanks with a total capacity of 100,000 pounds. A 90° V-notch weir calibrated by means of the weighing tanks is also available for measurement of flow.

**Surveying Camp.**—Course 3 in surveying, offered each summer at Camp Davis, is open to students who have completed Courses 1 and 2 in that subject. Camp Davis is located in the Jackson's Hole country, Wyoming, about 75 miles south of Yellowstone National Park. It is recommended that, wherever practicable, students in Civil Engineering avail themselves of the many unique advantages of the life and training at this camp.

**Combined Courses** have been arranged with Albion, Battle Creek and Olivet Colleges, and the College of the City of Detroit. For detailed information see section 15.

**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 14.

**Military Science.**—The attention of prospective students in Civil 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 64.

## 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 unless they specialize in Transportation for which a different curriculum follows. For the definition of an hour of credit see section 50.

| | *Hours* |
|---|---|
| a) Preparatory Courses | |
| English 1 and 2 and English 6 | 6 |
| Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 34 | 18 |
| Physics 45, 46 | 10 |
| Chemistry 5E | 5 |
| Drawing 1, 2, 3 | 8 |
| Geology 31 | 3 |
| Shop Work 2 | 2 |
| Total | 68 |
| b) Secondary and Technical Courses | |
| Chem. Eng. 1, Engineering Materials | 3 |
| Surveying 1, 2 | 7 |
| Eng. Mech. 1, Statics | 4 |
| Eng. Mech. 2, Strength and Elasticity | 3 |
| Eng. Mech. 3, Dynamics | 2 |
| Eng. Mech. 4, Hydromechanics | 3 |
| Civil Eng. 2, Theory of Structures | 3 |
| Civil Eng. 2*a*, Elementary Design of Structures | 3 |
| Civil Eng. 3, Masonry | 3 |
| Civil Eng. 10, Hydrology | 3 |
| Civil Eng. 26, Spec. and Contracts | 2 |
| Civil Eng. 30, Water Works | 3 |
| Civil Eng. 32, Sewerage | 2 |
| Civil Eng. 40, Highway Engineering | 2 |
| Civil Eng. 42*c*, Concrete Mixtures | 1 |
| Civil Eng. 50, Railroad Engineering | 2 |
| Mech. Eng. 3, Heat Engines | 4 |
| Elec. Eng. 2*a*, Electrical Apparatus and Circuits | 4 |
| Total | 54 |
| Summary: | |
| Preparatory Courses | 68 |
| Secondary and Technical Courses | 54 |
| Group Option | 7 |
| Electives | 11 |
| Total | 140 |

FIRST YEAR

| *First Semester* Courses | Hours | *Second Semester* Courses | Hours |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17 or 18 | | 16, 17 or 18 |

SECOND YEAR

| | | | |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 | 5 | Math. 34 | 5 |
| Physics 45 | 5 | Eng. Mech. 1 | 4 |
| Surveying 1 | 3 | Surveying 2 | 4 |
| | 17 | | 17 |

SUMMER SESSION

Electives, or required work, or a combination of electives and required work, to a total of 8 hours.

THIRD YEAR

| | | | |
|---|---|---|---|
| Electives | 2 | Geology 31 | 3 |
| Physics 46 | 5 | Chem. Eng. 1 | 3 |
| Civil Eng. 40 | 2 | Eng. Mech. 3 | 2 |
| Eng. Mech. 2 | 3 | Eng. Mech. 4 | 3 |
| Mech. Eng. 3 | 4 | Civil Eng. 2 | 3 |
| Drawing 3 | 2 | Civil Eng. 2*a* | 3 |
| | 18 | | 17 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Elective or Group Option | 2 | Elec. Eng. 2*a* | 4 |
| Civil Eng. 3 | 3 | Engl. 6 | 2 |
| Civil Eng. 10 | 3 | Civil Eng. 26 | 2 |
| Civil Eng. 30 | 3 | Elective or Group Option | 6 |
| Civil Eng. 32 | 2 | | |
| Civil Eng. 42*c* | 1 | | |
| Civil Eng. 50 | 2 | | |
| | 16 | | 14 |

*For nontechnical elective requirement see section 51.
†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Enrollment in Military Science is for a period of four semesters.

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*

Modern Language.
Economics: Courses 51, 52, 53, 54, 121, 122, 123, 131, 133, 173, 175, and 181.
English (Engineering College): Courses 3, 5, 21, 22, 23, 24, 25, 27, 28, 29, and 30.
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, and 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, 9, 12, 13, 15, and 16.
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, 105, 107, 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.
Co-operative Courses *9s*, *19s*, *29s*, *39s*, *49s*, and *59s*.

NOTE.—Military Science, after the freshman year, is classified as Group 2.

Students wishing to take electives not listed in Groups 1 and 2 may do so if they have the endorsement of the Professor of Civil Engineering.

## GROUP OPTIONS

Each student in Civil Engineering must elect seven hours' work from the courses listed under Group Options. One of the courses elected must in general be a design course.

The group options are arranged to assist the student in selecting a program of seven hours of specialized study in related subjects, and he is urged but not required to elect the entire seven hours in one group.

A. STRUCTURAL ENGINEERING.

| | Hours |
|---|---|
| Civil Eng. 4, Advanced Theory of Structures | 2 |
| Civil Eng. 5, Design of Structures | 3 |
| Civil Eng. 6, Foundations and Resistance of Soils | 3 |
| Civil Eng. 7, Advanced Design of Structures | |
| a) Bridge Design | 3 |
| b) Reinforced Concrete | 3 |
| c) Arches | 2 |
| d) Timber Construction | 1 |
| Civil Eng. 8, Construction Methods and Equipment | 2 |
| Civil Eng. 9, Cost Analysis and Estimating | 2 |
| Civil Eng. 27, Public Utility Problems | 2 |
| Civil Eng. 65, Structural Engineering Research | |
| Mech. Eng. 20, Mechanical Handling of Materials | 2 |
| Chem. Eng. 6, Iron and Steel | 2 |
| Chem. Eng. 8, Metallography | 2 |

Students electing Group A are required to elect Design Course 5.

B. HYDRAULIC ENGINEERING.

| | |
|---|---|
| Civil Eng. 11, Hydraulics | 2 |
| Civil Eng. 12, Development of Water Power | 3 |
| Civil Eng. 13, Administration of Water Resources | 2 |
| Civil Eng. 14, Irrigation and Drainage | 2 |
| Civil Eng. 16, Design of Hydraulic Structures | 3 |
| Civil Eng. 18, Rivers and Harbors | 1 |
| Civil Eng. 27, Public Utility Problems | 2 |
| Civil Eng. 61, Irrigation and Drainage, Advanced | 2 |
| Civil Eng. 62, Hydraulic Design, Advanced | 2 |
| Civil Eng. 64, Hydraulic Engineering Research | |
| Mech. Eng. 4, Hydraulic Machinery | 3 |
| Mech. Eng. 16, Water Turbines | 3 |
| Elec. Eng. 3a, Alternating Current Apparatus | 4 |
| Elec. Eng. 11, Power Plants, Transmission and Dis. | 5 |
| Elec. Eng. 33, Industrial Electrical Engineering | 2 |
| Elec. Eng. 36, Rates and Cost Analysis | 2 |

Students electing Group B are required to elect Design Course 16 and Course 12, the accompanying theory course.

| | Hours |
|---|---|
| C. TRANSPORTATION ENGINEERING. | |
| Civil Eng. 18, Rivers and Harbors | 1 |
| Civil Eng. 27, Public Utility Problems | 2 |
| Civil Eng. 36, Municipal Engineering | 2 |
| Civil Eng. 41, Highway Engineering, Theory and Economics | 2 |
| Civil Eng. 42*a*, Highway Materials Laboratory | 2 |
| Civil Eng. 42*b*, Bituminous Materials Laboratory | 2 |
| Civil Eng. 44, Highway Transport | 2 |
| Civil Eng. 45, Highway Traffic Control | 2 |
| Civil Eng. 46, Highway Administration | 2 |
| Civil Eng. 51, Railroad Location | 2 |
| Civil Eng. 52, Railroad Maintenance | 2 |
| Civil Eng. 52*a*, Heavy Excavation and Tunnel Work | 2 |
| Civil Eng. 53, Terminal Design | 3 |
| Civil Eng. 54, Railway and Highway Location Design | 3 |
| Civil Eng. 55, Transportation | 2 |
| Civil Eng. 55*a*, Transportation | 2 |
| Civil Eng. 58, Inland Waterway Transportation | 2 |
| Civil Eng. 63, Civil Engineering Research | |
| Civil Eng. 66, Highway Engineering and Highway Transport Research | |
| Civil Eng. 67, Railroad Engineering Research | |
| Mech. Eng. 29, Automobiles and Motor Trucks | 3 |
| Elec. Eng. 8, Electric Railways | 2 |
| Elec. Eng. 11, Power Plants, Transmission and Distribution | 5 |

Students electing Group C are required to elect a design course of this group.

| | |
|---|---|
| D. SANITARY AND MUNICIPAL ENGINEERING. | |
| Civil Eng. 7*a*, Concrete and Steel Highway Bridge Design | 3 |
| Civil Eng. 11, Hydraulics | 2 |
| Civil Eng. 27, Public Utility Problems | 2 |
| Civil Eng. 31, Water Purification | 2 |
| Civil Eng. 33, Sewage Disposal | 2 |
| Civil Eng. 34, Municipal and Industrial Sanitation | 3 |
| Civil Eng. 35, Sanitary Engineering Design | 3 |
| Civil Eng. 36, Municipal Engineering | 2 |
| Civil Eng. 41, Highway Engineering Theory and Economics | 2 |
| Civil Eng. 42, Highway Engineering Laboratory | 2 |
| Mech. Eng. 20, Mechanical Handling of Materials | 2 |
| Mech. Eng. 25, Heating and Ventilation | 2 |

Students electing Group D are required to elect Design Course 35 and Course 31, 33, or 34.

E. General Engineering Science.

| | |
|---|---|
| Physics | Mechanics |
| Chemistry | Mineralogy |
| Astronomy | Geology |
| Mathematics | |

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.

## CURRICULUM IN TRANSPORTATION AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Civil Engineering), who specialize in Transportation are required to complete the curriculum detailed below. For the definition of an hour of credit see section 50.

| | | *Hours* |
|---|---|---|
| a) | Preparatory Courses | |
| | English 1, 2, and 6 | 6 |
| | Nontechnical Electives | 16 |
| | Mathematics 3, 4, 33, and 38 | 16 |
| | Physics 45 and 46 | 10 |
| | Chemistry 5E | 5 |
| | Drawing 1, 2, and 3 | 8 |
| | Shop Work 2 | 2 |
| | Economics 53, 54*a*, and 173 | 9 |
| | Political Science 31*a* | 2 |
| | Total | 74 |
| b) | Secondary and Technical Courses | |
| | Chem. Eng. 1, Engineering Materials | 3 |
| | Surveying 1 | 3 |
| | Eng. Mech. 1, Statics | 4 |
| | Eng. Mech. 2, Strength and Elasticity | 3 |
| | Eng. Mech. 3, Dynamics | 2 |
| | Civil Eng. 2, Theory of Structures | 3 |
| | Civil Eng. 3, Masonry | 3 |

| | Hours |
|---|---|
| Civil Eng. 26, Spec. and Contracts | 2 |
| Civil Eng. 40, Highway Engineering | 2 |
| Civil Eng. 42*c*, Concrete Mixtures | 1 |
| Civil Eng. 50, Railroad Engineering | 2 |
| Mech. Eng. 3, Heat Engines | 4 |
| Elec. Eng. 2*a*, Electrical Apparatus and Circuits | 4 |
| Marine Engineering | 2 |
| Civil Eng. 58, Inland Waterway Transportation | 2 |
| Aeronautical Eng. 1, General Aeronautics | 2 |
| Mech. Eng. 29, Automobile and Motor Trucks | 2 |
| Civil Eng. 53, Terminal Design | 3 |
| Elec. Eng. 8, Principles of Electric Traction | 2 |
| Civil Eng. 55, Transportation | 2 |
| Elec. Eng. 13*a*, Communication | 2 |
| Major Electives | 8 |
| Total | 61 |

Summary:

| | |
|---|---|
| Preparatory Courses | 74 |
| Secondary and Technical Courses | 61 |
| Electives | 5 |
| Total | 140 |

FIRST YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chemistry 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Shop 2 and Engl. 1 and 2 or Chemistry 5E | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17 or 18 | | 16, 17 or 18 |

*For nontechnical elective requirement see section 51.
†Military Science, if elected, must be continued through four semesters.

SECOND YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 (Calculus) | 5 | Math. 38 (Calculus) | 3 |
| Physics 45 | 5 | Physics 46 | 5 |
| Surveying 1 | 3 | Eng. Mech. 1 | 4 |
| †Required Elective | 1 or 2 | †Required Elective | 1 or 2 |
| | 18 or 19 | | 18 or 19 |

SUMMER SESSION

Electives or required work scheduled in the eight semesters or a combination of them to a total of 8 hours.

THIRD YEAR

| | | | |
|---|---|---|---|
| Aeronautical Eng. 1 | 2 | Marine Eng. | 2 |
| Civil Eng. 50 (Railroad Eng.) | 2 | Mech. Eng. 29*a* | 2 |
| Drawing 3 | 2 | Economics 53 | 3 |
| Economics 173 | 3 | Civil Eng. 2 (Theory of Structures) | 3 |
| Eng. Mech. 2 | 3 | Civil Eng. 58 (Inland Waterways) | 2 |
| Elec. Eng. 2*a* | 4 | Eng. Mech. 3 | 2 |
| Civil Eng. 40 (Highway Eng.) | 2 | Mech. Eng. 3 | 4 |
| | 18 | | 18 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Chem. Eng. 1 | 3 | English 6 | 2 |
| Civil Eng. 53 (Terminal Design) | 3 | Elec. Eng. 8 | 2 |
| Economics 54*a* | 3 | Elec. Eng. 13*a* | 2 |
| Civil Eng. 3 (Masonry) | 3 | Civil Eng. 26 | 2 |
| Civil Eng. 42*c* | 1 | Civil Eng. 55 | 2 |
| ‡Major Electives | 4 | Pol. Sci. 31*a* | 2 |
| | 17 | ‡Major Electives | 4 |
| | | | 16 |

**Co-operative Courses with Industry.** Courses 9*s*, 19*s*, 29*s*, 39*s*, 49*s*, and 59*s* are offered to students in Civil Engineering. The work under these courses consists of employment by an approved company engaged in work in which Civil Engineering students are interested, during the summer vacation, June to October, or during a semester. While employed, the student will be paid standard

*For nontechnical elective requirement see section 51.
†Required electives may be chosen from Military Science, 5 hours; or co-operative courses in industries, 5 hours; or approved electives, 5 hours.
‡Major electives may be in Aeronautical, Automobile, Electrical, Highway, Marine, or Railway Engineering.

wages for work done. Work under these courses when completed carries a minimum of five hours credit for ten months of work and an additional hour for each additional two months of work up to a total of sixteen months. These courses must be elected during the freshman and sophomore years. The work is done in accordance with a prearranged plan and schedule and under close supervision of some member of the Civil Engineering staff. Credit for this work comes under Group 2, Electives for Civil Engineering.

**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. 1 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.

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.* 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. *Prerequisites*: *Drawing 3 and preceded or accompanied by C.E. 2.* Three hours credit. Each semester.

3. **Masonry Construction.** Properties of materials; analysis of stresses in plain and reinforced concrete structures; foundations for engineering structures. *Prerequisite*: *E.M. 2* Three 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, texts, 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.

**6. Foundations and Resistance of Soils.** A study of the theory and design of foundations with special reference to soil as an engineering material; physical characteristics of soils; determination of bearing capacity; plastic flow; pressure distribution; standard practice; recent developments in soil research. Lectures and references. *Prerequisite*: *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 *and 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.* 3. Three hours credit. Each semester.

**7c. Arches.** Analysis of stresses and design of arches, especially reinforced concrete arches. Lectures, drawing work. *Prerequisite*: *C.E.* 3. 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. *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. *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. Two recitations and one three-hour laboratory period. *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; critical depth and hydraulic jump. 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 experimental data to hydraulic problems; orifices, weirs, pipes 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; farm drainage; reclamation of overflowed areas; 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 hydraulic structures; water conveyance structures; dams; power houses; head gates; wasteways; regulating works. Lectures, computations, design. *Prerequisite: C.E. 3, and 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. *Open to junior, senior, and graduate students in Engineering and in Business Administration.* 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. *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 graduate students.* 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 graduate students.* 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 graduate students.* 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 graduate students.* Two hours credit. Second semester.

34. **Municipal and Industrial Sanitation.** The scientific foundations of public sanitation; the prevention of typhoid fever, malaria, and other diseases, through water purification, sewerage and drainage, and other major sanitary improvements involving community control of the environment; the collection, utilization, and disposal of garbage and other city wastes; street cleaning methods, organization, and management; and industrial sanitation. Lectures, library reading. *Open to seniors and graduate students.* Three hours credit. Each 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 sewerage disposal. Drawing room and visits to plants and work under construction. *Prerequisites*: *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.

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. *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. *Prerequisite 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 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 courses*: *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.* 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. *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. Each semester.

**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 railroad, highway, waterway, and airport 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. *Open to graduate students only.* Credit to be arranged.

**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 would 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. *Open to graduate students and fifth-year students who have elected Group Option A in structural engineering.* Credit to be arranged.

**65a. Seminar in Advanced Theory of Structures.** Study of special problems in theory of structures under the direction of Professor Timoshenko. *Open to qualified graduate students.* 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. 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, 7*c*, 40, 45, 65, and 66, or similar courses, will be given during the Summer Session of 1931.

## 76. ELECTRICAL ENGINEERING

Professors BAILEY, HIGBIE, LOVELL, and CANNON; Associate Professor MOORE; Assistant Professors ATTWOOD, STOUT, BULL, DOW, GAULT, and HOLLAND; Mr. HELLWARTH.

Electrical engineers practice in a field of great breadth; any true subdivision of it is very difficult. The six 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, generators, 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; Course 14 applies recent developments in electron physics to electrical power engineering problems.

**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 has been increasing every year, and is now one of the country's largest industries.

Courses 10, 21, and 22 in communication apply the principles developed in previous courses to new apparatus and circuits. Courses 23 and 24 have been developed for students outside the Electrical Engineering Department. Courses 40 and 41 cover practices and problems of telephone communication. These courses prepare 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, 71, 72, and 73, 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 comes into 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 a physicist.

**Electrical Theory and Laboratory Technique** constitute a division of work in the Department that is of growing importance in the field. The rapid development of electrical engineering and its relation to many applications of great variety have created a demand for workers with a more extensive training in fundamental electrical and physical theory and laboratory procedure.

Courses 1 and 25 develop the fundamental field theory of electricity and magnetism, and show the significance of recent developments in physics.

Course 12 forms the basis for the study of the theory of electronic phenomena and gives its application to many important engineering questions. Courses 16 and 21, respectively, discuss the application of electronic phenomena to the problems of rectification and vacuum tubes.

Course 26 develops the Heaviside operational method and gives its application to electrical circuit theory.

Course 28 provides the opportunity for the student to gain experience in the laboratory in making accurate measurements with equipment of the highest quality.

**Research.**—The staff in Electrical Engineering is always very glad to offer its laboratory facilities and advice to graduate students who wish to work on research problems leading to one of the higher degrees. In keeping with this policy the Department each year offers several teaching assistantships to graduate students.

Course 18 may be elected by graduate students pursuing research, while Course 9 serves the same purpose for undergraduates.

**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 12 introduces the fundamentals of electronic theory, and includes a study of the functions and uses of the simpler forms of thermonic vacuum tubes.

Courses 9 and 18 are open to more able students by permission, and give opportunity for study of any worth-while problems not excluded by the limitations of physical equipment.

Course 17, of a mathematical nature, develops electro-mechanics.

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 acquiring 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 program in Electrical Engineering and Industry is offered in co-operation with certain leading electrical industries. The student spends in all four semesters or sixteen months in one chosen industry. In this program the re-

quired university work is the same as that for students choosing the regular program in Electrical Engineering. However, successful completion of the industrial part of the program entitles the student to nine credit hours which may be counted as nine hours of elective studies. The time spent in the University will be made up of those semester and summer session periods during which the student is not connected with the industry. The work in industry will be closely supervised by an officer of the University.

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, a photometric laboratory, and an electrical standards 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. The equipment includes four oscillographs with all accessories.

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 the 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, of four different types, 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, an 80-inch sphere for large sources; a Taylor part-sphere for measuring the reflection coefficient of surfaces in place, and a most convenient form of spectrophotometer (Keuffel and Esser color analyzer), arranged especially for measurements of reflection and transmission of light. A Weber photometer with accessories, and a daylight recorder, consisting of a Case photoelectric cell connected to a Leeds and Northrup recording potentiometer, are available for use in research work. 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 some projectors. Special equipment has been developed for study of surface sources of light by means of which noteworthy investigations have been made and published.

**The Electrical Standards Laboratory** is provided with standards of resistance, inductance and capacitance, standard cells, potentiometers, galvanometers, meters of the precision type, and ratio and phase angle testing equipment for current and potential instrument transformers.

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 42.

**Combined Courses** have been arranged with Albion, Battle Creek and Olivet Colleges and the College of the City of Detroit. For detailed information see section 15.

**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 14.

**Military Science.**—The attention of prospective students in Electrical Engineering is called to the Reserve Officers Training Corps. Work offered in the Signal Corps group is of special interest to students in Electrical Engineering, as they are well qualified for it. Those who consider taking Military Science are urged to enroll at the beginning of their course. For further details see section 64.

## 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 50.

| | | *Hours* |
|---|---|---|
| a) | Preparatory Courses | |
| | English 1 and 2 and a course from Group 3 | 6 |
| | Nontechnical Electives | 16 |
| | Mathematics 3, 4, 33, 34 | 18 |
| | Physics 45, 46 | 10 |
| | Chemistry 5E | 5 |
| | Drawing 1, 2, 3 | 8 |
| | Shop 2 | 2 |
| | Total | 65 |
| b) | Secondary and Technical Courses | |
| | Physics 147, Electrical Measurements | 4 |
| | Surveying 4, Use of Instruments | 2 |
| | Eng. Mech. 1, Statics | 4 |
| | Eng. Mech. 2, Strength and Elasticity | 3 |
| | Eng. Mech. 3, Dynamics | 2 |
| | Eng. Mech. 4, Hydromechanics | 3 |
| | Civil Eng. 2, Theory of Structures | 3 |
| | Mech. Eng. 2a, Elements of Machine Design | 3 |
| | Mech. Eng. 3, Heat Engines | 4 |
| | Chem. Eng. 1, Engineering Materials | 3 |
| | Elec. Eng. 1, Prin. of Electricity and Magnetism | 4 |
| | Elec. Eng. 2, D.C. Apparatus and Circuits | 4 |
| | Elec. Eng. 3, A.C. Circuits | 4 |

| | |
|---|---|
| Elec. Eng. 4, A.C. Apparatus | 4 |
| Elec. Eng. 5, Design of Electrical Machinery | 4 |
| Elec. Eng. 7, Illumination and Photometry | 2 |
| Elec. Eng. 11, Power Plants, Transmission and Distribution | 5 |
| Elec. Eng. 12, Electronics and Vacuum Tubes | 4 |
| Elec. Eng. 17, Electro-mechanics | 4 |
| Total | 66 |

Summary:

| | |
|---|---|
| Preparatory Courses | 65 |
| Secondary and Technical Courses | 66 |
| Electives | 9 |
| Total | 140 |

FIRST YEAR

| *First Semester* Courses | Hours | *Second Semester* Courses | Hours |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

SECOND YEAR

| | | | |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 | 5 | Math. 34 | 5 |
| Physics 45 | 5 | Physics 46 | 5 |
| Drawing 3 | 2 | Eng. Mech. 1 | 4 |
| Surveying 4 | 2 | | |
| | 18 | | 18 |

SUMMER SESSION

| | |
|---|---|
| Mech. Eng. 3 | 4 |
| Elec. Eng. 2 | 4 |
| | 8 |

*For nontechnical elective requirement see section 51.
†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Enrollment in Military Science is for a period of four semesters.

THIRD YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Eng. Mech. 2 | 3 | Eng. Mech. 3 | 2 |
| Eng. Mech. 4 | 3 | Elec. Eng. 4 | 4 |
| Elec. Eng. 1 | 4 | Mech. Eng. 2*a* | 3 |
| Elec. Eng. 3 | 4 | Engl. from Group 3 | 2 |
| Chem. Eng. 1 | 3 | Elec. Eng. 7 | 2 |
| | | Elec. Eng. 12 | 4 |
| | 17 | | 17 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Civil Eng. 2 | 3 | Elec. Eng. 17 | 4 |
| Physics 147 | 4 | Electives | 9 |
| Elec. Eng. 5 | 4 | | |
| Elec. Eng. 11 | 5 | | |
| | 16 | | 13 |

## 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 1, 2, and choice from Group 3 | 6 |
| Nontechnical Electives | 8 |
| Mathematics 3, 4, 33, and 34 | 18 |
| Physics 45, 46, and 147 | 14 |
| Chemistry 5E | 5 |
| Drawing 1, 2, and 3 | 8 |
| Shop Work 2 | 2 |
| Engineering Mechanics 1, 2, 3, and 4 | 12 |
| Mechanical Engineering 2*a*, 3, 35, and 36 | 13 |
| Chemical Engineering 1 | 3 |
| Electrical Engineering 1, 2, 3, 4, 5, 7, 11, 17, 33, and 36 | 34 |
| Economics 51, 52, 134, 171, and 172 | 15 |
| Business Administration 102*, 113, 161, 162, 205, 281, and 282 | 21 |
| Civil Engineering 2 | 3 |
| Surveying 4 | 2 |
| Electives | 12 |
| Total required for degree of Bachelor of Science in Engineering (Electrical and Industrial Engineering) | 176 |

*Economics 121 may be substituted for Business Administration 102.

The schedule of work is as follows:

FIRST YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

SECOND YEAR

| | | | |
|---|---|---|---|
| Math. 33 | 5 | Math. 34 | 5 |
| Physics 45 | 5 | Physics 46 | 5 |
| Drawing 3 | 2 | Eng. Mech. 1 | 4 |
| Economics 51 | 3 | Economics 52 | 3 |
| Surveying 4 | 2 | | |
| | 17 | | 17 |

SUMMER SESSION

| | |
|---|---|
| Mech. Eng. 3 | 4 |
| Elec. Eng. 2 | 4 |
| | 8 |

THIRD YEAR

| | | | |
|---|---|---|---|
| Eng. Mech. 2 | 3 | Civil Eng. 2 | 3 |
| Eng. Mech. 3 | 2 | Chem. Eng. 1 | 3 |
| Elec. Eng. 1 | 4 | Eng. Mech. 4 | 3 |
| Elec. Eng. 3 | 4 | Elec. Eng. 4 | 4 |
| Econ. 171 | 3 | Econ. 172 | 3 |
| | 16 | | 16 |

*For nontechnical elective requirement see section 51.
†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Enrollment in Military Science is for a period of four semesters.

FOURTH YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Physics 147 | 4 | Mech. Eng. 2*a* | 3 |
| Elec. Eng. 11 | 5 | Elec. Eng. 17 | 4 |
| Engl. from Group 3 | 2 | M.E. 36 | 3 |
| M.E. 35 | 3 | Bus. Ad. 162 | 3 |
| Bus. Ad. 161 | 3 | Elec. Eng. 7 | 2 |
| | | Elective | 2 |
| | 17 | | 17 |

FIFTH YEAR

| | | | |
|---|---|---|---|
| Elec. Eng. 33 | 2 | Elec. Eng. 5 | 4 |
| Bus. Ad. 102, or Ec. 121 | 3 | Elec. Eng. 36 | 1 |
| Bus. Ad. 205 (Law) | 3 | Bus. Ad. 282 | 3 |
| Bus. Ad. 281 | 3 | Econ. 134 | 3 |
| Bus. Ad. 113 | 3 | Elective | 6 |
| Elective | 4 | | |
| | 18 | | 17 |

## CO-OPERATIVE COURSE IN ELECTRICAL ENGINEERING AND INDUSTRY (FIVE YEARS)

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.

Co-operative relations shall be established only with such industries as are able and willing to offer a definite program of graded work of educational value.

## 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. Three lectures and one three-hour computing period. *Prerequisites*: *Math.* 34 *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 calcula-

tions; power losses and efficiency of machines; commutation and armature reaction; parallel operation of generators; mechanical and electrical coupling of motors. Three lectures and one four-hour laboratory period. *Prerequisites*: *Physics* 45 *and* 46, *E.M.* 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. Three lectures and one four-hour laboratory period. *Not open to electrical engineering students. Required of all other students in Engineering.* 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 system; e.m.f.'s of armature windings—vector representation and calculation; transformers — construction, theory, operation, simple and complete vector diagrams, losses and constants, efficiency and regulation; instrument transformers; voltage regulators; constant current transformers. Three lectures and one four-hour laboratory period. *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, recitations, and one four-hour laboratory period. *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. Two lectures and two four-hour computing periods. *Prerequisites*: *M. E. 2a, E. E.* 1, *and E. E.* 3. Four hours credit. Each semester.

**6. Advanced Theory of the Induction Motor.** Continuation of Course 4. Both polyphase and single-phase motors are studied. One lecture and one four-hour computing period. *Prerequisite*: *E.E.* 4. 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 photom-

eters, 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 as they affect lighting; characteristics of lamps, reflectors, enclosing globes; glare and shadow; industrial, office, school, and residence lighting. Two lectures and one three-hour laboratory period. *Prerequisite*: *Phys.* 46 *and Math.* 4. 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, and residences. This course is 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. One lecture. *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. Recitations and problems. *Prerequisite*: *E.E. 3 or E.E. 2a.* 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, recitations, and problems. *Prerequisite*: *E.E.* 3, *or E.E. 2a.* Five hours credit. Each semester.

12. **Electronics and Vacuum Tubes.** An engineering approach to the theories of ionization, of the mechanisms of current flow and energy interchanges in ionized regions, and of thermionic, photoelectric, and other types of electron emission, as related to conducting gases at atmospheric and lower pressures. Study of thermionic vacuum tube characteristics, and of types of circuits and tubes suitable for rectifiers, amplifiers, detectors, and oscillators. Three lectures and one three-hour laboratory period. *Prerequisites*: *E. E.* 1, *and to be preceded or accompanied by E. E.* 3. Four hours credit. Each semester.

14. **Electronics in Power Transmission and Distribution.** Application to electric power engineering of the principles studied in E. E. 12. Mechanism of electrical failure of dielectrics, including air; methods and equipment used in experimental study of lightning problems; lightning arresters, high voltage fuses, and circuit breakers; vacuum tube relays; high voltage power rectifiers and oscillators. Two lectures. *Prerequisites*: *E. E.* 12, *and preceded or accompanied by E. E.* 11 *and E. E.* 17. Two hours credit. Second semester.

15. **Advanced Lighting.** Selection of a topic, with instructor's approval, for continued 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. *Prerequisites*: *E.E.* 7, *and preceded or accompanied by E.E.* 3. Two hours credit. Second semester.

16. **Electrical Rectification.** A study of the basic action in alternating current rectification by various types of rectifiers; gaseous ionization and electronic action as applied to rectifiers; wave form analysis of rectifiers under various load conditions; operating conditions and applications. Class library and laboratory study. Individual problems, involving use and study of the oscillograph. *Prerequisites*: *to be preceded by E.E.* 12 *and preceded or accompanied by E.E.* 17. 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. *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.

21. **Thermionic Vacuum Tubes in Engineering.** Advanced study of vacuum tube characteristics and the various factors affecting these characteristics; theory and design of amplifier circuits; mercury vapor tubes; oscillators; special vacuum tube circuits for control work. Engineering applications will be stressed throughout the course. Lectures and laboratory. *Prerequisites*: *preceded or accompanied by E.E.* 17 *and preceded by either E.E.* 12 *or Physics* 165. Three hours credit. First semester.

22. **Radio, Telegraphy, and Telephony.** Advanced work in resonant, coupled, and oscillatory circuits. Application of these circuits to radio problems. Audio and radio frequency amplification; transmitting and receiving circuits with especial attention to the use of vacuum tubes; antennae and principles of electromagnetic radiation; field measurements; frequency control. This course is so scheduled that it conflicts with E. E. 11. Students desiring to take E. E. 22 should arrange their schedules accordingly. Lectures and laboratory. *Prerequisites*: *preceded or accompanied by E. E.* 17 *and preceded by either E. E.* 12 *or Physics* 165. Four hours credit. Second semester.

23. **Elements of Radio Communication.** This course is designed for non-electrical students who are desirous of obtaining

a general knowledge of the radio field. After a short review of direct and alternating currents the following subjects are considered: series, parallel and coupled circuits; vacuum tubes; audio and radio frequency amplifiers; detection; receiving sets. Lectures and laboratory. *Prerequisite: E. E. 2a or equivalent. Not open to electrical students.* Three hours credit. First semester.

24. **Elements of Radio Communication.** This course is a continuation of E. E. 23. Oscillators; modulation; short wave and broadcast transmitters; antennae. Lectures and laboratory. *Prerequisite: E. E. 23.* Three hours credit. Second semester.

25. **Advanced Principles of Electricity and Magnetism.** Advanced theory and problems in electric and magnetic fields, using elementary vector methods which are introduced as required. This work amounts to a broader and continued treatment of the subject matter considered in E.E. 1, leading to Maxwell's equations and the radiation of energy from electric circuits. In addition, a brief historical sketch of electricity and magnetism is given, followed by a discussion of the influence of the later physical experiments and theories. *Prerequisites: E.E. 1, E.E. 3, and permission of the instructor.* This course runs through the year for a total credit of six hours. The first half of the course may however be elected for three hours credit.

26. **Heaviside Operators.** Advanced theory of electrical engineering, as developed by the application of Heaviside operators to electric circuits. Lectures and discussions. *Elected by permission of the instructor.* Two hours credit. Second semester.

28. **Technical Electrical Measurements.** Theory and practice in making measurements, particularly in alternating currents, to a precision and accuracy required by modern laboratories. Ratio and phase angle tests of current and potential instrument transformers, and their use with wattmeters and watt-hour meters are considered. Opportunity is provided for working with A. C. bridges and oscillographs of various types, including the cathode ray oscillograph. One afternoon of laboratory. *Must be preceded or accompanied by Physics 147.* 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. *Must be 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. *Prerequisite*: *E. E.* 11; *open to seniors only.* One hour credit. Second semester.

40. **Telephone Communication.** Study of equipment used in telephone communication, including practices in manual and mechanical central offices, toll offices, telephone repeater stations, carrier current systems, and outside plant. Lecture and discussion. *Prerequisite*: *to be preceded by E. E. 3.* Two hours credit. First semester.

41. **Telephone Communication.** Study of the characteristics of circuits, networks, and telephone apparatus at audio frequencies. Lecture and laboratory. *Prerequisite*: *to be preceded or accompanied by E. E.* 10. Two hours credit. Each semester.

51. **Electromagnetic Problems in Electrical Design.** Further study of field mapping; rough analyses of magnetic situations; further work in mmf. and flux distribution in machines; analyses of commutation and of action of equalizer connections; eddy currents; rise of current in inductive circuits; study of the single-phase watt-hour meter. *Prerequisites*: *E. E.* 5; *elected by permission of instructor.* Two hours credit. Given either semester and summer school, depending on sufficient demand; Course 51 and Course 52 will not, however, both be given at the same time.

52. **Heat Problems in Electrical Design.** Heat conduction, by field mapping and other attacks; temperature gradients and hot spots; heat transfer at surfaces,—the film theory; transfer by radiation, and general laws of radiation interchange; convection and air flow; temperature cycles in heating-cooling situations. *Prerequisite*: *elected by permission of instructor.* Two hours. Given either semester and summer school, depending on sufficient demand; Course 51 and Course 52 will not, however, both be given at the same time.

71. **Interior Illumination, Study of Design.** Advanced work in illumination design for graduate students, or for specially qualified and interested seniors. Lectures and laboratory. *Elected by permission of the instructor.* Two hours credit. First semester.

72. **Natural Lighting of Buildings.** Methods for prediction of daylight illumination of interiors from windows, and for designing the fenestration of buildings. A complete survey is made of all published and much unpublished information regarding factors which affect daylighting, such as glass in windows, window shades and blinds, color and finish of interior and exterior surfaces of buildings. The course being designed formerly for architects and other than electrical engineers, the essential knowledge about fundamental principles of lighting is treated briefly within the

course, for which there are no prerequisites except an ability to work accurately with simple algebra and plane trigonometry. Two hours credit. First semester.

**73. Photo-electric Cells and Their Applications.** Study of operating characteristics of photo-electric cells and their applications to photometry relays and other uses. Design of photo-electric photometers. Lectures and laboratory work. *Prerequisite: elected by permission of instructor.* Two hours credit. First semester.

### Summer Session

It is planned to offer Courses 1, 2, 2a, 3, 4, 7, 17, and 18 for the Summer Session of 1931. Courses 10, 11, 25, and 26 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.

## 77. ENGINEERING MECHANICS

Professors ERIKSEN, MENEFEE, VAN DEN BROEK, and TIMOSHENKO; Associate Professor STEVENS; Assistant Professors SWINTON, OLMSTED, LIDDICOAT, DODGE, FRANKLIN, and 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—

a) 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:

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

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

d) 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-pound, a 100,000-pound, and a 200,000-pound tension-compression machine, a 230,000-inch pound torsion machine with jaws for taking specimens 2⅞ inches in diameter, an Olsen impact machine, an Upton Lewis endurance tester, an electrically driven bar bender for bars up to 2½ inches diameter, a Brinell hardness tester, a wire tester, a transverse bending machine for cast iron arbitration bars and other short demonstration beams, a nine-foot transverse bending machine and a power saw and grinder, and electric furnace, a polishing table and wheel with photographic equipment, and cement testing equipment for all standard cement tests.

The special accessory equipment consists of one six element telemeter strain gage, one Huggenberger extensometer, one Martens mirror strain gage, one electrical micrometer gage, one contact micrometer gage, several Berry gages, one vertical and one horizontal portable seismograph.

## CURRICULUM IN ENGINEERING MECHANICS AND REQUIREMENTS FOR GRADUATION

The following program leading to the degree of Bachelor of Science in Engineering (Engineering Mechanics) has been provided to meet the increasing demand from industry for graduates with the thorough theoretical grounding in mechanics and mathematics needed to cope with difficult engineering problems of research type.

a) Preparatory Courses

| | *Hours* |
|---|---|
| English 1 and 2, and a course from Group 3 | 6 |
| *Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 34 | 18 |
| Physics 45, 46 | 10 |
| Chemistry 5E | 5 |
| Drawing 1, 2, 3 | 8 |
| Shop 2 | 2 |
| Total | 65 |

*Students in this curriculum may satisfy the nontechnical elective requirement by completing Course 31 in both French and German.

b) Secondary Courses

| | |
|---|---|
| Surveying 4 | 2 |
| Engineering Mechanics 1, 2, 3, 4 | 12 |
| Chemical Engineering 1 | 3 |
| Electrical Engineering 2a | 4 |
| Civil Engineering 2 | 3 |
| Mechanical Engineering 3 | 4 |
| Total | 28 |

c) Advanced Courses

| | |
|---|---|
| Technical Group, in some specified technical engineering department, including an advanced design course; approximately | 13 |
| Engineering Mechanics (advanced) | 16 |
| Mathematics Group; approximately | 10 |
| Electives; approximately | 8 |
| Grand Total | 140 |

The number of hours in the technical, mathematics and elective groups are subject to variation on the advice of the head of the department.

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. *Must be preceded by Mathematics* 33, *Physics* 45, *and preceded or accompanied by Mathematics* 34. 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.

**7. Research in Testing Materials.** *Prerequisite*: *E.M.* 2. Credit to be arranged. 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, *with a grade of B.* Three hours credit. Each semester.

**10. Research in Strength of Materials.** Special problems involving laboratory tests, and application of theory in E.M. 2, 2*a*, 3, and 5. Credit to be arranged. Each semester.

**10a. Research in Theory of Elasticity.** Special problems involving application of theory and experimental investigation. Credit to be arranged. Each semester.

**10b. Research in Theory of Structures.** Special problems such as arches, arch dams, suspension bridges, elastic stability of columns and framed structures, impact effect and vibration of bridges. Credit to be arranged. Each semester.

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

12. **Vibration Problems in Engineering.** Vibration of systems with one degree of freedom. Balancing of rotating machines; calculation of critical speeds of rotating shafts; theory of vibration-recording instruments; springs of variable flexibility. Systems with several degrees of freedom, and elastic bodies. Vibration of cars; torsional and lateral vibration of shafts; vibration of beams; vibration of bridges, turbine blades, and turbine discs. *Prerequisites*: *E.M.* 1, 2, *and* 3, *Mathematics* 105. Two hours credit. First semester.

13a. **Applied Elasticity.** Fundamentals of the theory of elasticity with its application to stress analysis in machine parts. Stress and strain. General equations of equilibrium. Two-dimensional problems of the theory of elasticity and the photo-elastic method of stress analysis. Stress concentration produced by fillets and holes. Stress in curved bars. Torsion of prismatical bars. Torsion of circular shafts of variable diameter. Bending of prismatical bars. *Prerequisites*: *E.M.* 1, 2, *and* 3, *and Mathematics* 105. Two hours credit. First semester.

13b. **Applied Elasticity, Theory of Thin Plates.** General equation for deflection of thin plates. Bending of circular plates under various loading conditions. Bending of rectangular plates. Buckling of plates. Application in design of tubular built-up sections and girders. Plates on elastic foundation. Designed principally for graduate students. *Prerequisites*: *E.M.* 1, 2, 3, *and Mathematics* 105. Two hours credit. Second semester.

14. **Stress Analysis in Machine Parts.** Stress concentration in tension and compression produced by fillets and holes. Photo-elastic method of studying stress concentration. Stresses in shafts of variable cross-section. Stresses due to shrink fit pressure. Stresses in curved bars, theory, and applications. Stresses in fly wheels, rotating discs, and rotors. Critical speeds. Designed principally for students interested in machine design. *Prerequisite*: *E.M.* 2. Two hours credit. Second semester.

15. **Theory of Thin Bars, Thin Plates, and Slabs.** With application to the solution of such problems as bending of beams on elastic foundation and track stresses; combined bending and tension or compression; buckling of solid, tubular, and built-up columns under various conditions; buckling of thin plates, such as flanges and webs of built-up sections, and the web of a plate girder; bending of slabs under various conditions, with application to highway and structural engineering. Designed principally for

students interested in structural design. *Prerequisite*: *E.M.* 2. Two hours credit. First semester.

16. **Seminar in Theory of Elasticity.** Credit to be arranged. Each semester.

17. **Library Research.** Devoted to the history and development of modern engineering practices. *Prerequisite*: *E.M.* 1. One or two hours credit. Each semester.

18. **Ductility of Materials.** The theory of strength and resistance of structures built of structural steel with reference to the ductility of the material. *Prerequisite*: *E.M.* 2. Three hours credit. Second semester.

**E.M.** 20. **Mechanical Properties of Metals.** Attention is directed to the general principles rather than to a description of established, standardized methods of testing materials and manipulating apparatus. Tension and compression tests. Leuders lines. Strain hardening. Residual stresses due to plastic flow of metals. Types of failures. Time effect and hysteresis. The fatigue of metals under cycles of stress. Causes of fatigue. Mechanical properties of metals at high temperatures. Various strength theories. Working stress. *Prerequisites*: *E.M.* 2 *and Math.* 105. One hour credit. Summer Session.

**E.M.** 21. **History of Mechanics of Materials.** History of development of fundamental principles of strength of materials will be discussed. The origin of statics. Origin of strength of material. The work of Galileo. Hooke's law. Theory of beams by Mariotte and Coulomb. Theory of elastic curves by Daniel Bernoulli, Euler, and Lagrange. The equations of the theory of elasticity by Navier, Canchy, and Poisson. Exact theory of torsion and bending of prismatical bars by Saint Venant. Reciprocity theorem. Theorem of least work. Modern development of the theory of elasticity. *Prerequisites*: *E.M.* 2 *and Math.* 105. One hour credit. Summer Session.

### Summer Session

Courses 1, 2, 2*a*, 3, 4, 5, 20, and 21, or similar courses, will be given during the Summer Session of 1931.

## 78. GEODESY AND SURVEYING

Professor JOHNSTON; Associate Professors CAREY, BRODIE, and BOUCHARD; Assistant Professors MITCHELL, MCFARLAN, YOUNG, and BLEEKMAN.

**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 posi-

tions 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 Department of Geodesy and Surveying,** one of the oldest departments of the College of Engineering, became by action of the Board of Regents in 1921 a professional department offering a curriculum leading to the degree of Bachelor of Science in Engineering (Geodesy and Surveying). The curriculum provides such training in pure and applied science as may be necessary to interest students in geodetic work, higher surveying, astronomy, and mathematics. Graduate work leading to the professional degree of Geodetic Engineer is done under the direction of the Graduate School. The Department is convinced that only by the mastery of fundamentals may students develop that proficiency which ultimately stimulates love of work. The 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. 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.**—The University of Michigan was the pioneer in the establishment and maintenance of a camp for field work in surveying. The camp was organized under the supervision of the late Professor J. B. Davis in 1874.

There are but few districts east of the Missouri River where field work in surveying is not handicapped by growths of brush and trees or by buildings and other structures. In February, 1929, the University of Michigan purchased lands in Jackson's Hole, Wyoming, for a new camp for surveying work. The new location was occupied for the first time during the following summer. It is in the valley of the Hoback River, twenty miles south and east of the town of Jackson and seventy-five miles south of the Yellowstone Park. An excellent road—U. S. 187—connecting the Lincoln Highway at Rock Springs, Wyoming, with the Yellowstone Park, passes within a mile of the camp site.

The Wyoming lands offer the following advantages: first, an almost unlimited area of open country; second, an adequate supply of water under gravity pressure; third, an ideal climate, with little cloudy weather, no oppressive heat, and cool nights; fourth, proximity to an improved highway which leads to the celebrated Jackson's Hole country, the Yellowstone Park, and to agricultural districts where mess supplies may be purchased; fifth, the beautiful mountains surrounding the valley of the Hoback River in which the camp is situated, which offer unlimited opportunities for exploration. The camp is within thirty-five miles of the celebrated Teton Mountains and seventy-five miles from the southern boundary of the Yellowstone Park.

All of the buildings at the camp have concrete floors and sheet steel superstructure. In addition to residence buildings, fourteen feet square, larger buildings for general use have been erected. Among these are a dining room and kitchen, a keeper's residence, instrument room, shop, and a garage. Each residence building is furnished with a stationary washbowl, a coal stove, bed and bedding, four chairs and a table. The camp has electric lights, hot and cold showers, and a modern sanitary system.

In 1931 instruction begins on Monday, June 29. Students should reach the camp on the preceding Saturday. Instruction runs for five and one-half days per week for eight weeks. Field conditions are so satisfactory that all instruction may relate to surveys for a single important project. The camp is open to students coming adequately prepared from any college of engineering. Necessary preparatory training with an outline of the work covered at the camp and other information is contained in a special circular which may be obtained upon application. Eight hours of credit are given those who complete the regular course, Surveying 3. For those unable to complete a two-hour course in practical astronomy, as a part of their preparation, a second course of two hours, Surveying 6, given at the Camp, must be elected.

Students should be able to complete the camp work at a cost of $200 or less. The University fee is $41. The cost of board is approximately $60. This leaves a balance of practically $100, which should cover round trip transportation costs from almost any part of the United States and leave a balance which would enable students to visit the Yellowstone Park and other points of interest. The estimated cost of travel is made on the assumption that from three to four persons travel together in one car.

Further information may be obtained by writing to Professor C. T. Johnston, 209 West Engineering Building, Ann Arbor, Michigan. Camp Davis mail address is Jackson, Wyoming; freight and express, Victor, Idaho.

**Combined Courses** have been arranged with Albion, Battle Creek, and Olivet Colleges and the College of the City of Detroit. For detailed information see section 15.

**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 14.

**Military Science.**—The attention of prospective students in Geodesy and Surveying 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 64.

## 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 50.

| | *Hours* |
|---|---|
| a) Preparatory Courses | |
| English 1 and 2, and a course from Group 3 | 6 |
| Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 34 | 18 |
| Physics 45, 46 | 10 |
| Chemistry 5E | 5 |
| Drawing 1, 2, 3 | 8 |
| Shop 2, Metal Working | 2 |
| Total | 65 |
| b) Secondary and Technical Courses | |
| Engineering Mechanics 1, 2, 3, 4 | 12 |
| Chemical Engineering 1 | 3 |
| Astronomy 31, 35 | 5 |
| Geology 31 | 3 |
| Electrical Engineering 2*a* | 4 |
| Mechanical Engineering 3 | 4 |
| Civil Engineering 2, 2*a*, 10 | 9 |
| Surveying 1, 2, 3, 5, 21 | 19 |
| Geodesy 1 | 3 |
| Total | 62 |
| Summary: | |
| Preparatory Courses | 65 |
| Secondary and Technical Courses | 62 |
| Electives | 13 |
| Total | 140 |

FIRST YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

SECOND YEAR

| | | | |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 | 5 | Math. 34 | 5 |
| Physics 45 | 5 | Physics 46 | 5 |
| Drawing 3 | 2 | Eng. Mech. 1 | 4 |
| | 16 | | 18 |

THIRD YEAR

| | | | |
|---|---|---|---|
| Surveying 5 | 2 | Astronomy 35 | 2 |
| Surveying 1 | 3 | Surveying 2 | 4 |
| Eng. Mech. 2 | 3 | Eng. Mech. 4 | 3 |
| Geology 31 | 3 | Civil Eng. 2 | 3 |
| Astronomy 31 | 3 | Chem. Eng. 1 | 3 |
| Eng. Mech. 3 | 2 | Electives | 3 |
| | 16 | | 18 |

SUMMER SESSION

Surveying 3 8

FOURTH YEAR

| | | | |
|---|---|---|---|
| Surveying 21 | 2 | Geodesy 1 | 3 |
| Civil Eng. 2*a* | 3 | Mech. Eng. 3 | 4 |
| Civil Eng. 10 | 3 | Electives | 10 |
| Speech | 2 | | |
| Elec. Eng. 2*a* | 4 | | |
| | 14 | | 17 |

*For nontechnical elective requirement see section 51.

†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hours credit each semester) is elected as a substitute. Military Science is for a period of four semesters.

COURSES IN 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, recitations, three four-hour periods of field practice. Required for students of Geodesy and Surveying and Civil Engineering. *Prerequisite*: *Math.* 4. 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, recitations, field practice, drawing. Two recitations and two four-hour field or drawing periods. Required for students of Geodesy and Surveying and Civil Engineering. *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, one recitation, and one four-hour field period. Required of all engineering students except Geodesy and Surveying, Civil and Chemical Engineering. *Prerequisite*: *Math.* 4. Two hours credit. Each semester.

5. **Least Squares.** Theory of least squares; adjustment and comparison of data; computation of triangulation systems; determination of empirical formulae. Lectures, text, problems, recitations. *Prerequisite*: *Math.* 4. Two hours credit. Each semester.

6. **Surveying.** See Summer Session courses.

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, drawing, one recitation and one four-hour field period. *Prerequisite*: *Surveying* 3. Two hours credit. Each semester.

9. **Railway Surveying.** Text, field, track problems. One recitation and one four-hour field period. *Prerequisite*: *Surveying* 3. Two hours credit. Second semester.

12. **Surveying.** Similar to Surveying 1 with drawing work added. Designed for Forestry students. Lectures, text, recita-

tions, field. Three four-hour field periods, and one one-hour drawing period. *Prerequisite*: *Math.* 4. Four hours credit. First semester.

13. **Surveying.** Similar to Surveying 2. Designed for Forestry students. Lectures, text, two recitations, and two four-hour field or drawing periods. *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, one recitation, and one four-hour field and laboratory period. *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, recitations, 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, recitations, 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.

## COURSES IN GEODESY

**1. Geodesy.** Introductory course; history; elements of modern practice and its application to several branches of surveying. Lectures, text, recitations. *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.** Adjustment of instruments; astronomical applications, time, azimuth, latitude, and longitude; lines of communication, circular and easement curves, profiles, topography, grades, cross-sections; baseline measurement; triangulation; Public Land surveys; topography; project surveys; computation of field data; making of maps and diagrams; preparation of permanent records of work performed; camp construction and maintenance and many things which relate to the welfare of those who live in the open. Field problems, office work, five and one-half days a week. *Prerequisites*: *Surveying* 1 *and* 2, *or* 12 *and* 13; *Astronomy* 35. See page 182 (relating to fees). Eight hours credit. Summer camp.

**4s. Surveying.** Use of instruments, same as Surveying 4; given at Ann Arbor. Lectures, text, one recitation, and one four-hour field period. *Prerequisite*: *Mathematics* 4. Two hours credit. Summer Session.

**6. Surveying.** Given only at Camp Davis. Credit two to eight hours depending upon the character of the work.

## 79. MATHEMATICS

Professor PETER FIELD, Chairman

Complete offerings of the Department of Mathematics will be found in the special bulletin published by the Department of Mathematics, which may be obtained from any University officer and, particularly, from Professor Peter Field.

The object of the work of this Department in the College of Engineering 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 1931-1932. 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.

There is an increasing demand in the engineering industries and in the faculties of technical schools for graduates who have taken considerably more mathematics and mechanics than is required in the other engineering curricula. To meet this demand, the following program has been provided:

## CURRICULUM IN MATHEMATICS AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Mathematics) are required to complete the following program of studies:

| | *Hours* |
|---|---|
| a) Preparatory Courses | |
| English 1 and 2, and a course from Group 3 | 6 |
| *Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 34 | 18 |
| Physics 45, 46 | 10 |
| Chemistry 5E | 5 |
| Drawing 1, 2, 3 | 8 |
| Shop 2 | 2 |
| Total | 65 |
| b) †Secondary Courses | |
| Astronomy 31 or Mathematics 145 | 3 |
| Surveying 1 | 3 |
| Engineering Mechanics 1, 2, 3, 4 | 12 |
| Chemical Engineering 1 | 3 |
| Electrical Engineering 2*a* | 4 |
| Civil Engineering 2 | 3 |
| Mechanical Engineering 3 | 4 |
| Total | 32 |
| c) Advanced Courses | |
| Technical Group, in some specified technical engineering department including an advanced design course or advanced courses in technical mechanics (Approx.) | 15 |
| Mathematics Group (Approx.) | 12 |
| *Electives | 8 |
| Group Options in Engineering Mechanics, Astronomy, Physics, Mathematics, or Technical Engineering | 8 |
| Total | 140 |

*Students in this curriculum may satisfy the nontechnical elective requirement in the College of Engineering in the usual way, or they may elect twelve hours each of French and German.

†Students in Chemical Engineering who wish to become candidates also in Mathematics are permitted to substitute for Astronomy 35, Engineering Mechanics 3 and 4, Surveying 1 and Civil Engineering 2, such other courses as may be approved by the Department of Mathematics. For students pursuing a program leading to a technical degree in Engineering simultaneously with the program in Mathematics, Surveying 4 may be substituted for Surveying 1.

## COURSES IN MATHEMATICS

*3 **(Formerly 1). Algebra and Analytic Geometry.** Review of exponents, radicals, quadratic equations, systems of equations involving quadratics; theory of equations including Horner's method; determinants; complex numbers; curve tracing and locus problems in Cartesian and polar co-ordinates; straight line; circle. Four hours credit. Each semester.

4 **(Formerly 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.

*7 **(Formerly 1b). Algebra and Trigonometry.** Review of elementary operations; factoring, fractions; linear equations in one unknown; simultaneous linear equations; exponents; radicals; quadratic equations; systems of equations involving quadratics; progressions; binomial theorem; trigonometry, the same as in Math. 8. Four hours for two hours credit. Each semester.

*8 **(Formerly 1a). Trigonometry.** Radian measure; co-ordinate system; trigonometric ratios; trigonometric identities and equations; inverse functions; graphs; reduction and addition formulas; laws of sines, cosines, and tangents; theory and use of logarithms; orthogonal projections; solution of triangles. Two hours credit. Each semester.

9 **(Formerly 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.

33 **(Formerly 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.

34 **(Formerly 4). Calculus and Differential Equations.** Topics the same as in Math. 38 and 39 combined. Five hours credit. Each semester.

*Students entering with credit in trigonometry will take Course 3. Students entering without trigonometry will take Course 7, except that those whose high school records show unusual proficiency in mathematics may take Courses 3 and 8 instead. Permission to do this must be obtained from the Department of Mathematics at the time of classification.

**38 (Formerly 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, multiple integrals. Three hours credit. Each semester.

**39 (Formerly 4b). Differential Equations.** 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.

**49. Introduction to the Mathematical Analysis of Statistics, I.** This course deals with the elementary theory and applications of mathematical statistics, treating in detail the following topics: averages, dispersion, skewness, sampling, and correlation. Assignments require the operation of computing, punching, sorting, and tabulating machines. The course is designed to serve as a background for students dealing with statistical and observational data. Two hours credit. Each semester.

**51. Mathematics of Finance.** The elementary theory of compound interest functions is developed as a preliminary to the solution of practical problems in annuities, sinking funds, depreciation, amortization, building and loan associations, capitalized cost and replacement, and the valuation of various types of contracts, bonds, and other securities. Systematic and accurate computation with the use of compound interest and seven place logarithmic tables is stressed throughout the course. Three hours credit. Each semester.

**105. Differential Equations.** Should be preceded by Math. 39. 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.

**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.

**141. Analytic Mechanics.** An introduction to theoretical mechanics and to vector methods in mechanics. No previous knowledge of vectors is assumed, the fundamental portions of vector analysis being developed as required in the study of the following topics in mechanics: rectilinear and curvilinear motion of a point; velocities and accelerations in the rigid body; relative motion; statics of a rigid body. Three hours credit. First semester.

**142. Analytic Mechanics.** Continuation of Math. 141. Continued study of theoretical mechanics by vector methods. The differential and integral vector operations developed and employed in the study of theory of attractive forces; free and constrained motion of a particle; free and constrained motion of a rigid body; general principles of mechanics. Three hours credit. Second semester.

**145, 146. 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. Problems of three and $n$ bodies; geometric introduction to the lunar theory; general perturbations; introduction to periodic orbits. Three hours credit each. Throughout the year.

**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.

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

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

**177. The Theory of Elasticity.** This is a general course in the elastic solid theory. It will be adjusted to the preparation and maturity of the students. Two hours credit. First semester.

**178. Hydrodynamics.** This is a general course in hydrodynamics. The subject matter will be chosen subject to the inter-

est and ability of the students. 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 mathematical physics and to other branches of mathematics. Three hours credit each. Throughout the year.

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.

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.

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.

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 Math.* 39 *and Math.* 201. Two hours credit. First semester.

238. **Advanced Stability.** Advanced study of more complicated phenomena of stability according to Bryan, with Bairstow's applications of experimentally determined resistance derivatives and rotary coefficients. *Must be preceded by Math.* 39. Two hours credit. Second semester.

241. **Applied Mathematics—Engineering Problems.** The problem will first be formulated mathematically and then the necessary mathematical theory for a solution will be developed. The problems will be so selected that their solutions will cover a

wide field mathematically; such as ordinary and partial differential equations, difference equations, harmonic analysis, and approximate solutions. Three hours credit. First semester.

**245, 246. Advanced Celestial Mechanics.** Studies in continuation of Math. 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. Throughout the year.

**Summer Session**

The following or similar courses will be offered in the Summer Session of 1931: 3, 4, 33, 34, 141*s*, 145, 169, 176, 201, and 241.

## 80. MECHANICAL ENGINEERING

Professors ANDERSON, BURSLEY, EMSWILER, WILSON, FESSENDEN, and HAWLEY; Associate Professors LAY, SHERZER, KEELER, and NICKELSEN; Assistant Professors MICKLE, WATSON, GORDY, LLOYD, GOOD, KESSLER, MARIN, and CALHOON; Mr. JENSEN.

**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 and airplane, 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, testing, 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 with industrial plant operation and management, efficiency and safety 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 a manufacturer of 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 one or more 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. 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. For this reason students are urged to elect courses in several departments of the Engineering College, and also in the College of Literature, Science, and the Arts.

## 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 supplement properly the work of the classroom.

**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 power plant of the University (for description see section 41) 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. The laboratory is well equipped with power machines of all kinds, which furnish the means of instruction in the principles of testing. Separate laboratory instruction is given along the lines of automotive work, and that part of the equipment applying especially to this division is segregated to form the automotive division of the laboratory.

For hydro-mechanical work the 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 Automotive 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 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, Battle Creek, and Olivet Colleges, and the College of the City of Detroit. For detailed information see section 15.

**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 14.

**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 in Military Science and Tactics see section 64.

## 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 198.

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 201.

For the definition of an hour of credit see section 50.

a) *Outline of Required Courses, Four-Year Curriculum*

| | Hours |
|---|---|
| 1) Preparatory Courses | |
| English 1 and 2, and a course from Group 3 | 6 |
| Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 34 | 18 |
| Physics 45, 46 | 10 |
| Chemistry 5E | 5 |
| Drawing and Descriptive Geometry 1, 2, 3 | 8 |
| Shop 2, Metal Working and Treating | 2 |
| Shop 3, Foundry | 4 |
| Shop 4, Machine Shop | 4 |
| Total | 73 |
| 2) Secondary and Technical Courses | |
| Surveying 4, Use of Instruments | 2 |
| Eng. Mech. 1, Statics | 4 |
| Eng. Mech. 2, Strength and Elasticity | 3 |
| Eng. Mech. 3, Dynamics | 2 |
| Eng. Mech. 4, Hydromechanics | 3 |
| Mech. Eng. 2, Elements of Machine Design | 3 |
| Mech. Eng. 3, Heat Engines | 4 |
| Mech. Eng. 4, Hydraulic Machinery | 3 |
| Mech. Eng. 5, Thermodynamics | 3 |
| Mech. Eng. 6, Machine Design | 4 |
| Mech. Eng. 7, Laboratory, First Course | 2 |
| Mech. Eng. 8, Laboratory, Second Course | 3 |
| Mech. Eng. 9, Power Plants | 3 |
| Mech. Eng. 10, Theory of Machine Movements | 2 |
| Civil Eng. 2, Theory of Structures | 3 |
| Elec. Eng. 2a, D.C. App. and Cir. | 4 |
| Chem. Eng. 1, Engineering Materials | 3 |
| Chem. Eng. 10, Exam. of Gas and Fuel | 1 |
| Total | 52 |
| Summary: | |
| Preparatory Courses | 73 |
| Secondary and Technical Courses | 52 |
| Electives | 15 |
| Total | 140 |

b) *Selection of Elective Courses*

The 15 hours of elective work is to be filled partly by "Restricted Electives" and partly by "Free Electives."

(1) Restricted Electives:

The student must elect one 3-hour design course from the following list: M.E. 9*a*, 11*a*, 12*a*, 15*a*, 16*a*, 17*a*, 20*a*, 25*a*, 30*a*, 31*a*. Of this group, Course 15*a* must be preceded or accompanied by 15. Courses 30*a* and 31*a* must be preceded by the corresponding classroom course and by M.E. 29.

Students who elect a design course other than M.E. 15*a*, 30*a*, or 31*a*, 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, 55.

(2) 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* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

*For nontechnical elective requirement see section 51.

†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Military Science is for a period of four semesters.

SECOND YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 | 5 | Math. 34 | 5 |
| Physics 45 | 5 | Physics 46 | 5 |
| Chem. Eng. 1 | 3 | Eng. Mech. 1 | 4 |
| Drawing 3 | 2 | | |
| | 19 | | 18 |

SUMMER SESSION

| | |
|---|---|
| Elec. Eng. 2*a* | 4 |
| Shop 3 | 4 |
| | 8 |

THIRD YEAR

| | | | |
|---|---|---|---|
| Eng. Mech. 2 | 3 | Shop 4 | 4 |
| Eng. Mech. 3 | 2 | Eng. Mech. 4 | 3 |
| Mech. Eng. 2 | 3 | Mech. Eng. 5 | 3 |
| Mech. Eng. 3 | 4 | a) Mech. Eng. 6 | 4 |
| a) Mech. Eng. 7 and Chem. Eng. 10 | 3 | or b) Mech. Eng. 4, 8 | 6 |
| b) Mech. Eng. 10 | 2 | b) Mech. Eng. 7 and Chem. Eng. 10 | 3 |
| | | a) Mech. Eng. 10 | 2 |
| | 14 or 15 | | 18 or 17 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| a) Mech. Eng. 4, 8 | 6 | Mech. Eng. 9 | 3 |
| or | | Mech. Eng. 9*a*, 11*a*, 12*a*, 15*a*, 16*a*, 17*a*, 20*a*, 21*a*, 25*a*, 30*a*, or 31*a* | 3 |
| b) Mech. Eng. 6 | 4 | Other electives | 8 or 7 |
| Surveying 4 | 2 | | |
| Mech. Eng. 11, 12, 13, 15, 16, 17, 19, 20, 25, 30, 31, 32, 35, or 55 | 2 or 3 | | |
| Engl. from Group 3 | 2 | | |
| Civil Eng. 2 | 3 | | |
| Other electives | 2 | | |
| | 16, 17, or 18 | | 13 or 14 |

*For nontechnical elective requirement see section 51.

## 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:

| *Subjects* | *Hours* |
|---|---|
| English 1, 2, and choice from Group 3 | 6 |
| Nontechnical Electives | 16 |
| Physics 45, 46 | 10 |
| Mathematics 3, 4, 33, 34, 49 | 20 |
| Chemistry 5E | 5 |
| Drawing and Descriptive Geometry 1, 2, 3 | 8 |
| Shop Work 2, 3, 4, 7 | 12 |
| Engineering Mechanics 1, 2, 3, 4 | 12 |
| Mechanical Engineering 2, 3, 5, 6, 7, 8, 9, 10 | 24 |
| Factory Mgt., M.E. 20, 35, 36, 40, 42 | 12 |
| Chemical Engineering 1, 10 | 4 |
| Electrical Engineering 2a | 4 |
| Civil Engineering 2 | 3 |
| Econ. 51, 52, 121, 171, 172 | 15 |
| Bus. Admin. 113, 161, 162, 202 | 12 |
| Electives | 13 |
| Total hours | 176 |

The schedule of work is as follows:

FIRST YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

*For nontechnical elective requirement see section 51.
†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Military Science is for a period of four semesters.

SECOND YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 | 5 | Math. 34 | 5 |
| Chem. Eng. 1 | 3 | Physics 45 | 5 |
| Drawing 3 | 2 | Economics 52 | 3 |
| Economics 51 | 3 | | |
| | 17 | | 17 |

SUMMER SESSION

| | |
|---|---|
| Shop 3 | 4 |
| Shop 4 | 4 |
| | 8 |

THIRD YEAR

| | | | |
|---|---|---|---|
| E. M. 1 | 4 | E. M. 2 | 3 |
| Physics 46 | 5 | E. M. 3 | 2 |
| Economics 121 | 3 | M. E. 2 | 3 |
| Economics 171 | 3 | M. E. 3 | 4 |
| Elective | 3 | Economics 172 | 3 |
| | | Elective | 3 |
| | 18 | | 18 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| E. M. 4 | 3 | Shop 7 | 2 |
| M. E. 6 | 4 | M. E. 5 | 3 |
| M. E. 7 | 2 | M. E. 8 | 3 |
| Chem. Eng. 10 | 1 | M. E. 10 | 2 |
| M. E. 35 | 3 | M. E. 36 | 3 |
| Bus. Ad. 113 | 3 | Elective | 3 |
| Elective | 2 | | |
| | 18 | | 16 |

FIFTH YEAR

| | | | |
|---|---|---|---|
| Math. 49 | 2 | Engl. | 2 |
| M. E. 9 | 3 | Bus. Ad. 202 | 3 |
| E. E. 2a | 4 | Bus. Ad. 162 | 3 |
| Bus. Ad. 161 | 3 | M. E. 20 | 2 |
| M. E. 40 | 3 | M. E. 42 | 3 |
| C. E. 2 | 3 | | |
| | 18 | | 13 |

*For nontechnical elective requirement see section 51.

COURSES IN MECHANICAL ENGINEERING

2. **Elements of Machine Design.** This course covers the practical application of theory to elementary machine design and includes thin cylinders, riveted joints, keys and cotters, screw fastenings, power screws, shafts, permanent couplings, journals and bearings, and spur gearing. Two recitations, and one three-hour drawing period a week. *Prerequisites*: *Drawing* 3, *and preceded or accompanied by E.M.* 2. Three hours credit. Each semester.

2a. **Elements of Machine Design.** This course covers the same material as M.E. 2 but omits thin cylinders and riveted joints, and includes belts, ropes, chains, brakes, and clutches. Three recitations a week. *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, *and Math.* 33. Four hours credit. Each semester.

3a. **Mechanical Engineering Laboratory.** An elective course for students who are not required to take M.E. 7, intended to give an insight into methods of testing and to exemplify some of the principles of power engineering. *Must be preceded or accompanied by M.E.* 3. One hour credit. Each semester.

4. **Hydraulic Machinery.** General consideration of the theory, construction, and operation of the 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 of energy transformation in steam and internal combustion engines, air compressors, and refrigerating apparatus. Lectures, recitations. *Prerequisite*: *M.E.* 3. Three hours credit. Each semester.

6. **Theory of Machine Design.** Continuation of M.E. 2 but more advanced in character and covers the analysis of loads and forces, the design of parts, considering wear, dynamic and static forces including critical speeds, and the application of the theory of elasticity. Two recitations, and two three-hour drawing periods a week. *Prerequisites*: *M.E.* 2, *and preceded or accompanied by M.E.* 10. Four hours credit. Each semester.

7. **Mechanical Engineering Laboratory.** First Course. This course includes elementary tests of a steam engine, steam turbine, gas or oil engine, power pump, and steam boiler. The use and calibration of instruments used in mechanical engineering work exemplified in connection with these tests and in the calculation of the results. Laboratory, computations, reports; two periods of four and one-half hours each a week. *Prerequisites*: *E.M.* 1, *preceded or accompanied by M.E.* 3, *and accompanied by Ch.E.* 10. Two hours credit. Each semester.

8. **Mechanical Engineering Laboratory.** Second Course. Experimental study of a steam turbine, a Diesel engine, fan, steam injector, air compressor, refrigerating machine, steam power plant, and several forms of hydraulic machinery. Laboratory, computations, reports; two periods of four and one-half hours each a week. *Prerequisites*: *M.E.* 7 *and preceded or accompanied by M.E.* 5. Three hours credit. Each semester.

9. **Power Plants.** A study of the engineering, operation, and economics of power plants. Lectures, recitations, and problems. *Prerequisites*: *preceded or accompanied by M.E.* 8. Three hours credit. Each semester.

9a. **Design of Power Plants.** A study of the type, capacity, and arrangement of equipment to meet the requirements of a modern steam power plant. The drafting room work consists of a layout of the power house, and includes setting and piping plans for all the principal machines to be installed. Computations and drawing; two four-hour periods a week. *Prerequisites*: *M.E.* 9 *and E.M.* 4. Three hours credit. Second semester.

10. **Theory of Machine Movements.** This course covers gear trains, linkages, cams, intermittent motions, instantaneous centers, periodic centers, and acceleration. Lectures, recitations, drawing; two three-hour periods a week. *Prerequisites*: *E.M.* 3 *and preceded or accompanied by M.E.* 2. Two hours credit. Each semester.

11. **Steam Boilers.** A study of commercial types of boilers, stokers, and superheaters; principles of boiler economy and operation; combustion of fuels; theory of heat tranference; 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.** This course covers the design of boilers of different types, including calculations and drawing of important details. Drawing, problems; two four-hour periods a week. *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; two four-hour periods a week. *Prerequisite*: *M.E.* 6. Three hours credit. Second semester.

13. **Steam Turbines.** A course in the advanced study of the flow of fluids, kinetic effects, thermodynamics, with the steam turbine used as a concrete example. Attention is given to the influence of vacuum, pressure, and superheat; stage bleeding; the bleeder turbine; governing; and the field of application of the turbine. Lectures, recitations, problems. *Prerequisite*: *M.E.* 5. Three hours credit. Each semester.

15. **Internal Combustion Engines.** This course covers the theory of Otto and Diesel type engines; thermodynamics; fuels and combustion; 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.** Calculations, design of important details, and layout drawings of a standard Diesel or Otto type internal combustion engine. Drawing, problems; two four-hour periods a week. *Prerequisites*: *M.E.* 6 *and preceded or accompanied by M.E.* 15. Three hours credit. Second semester.

16. **Water Turbines.** A course covering the hydrodynamic theory of the operation of the various types of water turbines. Considerable attention is given to the analysis of test data and the 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.** This course includes calculations and drawings for runners, guide vanes, draft tubes, etc., with special attention given to the layout of runners. Two four-hour periods a week. *Prerequisite*: *M.E.* 6. Three hours credit. Second semester.

17. **Pumping Machinery.** An advanced course covering the theory and operation of reciprocating and centrifugal pumps, the application of pumps to definite pumping problems, economic con-

siderations, and graphical methods. Lectures, recitations, problems. *Prerequisite*: *M.E.* 4. Three hours credit. Second semester.

17a. **Design of Pumping Machinery.** This course includes calculations and drawings for a centrifugal or reciprocating pump. Special attention is given to the design of runners, casings, and valves. Two four-hour periods a week. *Prerequisites*: *M.E.* 4 *and M.E.* 6. *Preferably accompanied by M.E.* 17. Three hours credit. Second semester.

18. **Heating and Ventilation.** A study of the theory, design, and construction of hot air, direct and indirect steam, hot water and fan heating systems, air conditioning, and temperature control. 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. **Materials Handling and Factory Transportation.** A study of cranes, hand and electric travelers, hoisting, and haulage systems, aerial and surface cableways, factory trucks, and conveyors and their application to various classes of plants, processes, and materials. Considerable time is devoted to the economics involved in the use of labor-saving machinery. 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. Two four-hour periods a week. *Prerequisite*: *M.E.* 6. Three hours credit. Each semester.

21a. **Design of Machine Tools.** Complete layout of a 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. Two four-hour periods a week. *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; student 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; student 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.** The student is given the usual data furnished the heating and ventilating engineer. He then makes a layout of piping, ducts, auxiliary apparatus with computations for the size of principal parts. Two four-hour periods a week. *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.** The student selects the type of car or truck; makes expectancy curves for engine performance; then computes and sketches principal parts. Lectures, problems, drawing. Two four-hour periods a week. *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. Two four-hour periods a week. *Prerequisite*: *M.E.* 30. Three hours credit. Second semester.

**31. Design of Automobile and Motor Truck Chassis.** The student selects the 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. Automotive Laboratory.** An 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 include speed range, acceleration, braking, and fuel mileage. Laboratory, reports. Two periods of four and one-half hours each a week. *Prerequisites*: *M.E.* 7 *and M.E.* 29. Three hours credit. Each semester.

**33. Advanced Automobile Testing and Research.** An opportunity for advanced experimental and research work. The student is left largely to his own resources in planning apparatus and in carrying out the 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 scientific methods to the operation of the shop and other departments of a factory, and includes 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—Purchasing and Traffic.** This course treats of the principles of purchasing material and the relation of this function to other functions in a business. A study is made of the economic aspects of freight transportation, including rates, privileges, and claims. *Prerequisite*: *M.E.* 35. Three hours credit. Second semester.

**37. Special Topics on the Internal Combustion Engine.** This course affords the student an opportunity of investigating the theory, design, and construction of one or more types of internal combustion engines according to his interests. Reading, reports. *Prerequisite*: *M.E.* 15. Two hours credit. Each semester.

**38. Internal Combustion Engineering.** Research work on Diesel or other types of 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.* 15*a*. Credit and hours to be arranged. Each semester.

40. **Factory Management. Field Work.** Lectures and problems are presented by prominent men in the industrial field. The topics included are storeroom 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. First semester.

41. **Automobile Engineering Seminar.** The student prepares one paper on current topics of the automobile industry and one covering an investigation of some special subject. Reading, preparation of papers, and class discussions. 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. Second semester.

44. **Automotive Electrical Equipment.** A study of 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. *Prerequisite*: *E.M.* 3. Two hours credit. Each semester.

52. **Accident Prevention and Safety Engineering.** This course is designed to give the student an appreciation of the technical elements and human factors involved in accident prevention. Accident and fire prevention methods and devices are considered. Lectures, recitations, and reports. *Not open to freshmen.* Two hours credit. Each semester.

53. **Personnel Problems in Engineering.** This course is designed to give the student an appreciation of the personnel or human problems in engineering. Typical problems and situations are featured. Lectures, demonstrations, discussions, and recitations. *Not open to freshmen.* Three hours credit. Each semester.

**55. Advanced Thermodynamics.** A continuation of M.E. 5 consisting of the application of principles to advanced problems in heat engines, air compressors, and refrigerating machines, together with lectures dealing both with engineering phases and the relation of the laws of thermodynamics to modern physical concepts of matter and energy. *Prerequisites*: *M.E.* 5 *and* 8. Three hours credit. Second semester.

**Summer Session**

Courses 2, 3, 6, 7, and 8, or similar courses, will be given during the Summer Session of 1931.

## 81. NAVAL ARCHITECTURE AND MARINE ENGINEERING

Professors SADLER and BRAGG; Associate Professor LINDBLAD; Assistant Professor ADAMS.

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 workshop for the purpose of making models of vessels.

The models used in the tank for testing purposes are from 8 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, Battle Creek, and Olivet Colleges and the College of the City of Detroit. For detailed information see section 15.

**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 14.

**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 64.

## 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 50.

| a) *Outline of Required Courses* | *Hours* |
|---|---|
| 1) Preparatory Courses | |
| English 1 and 2, and a course from Group 3 | 6 |
| Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 34 | 18 |
| Physics 45, 46 | 10 |
| Chemistry 5 | 5 |
| Drawing 1, 2, 3 | 8 |
| Shop 2, Metal Working and Treating | 2 |
| Total | 65 |
| 2) Secondary and Technical Courses | |
| Surveying 4, Use of Instruments | 2 |
| E. M. 1, Statics | 4 |
| E. M. 2, Strength and Elasticity | 3 |
| E. M. 3, Dynamics | 2 |
| E. M. 4, Hydromechanics | 3 |
| M. E. 2, Elements of Machine Design | 3 |
| M. E. 3, Heat Engines | 4 |
| M. E. 4, Hydraulic Machinery | 3 |
| M. E. 6, Machine Design | 4 |
| M. E. 7, Mechanical Laboratory | 2 |
| Elec. Eng. 2a, Electric Apparatus and Circuits | 4 |
| Chem. Eng. 1, Engineering Materials | 3 |
| N. A. 1, Structural Design | 1 |
| N. A. 2, Ship Calculations | 3 |
| N. A. 4, Resistance and Propulsion of Ships | 3 |
| N. A. 5, Structural Drawing | 2 |
| Mar. Eng. 9, Marine Machinery | 3 |
| *Mar. Eng. 10, Marine Boiler Design | 3 |
| *C. E. 2, Theory of Structures | 3 |
| Total | 55 |

*Students electing Group C, Water Transportation, for their group options, will substitute Economics 51 and 52 in their junior year in place of Mar. Eng. 10 and C.E. 2.

Summary:

| | |
|---|---|
| Preparatory Courses | 65 |
| Secondary and Technical Courses | 55 |
| Group Options | 20 |
| Total | 140 |

**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.

| | *Hours* |
|---|---|
| A. NAVAL ARCHITECTURE | |
| N. A. 3, Stability, etc. | 3 |
| N. A. 6, Ship Drawing and Design | 3 |
| N. A. 7, Ship Drawing and Design | 3 |
| N. A. 12, Experimental Tank Work | 2 |
| N. A. 13, Ship and Engine Specifications | 1 |
| Electives | 8 |
| Total | 20 |
| B. MARINE ENGINEERING | |
| M. E. 5, Thermodynamics | 3 |
| M. E. 8, Mechanical Laboratory | 3 |
| M. E. 13, Steam Turbines | 3 |
| M. E. 15, Gas Engines | 3 |
| Mar. Eng. 11, Marine Engine Design | 3 |
| Electives | 5 |
| Total | 20 |
| *C. WATER TRANSPORTATION | |
| Ec. 130, Transportation | 3 |
| Ec. 173, Accounting | 3 |
| N. A. 13, Specifications | 1 |
| C. E. 55, Transportation | 2 |
| Electives | 11 |
| Total | 20 |

In this group students will substitute Ec. 51 and 52 in their junior year for Mar. Eng. 10 and C. E. 2 in the regular schedule.

*See footnote on page 212.

## PROGRAM

### FIRST YEAR

| *First Semester* Courses | Hours | *Second Semester* Courses | Hours |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education or Military Science | 0 or 1 | †Physical Education or Military Science | 0 or 1 |
| | 16, 17, or 18 | | 16, 17, or 18 |

### SECOND YEAR

| | | | |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Math. 33 | 5 | Math. 34 | 5 |
| Physics 45 | 5 | Physics 46 | 5 |
| Surveying 4 | 2 | Eng. Mech. 1 | 4 |
| Drawing 3 | 2 | | |
| | 18 | | 18 |

### SUMMER SESSION

| | |
|---|---|
| Elec. Eng. 2*a* | 4 |
| Elective | 4 |
| | 8 |

### THIRD YEAR

| | | | |
|---|---|---|---|
| Eng. Mech. 2 | 3 | Eng. Mech. 4 | 3 |
| Eng. Mech. 3 | 2 | Mech. Eng. 5 or Naval Arch. 6 | 3 |
| Mech. Eng. 2 | 3 | Mech. Eng. 6 | 4 |
| Mech. Eng. 3 | 4 | Mech. Eng. 7 | 2 |
| Naval Arch. 1 | 1 | Chem. Eng. 1 | 3 |
| Naval Arch. 5 | 2 | Naval Arch. 2 | 3 |
| ‡See footnote | | | |
| | 15 | | 18 |

*For nontechnical elective requirement see section 51.
†Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Military Science is for a period of four semesters.
‡Students intending to take Group C, Water Transportation, should take Ec. 51 and 52 in their junior year in order to get in Ec. 130 in the first semester of their senior year.

FOURTH YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Mech. Eng. 4 | 3 | Engl. from Group 3 | 2 |
| Mech. Eng. 8 or Naval Arch. 7 | 3 | Naval Arch. 4 | 3 |
| Mech. Eng. 15 or Naval Arch. 3 | 3 | Group Options | 7 |
| Mar. Eng. 9 | 3 | | |
| Mar. Eng. 10 | 3 | | |
| Civil Eng. 2 | 3 | | |
| | 18 | | 12 |

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. *To be accompanied by N.A.* 5. One hour credit. Each 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*: *N.A.* 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*: *N.A.* 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. *To be accompanied by N.A.* 1. 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. *To be accompanied or preceded by N.A. 2.* 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. *Prerequisites: N.A. 3 and 6.* Three hours credit. Each semester.

9. **Marine Machinery.** It is the purpose of this course to familiarize the student with the different types of machinery used for propelling vessels. A study is made of the steam consumption of reciprocating engines and turbines, and of the capacity of different types of boilers to supply steam for their needs. The use of coal, pulverized coal, and fuel oil in connection with boilers is studied, and also the use of oil in internal combustion engines. The preliminary calculations are made for a triple expansion reciprocating engine and the sizes of the main parts are worked out. A brief study is made also of condensers and air pumps. Lectures, recitations. *Prerequisites: M.E. 3 and E.M. 1.* Three 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. *Prerequisite: Mar.Eng. 9.* Each semester.

12. **Naval Architecture.** Laboratory Work in Experimental Tank. Two three-hour laboratory periods. Two hours credit. Each semester.

13. **Naval Architecture.** Specifications and Contracts. One hour credit. Second semester.

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.

## 82. PHYSICS

Professors RANDALL, WILLIAMS, COLBY, SMITH, and SAWYER; Associate Professors RICH, BARKER, LINDSAY, GOUDSMIT, UHLENBECK, MEYER, and DENNISON; Assistant Professors SLEATOR, CORK, DUFFENDACK, FIRESTONE; Mr. BREWINGTON, Mr. FISHER, Mr. GLATHART, Mr. THATCHER, Mr. THOMSON, and Mr. UEHLING.

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.

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 room 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, 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 four stories, a basement, and a first and second sub-basement, all seven floors connected by an elevator.

Laboratories are provided for heat and high temperature measurements, sound, light and applied optics, radioactivity, electrical measurements, and vacuum tubes, all supplied with adjacent apparatus, research, and consultation rooms. Sound has a two-story structure extending through the first and second basements entirely disconnected from the walls of the surrounding building. X-ray research has ample quarters in the first and second basements. 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 two 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.

The inclusion of a degree in physics, among other degrees offered by this college, has its justification in the rapid introduction of the findings of physics and the methods of physical research into industry. The demand for physicists far exceeds the supply, and is continually increasing. Anyone finding the subject attractive may become an industrial physicist, confident that his profession is one of great usefulness and ever expanding possibilities.

The schedule of courses leading to the degree of Bachelor of Science in Engineering (Physics) is to be considered as illustrative rather than as fixed. The Department will be glad to consult with all students interested, both as to the possibilities of the new profession and the particular work best suited to each individual.

## CURRICULUM IN PHYSICS

Candidates for the degree of Bachelor of Science in Engineering (Physics) are required to complete the following program of studies:

| | *Hours* |
|---|---|
| a) Preparatory Courses | |
| English 1 and 2, and a course from Group 3 | 6 |
| *Nontechnical Electives | 16 |
| Mathematics 3, 4, 33, 34 | 18 |
| Physics 45, 46 | 10 |
| Chemistry 5 and 17 | 10 |
| Drawing 1, 2, 3 | 8 |
| Shop 2 | 2 |
| | 70 |
| b) Secondary and Technical Courses | |
| Eng. Mech. 1, Statics | 4 |
| Eng. Mech. 2, Strength and Elasticity | 3 |
| Eng. Mech. 3, Dynamics | 2 |
| Eng. Mech. 4, Hydromechanics | 3 |
| Mech. Eng. 3, Heat Engines | 4 |
| Chem. Eng. 1, Engineering Materials | 3 |
| Elec. Eng. 1, Principles of Electricity and Magnetism | 4 |
| Elec. Eng. 2, Direct Current Apparatus and Circuits | 4 |

*Students in this curriculum may satisfy the nontechnical elective requirement in the College of Engineering in the usual way, or they may elect twelve hours each of French and German.

| | |
|---|---|
| Elec. Eng. 3, Alternating Current Circuits | 4 |
| Physics 105, Modern Physics | 2 |
| Physics 147, Electrical Measurements | 4 |
| Physics 165, Vacuum Tubes | 2 |
| Physics 186, Light | 4 |
| | 43 |

c) Group Options and Electives

| | |
|---|---|
| Group Options in Physics and Mathematics to meet the particular needs of the individual student | 12 |
| General Electives | 15 |
| | 27 |

Summary:

| | |
|---|---|
| Preparatory Courses | 70 |
| Secondary and Technical Courses | 43 |
| Group Options and Electives | 27 |
| | 140 |

## COURSES IN PHYSICS

**Description of Courses.**—For all courses beyond 100, except Physics 130 which requires 45 only, Physics 45 and 46 are prerequisites. The individual courses may have particular prerequisites besides. Physics 45 and 46 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 Physics 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 is the regular one for students in Architecture 1 and 2. At least half the semester is devoted to elementary mechanics, the remainder to sound and heat, all with experimental illustrations in the lectures. Two lectures, and three recitations, of which one is for problems, a week. *A knowledge of plane trigonometry is indispensable. No student is admitted to the class who has not had a preparatory course in physics.* Four hours credit. Each semester.

**45. Mechanics, Sound, and Heat.** At least half the semester is devoted to elementary mechanics; the remainder of the time to sound and heat; all with experimental illustrations. Two lectures, three recitations, and one two-hour laboratory period a week. *No student is admitted to the class who has not had a*

*preparatory course in physics. A knowledge of plane trigonometry is indispensable.* Five hours credit. Each semester.

46. **Electricity and Light.** A continuation of Course 45. It takes up the fundamental phenomena and laws of electricity and light with ample class illustrations. Physics 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 Physics 35, 36, 37, and 38 as equivalents of Physics 45 and 46. *Must be preceded by Physics* 45 *and by Chem.* 5*E, or an equivalent.* Two lectures, three recitations, and one two-hour laboratory period a week. Five hours credit. Each semester.

105. **Modern Physics.** This course treats of radioactivity, X-rays, a vacuum tube, and other electron and allied phenomena which lead to the theory of matter. It 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 lectures a week, with discussions and demonstrations. The course will be non-mathematical, *requiring as prerequisites Physics* 35 *and* 36 *or* 45 *and* 46. Two hours credit. First semester.

121. **X-ray Equipment and Apparatus.** 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*: *Physics* 36 *or Physics* 46. One lecture and one two-hour laboratory period a week. Two hours credit. First 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*: *Physics* 45 (*or* 41 *or* 35). Two hours credit. Second semester.

145. **Electrical Measurements.** This course is not intended for electrical engineers. 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. Three lectures and one four-hour laboratory period a week. Four hours credit. First semester.

**147. Electrical Measurements.** 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 is the regular one for electrical engineering students. *Prerequisites: Physics* 46 *and E.E.* 3. Two lectures and one four-hour laboratory period a week. Four hours credit. Each semester.

**154. Electrical Measurements.** This is a continuation of Physics 145 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. Three lectures and one four-hour laboratory period a week. 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. One two-hour laboratory period a week. *Must be preceded or accompanied by Physics* 156. One hour 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. One lecture and one three-hour laboratory period a week. A knowledge of alternating currents is necessary. 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. Two three-hour laboratory periods a week. *Prerequisite*: *Physics* 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.

174. **Sound.** Lectures and recitations covering the theory of vibrating systems; the production, propagation, and measurement of sound; and subjective sound phenomena. Text, Richardson, *Sound*. Students intending to take Physics 165, Vacuum Tubes, should do so before entering this course. Two hours credit. Second semester.

176. **Laboratory Work in Sound.** A course to accompany or follow Physics 174. Four hours per week in the laboratory are devoted to experiments on vibrating systems, the condenser transmitter and thermophone for absolute intensity measurements, binaural localization, the absolute sensitivity of the ear, and other subjective phenomena. Since vacuum tube amplifiers and oscillators will be used, students intending to take Physics 165, Vacuum Tubes, should do so before entering this course. Two hours credit. Second semester.

181. **Heat.** The work covers the fundamental principles of heat phenomena. Such subjects as temperature measurement, thermal expansion, heat transfer, specific heats, change of state, elementary kinetic theory, and thermodynamics are treated. Lectures and recitations. Two hours credit. First semester.

182. **Measurements of High Temperature.** A survey of the various types of furnaces now in use in the industries for the production of high temperatures is briefly made. Opportunity is given the student to work with laboratory models of such various types as the gas combustion furnace, electric arc, electric conduction and electric induction furnaces. In the measurement of high temperatures, practice is given in the calibration and use of resistance thermometers, thermo-electric devices, total radiation and optical pyrometers, as well as temperature recording and controlling devices and transition point apparatus. The subject matter is taken up from both practical and theoretical standpoints. Opportunity for work on special problems might be given to students qualified. Two hours credit. Second semester.

183. **Laboratory Work in Heat.** A course to accompany or follow Physics 181. Four hours per week in the laboratory are given to a study of modern accurate methods of measuring various thermal quantities, the need of the determination of which often arises in the course of scientific research. The student is given opportunity to become familiar with any of the modern temperature measuring devices, the determination of thermal expansion by several methods, including the interferometer and X-rays, measurement of specific heats, ratio of specific heats, thermal conductivities, etc. Two hours credit. First semester.

186. **Light.** An intermediate theoretical course treating the subjects of interference, diffraction, law of extreme path and aplanatic surfaces, polarization and double refraction, the nature of white light, and experiments on ether drift. Two 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. Three lectures or recitations a week and occasional laboratory exercises. Three hours credit. First semester.

188. **Laboratory Work in Light.** A course to accompany or follow Physics 186. Four hours per week in the laboratory are used in the study of refraction, interference, diffraction, the examination of spectra and practice in the use of optical instruments. Four hours per week to be arranged. Two hours credit. Second semester.

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

201, 202. **Physics Pro-Seminar.** Discussion groups for the study of the current literature of physics. Recommended for all graduate students in their first year of residence. Required of all candidates for the master's degree. Hours to be arranged. One hour credit each. Throughout the year.

203, 204. **Molecular Physics.** An introduction to the theory of matter, with emphasis upon the mechanics of gases, mean free path phenomena, and specific heats. Spectroscopy and the quantum hypothesis are presented as tools for the study of the structure and properties of matter. This course is intended primarily for

students in Chemical Engineering. Three hours credit each semester. *Physics* 203 *is a prerequisite for* 204. First semester, 203; second semester, 204.

205, 206. **Electricity and Magnetism.** A fundamental treatment of the Maxwell electromagnetic theory. Discussion of electrostatic and electromagnetic phenomena on the basis of Maxwell's equations. In the second semester the theory of electromagnetic waves is developed and the radiation from a Hertzian oscillator is derived. The connection with the special relativity theory is discussed. *Prerequisite*: *Physics* 154. *Physics* 205 *is a prerequisite for* 206. Three hours credit each semester. First semester, 205; second semester, 206.

207, 208. **Theoretical Mechanics.** Statics and dynamics of a particle and of a rigid body. The equation of Lagrange. The Hamilton-Jacobi equation. The general transformation theory. *Prerequisite*: *an adequate course in ordinary differential equations. Physics* 207 *is a prerequisite for* 208. Three hours credit each semester. First semester, 207; second semester, 208.

209. **Thermodynamics.** A discussion of the two laws and their foundation. Applications to gas equilibria and dilute solutions. The phase rule of Gibbs. Theory of binary mixtures after van der Waals. *Prerequisite*: *Physics* 181. Three hours credit. First semester.

210. **The Kinetic Theory of Matter.** Development of the kinetic and statistical method of Boltzmann, in connection with the explanation of the second law of thermodynamics. Extension to the quantum theory. Non-ideal gases and the theory of the solid body. Dissociation equilibria and the theorem of Nernst. The theory of radiation. Fluctuation phenomena. *Prerequisite*: *Physics* 209. Four hours credit. Second semester.

211, 212. **Quantum Theory and Atomic Structure.** The Bohr formulation of the quantization of multiple periodic systems and its application to atomic spectra (optical and X-ray) and molecular spectra. Heisenberg's uncertainty principle and matrix mechanics. De Broglie waves and the Schrödinger wave equation. Application to physical problems. *Prerequisite*: *Physics* 196. *Physics* 211 *is a prerequisite for* 212. Three hours credit each semester. First semester, 211; second semester, 212.

213, 214. **Introduction to Theoretical Physics.** The partial differential equations of mathematical physics and their boundary condition problems. Potential theory. The method of the particular solution. Distinction between elliptic, parabolic, and hyperbolic partial differential equations. The method of conformal representation. Eigen value problems. The connection with the

theory of integral equations and the calculus of variations. *Physics 213 is a prerequisite for 214.* Four hours credit each semester. First semester, 213; second semester, 214.

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, 160, 165, 171, 181, 183, 186, 195, 205*s*, 210*s*, 218*s*, 247*s*, 250*s*, 255*s*, 280, 281, 290, 291, and 292, or similar courses, will be offered in the Summer Session of 1931.

## 83. ENGINEERING-LAW COMBINED CURRICULUM

The College of Engineering and the Law School of the University offer a six-year combined course to meet the needs of those members of the bar whose practice is in fields for which an engineering foundation is desirable.

Such fields include patent-law, for which a knowledge of mechanical and electrical devices and of processes is important, and law as affecting the operation and the business of public-service, manufacturing, and other corporations.

There is moreover an increasing tendency for graduates in law to engage in the management of corporations. The combined course should therefore be of value to many also who are not actively engaged in the practice of law.

It is believed that many of the studies in an engineering curriculum, such as mathematics, physics, and engineering mechanics in which the faculty of analysis is trained, are very helpful as preparation for the study of law.

The student in the combined course is registered in the College of Engineering for three years and then in the Law School for a like period. On the completion of the three-year curriculum in the College of Engineering with a minimum average grade* of 2.5, the student is recommended for transfer to the Law School. On the satisfactory completion of the first year of the law curriculum, the student will be recommended for the degree of Bachelor of Science in Engineering. The diploma given will bear the legend Law.

Students of the College of Engineering transferring to the Law School without having completed the first three years of the combined course with the required grade will not be recommended by the College of Engineering for its degree.

The following schedule for the first three years has been approved by the two faculties as the general requirement for the Engineering-Law Combined Course. Minor modifications or substitutions in the purely engineering courses may be made, subject to the permission of the committee in charge. Students should note that application for admission to the Law School must be made before April 20, and that the College of Engineering requires a higher average grade for its recommendation for transfer to the Law School on the combined course than it requires for graduation in the four-year curricula.

| | | *Hours* |
|---|---|---|
| a) | Preparatory Courses | |
| | English 1 and 2, and choice of Group 3 | 6 |
| | Nontechnical Electives | 8 |
| | Mathematics 3, 4, 33, 38 | 16 |
| | Physics 45, 46 | 10 |
| | Chemistry 5E | 5 |
| | Drawing 1, 2, 3 | 8 |
| | Shop 2 | 2 |
| | Total | 55 |
| b) | Secondary and Technical Courses | |
| | Surveying 4 | 2 |
| | Eng. Mech. 1, Statics | 4 |
| | Eng. Mech. 2, Strength and Elasticity | 3 |
| | Eng. Mech. 3, Dynamics | 2 |
| | Eng. Mech. 4, Hydromechanics | 3 |
| | Civil Eng. 2, Theory of Structures | 3 |
| | Chem. Eng. 1, Engineering Materials | 3 |
| | Elec. Eng. 2a, Electric Apparatus and Circuits | 4 |
| | Mech. Eng. 2a, Elements of Machine Design | 3 |
| | Mech. Eng. 3, Heat Engines | 4 |
| | Mech. Eng. 5, Thermodynamics | 3 |

*See section 35 for the grading system.

| | |
|---|---|
| Economics 53, 54, General Economics | 6 |
| Political Science 31, 32, American Govt. | 6 |
| Total | 46 |

c) Electives to be selected from the following group: Engineering, Mathematics, Physics, Chemistry, Astronomy, Geology, Economics, Political Science, History, Psychology, English, Modern Language, Accounting.. 10

Summary:

| | |
|---|---|
| Preparatory Courses | 55 |
| Secondary and Technical Courses | 46 |
| Electives | 10 |
| Total for three years in Engineering | 111 |

FIRST YEAR

| *First Semester* Courses | Hours | *Second Semester* Courses | Hours |
|---|---|---|---|
| *Nontechnical Elective | 4 | *Nontechnical Elective | 4 |
| Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 | Chem. 5E or Shop 2 and Engl. 1 and 2 | 5 or 6 |
| Math. 3 (Alg. and Anal. Geom.) | 4 | Math. 4 (Pl. and Sol. Anal. Geom.) | 4 |
| Draw. 1 | 3 | Draw. 2 | 3 |
| Assembly | 0 | Assembly | 0 |
| †Physical Education | 0 | †Physical Education | 0 |
| | 16 or 17 | | 16 or 17 |

SECOND SEMESTER

| | | | |
|---|---|---|---|
| Math. 33 | 5 | Math. 38 | 3 |
| Phys. 45 | 5 | Phys. 46 | 5 |
| Ch. E. 1 | 3 | E. M. 1 | 4 |
| Draw. 3 | 2 | Ec. 54 | 3 |
| Ec. 53 | 3 | Surv. 4 | 2 |
| | 18 | | 17 |

SUMMER SESSION

| | |
|---|---|
| E. E. 2a | 4 |
| E. M. 2 | 3 |
| | 7 |

*For nontechnical elective requirement see section 51.
†Physical education twice a week throughout the year is required of all first-year students, unless Military Science (one hour credit each semester) is elected as a substitute. Military Science is for a period of four semesters.

THIRD YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| E. M. 3 | 2 | †Pol. Sci. 32 | 3 |
| M. E. 3 | 4 | M. E. 5 | 3 |
| †Pol. Sci. 31 | 3 | C. E. 2 | 3 |
| E. M. 4 | 3 | M. E. 2*a* | 3 |
| *Elective | 6 | Engl. (from Group 3) | 2 |
| | | *Elective | 4 |
| | 18 | | 18 |

†Courses in History, when approved, may be substituted for Political Science.
*Elective courses must be selected from the following group: Engineering, Mathematics, Physics, Chemistry, Astronomy, Geology, Economics, Political Science, History, Psychology, English, Modern Languages, Accounting.

# Part VI

# COLLEGE OF ARCHITECTURE*

## GENERAL STATEMENT

84. 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

85. 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.

## SERVICES RENDERED BY THE ARCHITECT

86. 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

*For admission requirements, etc., see sections 8 to 10. For courses other than those in Architecture, see Parts IV and V.

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

87. 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 confined 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 portion 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 co-operating 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 the products of numberless industries, and with an exceptionally wide range of activities and human endeavor, extending from those of laborers and artisans to those of artists and technical specialists.

## TRAINING OF THE ARCHITECT

88. 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 nontechnical 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 nontechnical subjects, such as English, foreign language, economics, physics, mathematics, geology or mineralogy, fine arts and electives. By apportioning the 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 keep him 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

89. 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

90. 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, residences, 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

91. 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 continues 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 for the architectural school.

## FOUR-YEAR PROGRAMS OF STUDY

92. 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 architectural 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, with faculty permission, 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 ventilation, 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 engineer-

ing 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 free-hand 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 nontechnical 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

93. 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

94. 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 Announcement of the Graduate School.

## OTHER CLASSES OF STUDENTS

95. 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.

College graduates who hold the Bachelor of Arts degree are able to earn the professional degree in from two to three years,

according to the program pursued and the extent of their undergraduate preparation.

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

96. A two-year program is provided for special students in Architecture upon the completion of which there is awarded a certificate of proficiency.

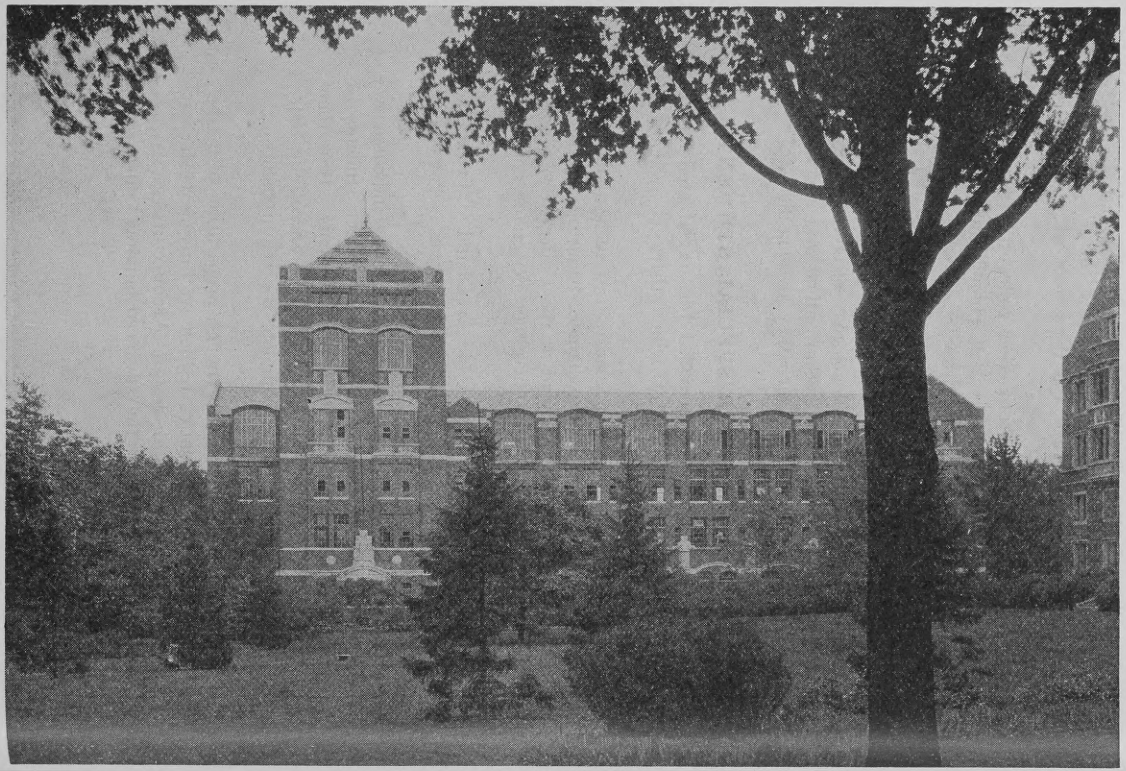
Owing to the difference in the preparation of such students but part of the work is prescribed, the remainder being elective, to be arranged in consultation with the head of the College.

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 Architecture Building

## THE WORK OF THE COLLEGE

**97. 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. It develops 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.

**98. 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 post office, museum, the monument, and the bridge, as well as the various kinds of business, 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, and 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.

**99. 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.

**100. 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 for other objects or features commonly used in connection with architecture.

101. **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 the 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.

102. **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

molded 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.

**103. 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.

**104. 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.

**105. 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.

106. **Pen and Ink.**—Rendering in pen and ink is taught for advanced students.

107. **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.

108. **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.

109. **Summer Session.**—The courses offered for Architectural students and others during the summer of 1931 will include architectural design and outdoor sketching and painting.

The Summer Session will begin June 29.

The Complete Announcement of the Summer Session may be had by addressing the Secretary of the University.

110. **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 Alumni Memorial Hall 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.

111. **Exhibitions.**—Each year there is a series of art exhibitions in the Architectural Building, and during the past year these consisted of the following: premiated designs in the Chicago War Memorial Competition; architects' drawings for the annual Lehigh Airports Competition; honor award drawings selected by the Detroit Chapter of the American Institute of Architects; *Christian Herald* premiated designs for church buildings; architectural student drawings from the Vienna Academy of Fine Arts; designs and pencil sketches by students of the 1929 Lake Forest Institute of Architecture and Landscape Design; student work in architectural design from schools affiliated with the Association of Collegiate Schools of Architecture; work in architectural and decorative design, building construction, drawing, painting and modeling, by students of the College of Architecture; photographs of the work of Lee Lawrie, New York sculptor, and small bronzes by Albert Stewart and by contemporary American artists; silk and cotton prints by American designers and manufacturers; student work of the New York School of Applied Art, in interior decoration, costume, and advertising design; original studies for mural paintings, circulated by the Society of American Mural Painters; drawings by American illustrators; water-color paintings by Vernon Howe Bailey; travel posters from European countries; lithographs and etchings by Jean Louis Forain; pencil sketches by a group of New York artists; wood engravings by Clare Leighton; lithographs by C. A. Seward; graphic arts collection from the Smithsonian Institution; selected art work by Ann Arbor school children; art work by German school children, sent from Prague.

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.

112. **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 achievement in architecture 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 Architecture Library is conveniently housed in a room 40 x 90 feet on the second floor. It comprises 5,000 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 15,000 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 architecture, the Newton and Marino edition of Vitruvius, Palladio's *Fabbriche Antiche,* the works of Stuart and Revett, Desgodetz, Cresy and Taylor, Koldewey 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 medieval architecture, the works of Dehio and von Bezold, Britton, Pugin, Viollet-le-Duc, and 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 archaeology, a large number of photographs of Greek and Roman sculpture, and a collection of nearly five thousand prints, mostly art subject materials.

**113. 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.

**114. 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 will be invited to assist in grading design problems.

**Association of Collegiate Schools of Architecture.**—The College is a charter member of this organization.

## 115. FELLOWSHIPS, SCHOLARSHIPS, AND HONORS

**George G. Booth Traveling Fellowship in Architecture.**—This fellowship is awarded annually, the stipend for the year being $1200. To be eligible the candidate must be not more than thirty years of age, and either be a graduate of the College of Architecture of the University of Michigan or have been in residence for, and have substantially completed, the last two years of the four-year course. The award is made on the basis of the student's general record and a competition in design.

**Sculpture Prize.**—For the year 1930-1931, through a friend of the College of Architecture, a prize of $50 is offered to the student submitting the best work in the course in clay modeling.

**Eisenstaedt Award in Drawing and Painting.**—Dr. S. Eisenstaedt, Chicago, Illinois, provides annually the sum of $100 for awards in the classes in drawing and painting in the College 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 Architects.**—Graduates in Architecture of the University of Michigan are received as candidates

for membership 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 to graduates from this and other recognized schools of the Institute.

**Medal of the American Institute of Architects.**—The American Institute of Architects annually awards a medal to that member of the graduating class of the College of Architecture having the highest standing during the four-year period of study in Architecture.

**Tau Sigma Delta** is an international honorary fraternity which fosters and promotes high standards in the schools and colleges of architecture and the allied arts. Second semester junior and senior students of marked scholastic ability are eligible.

## 116. CREDIT HOURS REQUIRED IN THE THREE FOUR-YEAR PROGRAMS, THE TWO-YEAR PROGRAM FOR SPECIAL STUDENTS, AND THE PROGRAMS IN DECORATIVE DESIGN

One hour of credit represents ordinarily about three hours of actual work during each week of one semester.

| | I | II | III | Spl. | Dec. Des. |
|---|---|---|---|---|---|
| ARCHITECTURE: | | | | | |
| Elements of architecture | 3 | 3 | 3 | .. | 3 |
| Architectural design | 31 | 37 | 17 | 23 | 7 |
| Allied arts design | 3 | 3 | .. | .. | 33 |
| History of architecture | 8 | 8 | 6 | 8 | 6 |
| Office work | 4 | 4 | 4 | .. | 4 |
| CONSTRUCTION: | | | | | |
| Construction (elementary) | 2 | 2 | 2 | 2 | 2 |
| Structural mechanics | 6 | 6 | 7 | .. | .. |
| Roofs, girders, and framed structures | 5 | 5 | 5 | .. | .. |
| Masonry and reinforced concrete | 4 | 4 | 3 | .. | .. |
| Advanced structural design | .. | .. | 4 | .. | .. |
| Testing materials | .. | .. | 2 | .. | .. |
| Chemistry of materials | .. | .. | 3 | .. | .. |
| Surveying | .. | .. | 2 | .. | .. |
| BUILDING EQUIPMENT: | | | | | |
| Building sanitation | 1 | 1 | 1 | 1 | .. |
| Heating and ventilation | 2 | 2 | 2 | 2 | .. |
| Heat engines | .. | .. | 4 | .. | .. |

| | | | | | |
|---|---|---|---|---|---|
| DRAWING: | | | | | |
| Free-hand drawing | 10 | 10 | 6 | 6 | 14 |
| Water-color painting | 2 | 2 | 2 | 2 | 2 |
| Clay modeling | .. | .. | .. | .. | 2 |
| Lettering | .. | .. | .. | .. | 1 |
| Mechanical drawing and shades and shadows | .. | .. | .. | .. | 4 |
| Descriptive geometry and shades and shadows | 3 | 3 | 3 | 1 | .. |
| Perspective and stereotomy | 2 | 2 | 2 | 2 | 1 |
| SCIENCE: | | | | | |
| Mathematics | 13 | 4 | 18 | .. | .. |
| Physics | 4 | 4 | 10 | .. | .. |
| Acoustics | 2 | 2 | .. | .. | .. |
| Chemistry | .. | .. | 5 | .. | 4 |
| Mineralogy or geology | 3 | 3 | 3 | .. | .. |
| MODERN 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 | 9 |
| Landscape design or city planning | .. | 3 | .. | .. | .. |
| Philosophy or psychology | .. | .. | .. | .. | 3 |
| Cultural and free electives | 8 | 8 | 10 | 16 | 21 |
| | 140 | 140 | 140 | 66 | 140 |

## 117. PROGRAM I. ARCHITECTURE

FIRST YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| English 1 and 2 | 4 | *Mod. Language | 4 |
| Math. 3 | 4 | Analytic Geom. (Math. 4) | 4 |
| Elements of Arch. (A. 1) | 3 | Arch. Design (A. 4) | 3 |
| Descriptive Geom. (A. 2) | 3 | Ancient, Med. Arch. (A. 12) | 3 |
| Free-hand Drawing (Dr. 21) | 2 | Bldg. Construction (A. 21) | 2 |
| | | Free-hand Drawing (Dr. 22) | 2 |

*For Modern Language requirement see section 51.

SECOND YEAR

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Calculus (Math. 33) | 5 | English | 2 |
| Physics 41 | 4 | Min. 104 or Geol. 31 | 3 |
| Perspective, Stereotomy (A. 3) | 2 | Arch. Design (A. 6) | 4 |
| Arch. Design (A. 5) | 4 | Arch. Mechanics (A. 19) | 3 |
| Gothic, Renaissance, Mod. Arch. (A. 13) | 3 | Prin. of Design (D. D. 2) | 3 |
| | | Free-hand Drawing (Dr. 23) | 2 |

THIRD YEAR

| | | | |
|---|---|---|---|
| *Mod. Language | 4 | *Mod. Language | 4 |
| Arch. Design (A. 7) | 6 | Arch. Design (A. 8) | 6 |
| Arch. Mechanics (A. 20) | 3 | Arch. Hist. Research (A. 14) | 2 |
| Bldg. Sanitation (A. 24) | 1 | Steel Construction (A. 22) | 3 |
| Water Color (Dr. 24) | 2 | Structural Design (A. 23) | 2 |
| Elective | 2 | | |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Dec. Des. 21 | 3 | Bus. Ad. | 3 |
| M. E. 18 | 2 | Acoustics (Phys. 130) | 2 |
| Reinforced Concrete (A. 26) | 2 | Arch. Design (A. 10) | 8 |
| Structural Design (A. 27) | 2 | Life Drawing (Dr. 27) | 2 |
| Free-hand Drawing (Dr. 25) | 2 | | |
| Electives | 6 | | |

## 118. PROGRAM II. ARCHITECTURAL DESIGN

FIRST YEAR

| | | | |
|---|---|---|---|
| English 1 and 2 | 4 | *Mod. Language | 4 |
| *Mod. Language | 4 | Alg., Anal. Geom. (Math. 3) | 4 |
| Elements of Arch. (A. 1) | 3 | Arch. Design (A. 4) | 3 |
| Descriptive Geom. (A. 2) | 3 | Ancient, Med. Arch. (A. 12) | 3 |
| Free-hand Drawing (Dr. 21) | 2 | Bldg. Construction (A. 21) | 2 |
| | | Free-hand Drawing (Dr. 22) | 2 |

*For Modern Language requirement see section 51.

SECOND YEAR

| *First Semester* Courses | Hours | *Second Semester* Courses | Hours |
|---|---|---|---|
| *Mod. Language | 4 | English | 2 |
| Physics 41 | 4 | Min. 104 or Geol. 31 | 3 |
| Perspective, Stereotomy (A. 3) | 2 | Arch. Design (A. 6) | 4 |
| Arch. Design (A. 5) | 4 | Arch. Mech. (A. 19) | 3 |
| Gothic, Renaissance, Mod. Arch. (A. 13) | 3 | Prin. of Design (D. D. 2) | 3 |
| | | Free-hand Drawing (Dr. 23) | 2 |

THIRD YEAR

| | | | |
|---|---|---|---|
| Arch. Design (A. 7) | 6 | Arch. Design (A. 8) | 6 |
| Arch. Mech. (A. 20) | 3 | Arch. Hist. Research (A. 14) | 2 |
| Bldg. Sanitation (A. 24) | 1 | Steel Construction (A. 22) | 3 |
| Water Color (Dr. 24) | 2 | Structural Design (A. 23) | 2 |
| Elective | 5 | Free-hand Drawing (Dr. 25) | 2 |
| | | Elective | 3 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Dec. Des. 21 | 3 | Bus. Ad. | 3 |
| Landscape Design 111 or 112 | 3 | Acoustics (Phys. 130) | 2 |
| Heat. and Vent. (M. E. 18) | 2 | Arch. Design (A. 10) | 8 |
| Arch. Design (A. 9) | 6 | Life Drawing (Dr. 27) | 2 |
| Reinforced Concrete (A. 26) | 2 | | |
| Structural Design (A. 27) | 2 | | |

## 119. PROGRAM III. ARCHITECTURAL ENGINEERING

FIRST YEAR

| | | | |
|---|---|---|---|
| English 1 and 2 | 4 | *Mod. Language | 4 |
| Math. 3 | 4 | Analytic Geom. (Math. 4) | 4 |
| Elements of Arch. (A. 1) | 3 | Arch. Design (A. 4) | 3 |
| Descriptive Geom. (A. 2) | 3 | Ancient, Med. Arch. (A. 12) | 3 |
| Free-hand Drawing (Draw. 21) | 2 | Bldg. Construction (A. 21) | 2 |
| | | Free-hand Drawing (Draw. 22) | 2 |

*For Modern Language requirement see section 51.

SECOND YEAR

| *First Semester* Courses | Hours | *Second Semester* Courses | Hours |
|---|---|---|---|
| Calculus (Math. 33) | 5 | Calculus (Math. 38) | 3 |
| Physics 45 | 5 | Physics 46 | 5 |
| Perspective, Stereotomy (A. 3) | 2 | Engineering Mech. 1 | 4 |
| Arch. Design (A. 5) | 4 | Arch. Design (A. 6) | 4 |
| Gothic, Renaissance, Mod. Arch. (A. 13) | 3 | Free-hand Drawing (Dr. 23) | 2 |

THIRD YEAR

| | | | |
|---|---|---|---|
| *Mod. Language | 4 | English | 2 |
| Differential Equations (Math. 39) | 2 | *Mod. Language | 4 |
| Engineering Mech. 2 | 3 | Min. 104 or Geol. 31 | 3 |
| Chemistry 5 | 5 | Chem. Eng. 1 | 3 |
| Arch. Design (A. 7a) | 4 | Steel Construction (A. 22a) | 3 |
| | | Structural Design (A. 23a) | 2 |

FOURTH YEAR

| | | | |
|---|---|---|---|
| Heat Engines (M.E. 3) | 4 | Heat. and Vent. (M. E. 25) | 2 |
| Surveying 4 | 2 | Testing Materials (E. M. 5) | 2 |
| Bldg. Sanitation (A. 24) | 1 | Arch. Design (A. 7b) | 2 |
| Masonry (A. 36) | 3 | Adv. Structural Design (A. 35) | 4 |
| Elective | 5 | Elective | 5 |

## 120. 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,—Statics (A. 19) and Strength of Materials (A. 20). They are, therefore, advised to bring preparation in high school algebra, trigonometry, and physics, taking Mathematics 3 at the University, then going on with Mechanics,—Architecture 19 and 20. With this training they can elect steel and reinforced concrete

*For Modern Language requirement see section 51.

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

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Shades and Shadows (Part of A. 2) | 1 | Arch. Design (A. 6) | 4 |
| Free-hand Dr. (Dr. 22 or 23) | 2 | Ancient, Med. Arch. (A. 12) | 3 |
| Arch. Design (A. 4) | 3 | Mechanics (A. 19) or Elective | 3 |
| Arch. Design (A. 5) | 4 | Bldg. Construction (A. 21) | 2 |
| Alg., Anal. Geom. (Math. 3) | 4 | Water Color (Dr. 24) | 2 |
| Perspective, Stereotomy (A. 3) | 2 | Elective | 1 |

SECOND YEAR

| | | | |
|---|---|---|---|
| Arch. Design (A. 7) | 6 | Arch. Design (A. 8) | 6 |
| Arch. 13 | 3 | Arch. Hist. Research (A. 14) | 2 |
| Mechanics (A. 20) or Elective | 3 | Steel Construction (A. 22) | 3 |
| Bldg. Sanitation (A. 24) | 1 | *Structural Design (A. 23) or Elective | 2 |
| M. E. 18 or Elective | 2 | Water Color or Pen and Ink | 2 |
| Free-hand Draw. (Dr. 25) | 2 | Dec. Des. 21 | 3 |

## 121. PROGRAMS IN DECORATIVE DESIGN†

Four majors are outlined in Decorative Design, differentiation in the various groups occurring in the fourth year. Group I is fully established. Groups II, III, and IV are tentative, and represent major options in which it is hoped instruction may be offered soon. 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.

Instruction in design for technical students begins with Course

*Arch. 26, Masonry and Reinforced Concrete, may be substituted.
†In addition to the courses listed for this program, students will be required to earn 4 hours credit in practical or other approved work.

2 (Decorative Design 2). Simple problems illustrating fundamental principles are worked out before studying design in specific materials and fields such as wood, clay, metals, 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

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| English 1 and 2 | 4 | English Literature 31 | 3 |
| *Mod. Language | 4 | *Mod. Language | 4 |
| Mech. Drawing (A. 2d) | 4 | †Chemistry 3 or Elective | 4 |
| Free-hand Drawing (Dr. 21) | 2 | Elements of Arch. (A. 1) | 3 |
| Clay Modeling (Dr. 33) | 2 | Perspective (A. 3d) | 1 |
| | | Free-hand Drawing (Dr. 22) | 2 |

SECOND YEAR

| | | | |
|---|---|---|---|
| English | 2 | Philosophy 31 or Psych. 31 | 3 |
| *Mod. Language | 4 | Theory of Color (D. D. 4) | 3 |
| Prin. of Design (D. D. 2) | 3 | Ancient, Med. Arch. (A. 12) | 3 |
| Lettering (D. D. 3) | 1 | Bldg. Construction (A. 21d) | 2 |
| Arch. Design (A. 4) | 3 | Water Color (Dr. 24) | 2 |
| Free-hand Drawing (Dr. 23) | 2 | Elective | 4 |
| Elective | 3 | | |

THIRD YEAR

| | | | |
|---|---|---|---|
| Nature and Design (D. D. 6) | 3 | Hist of Painting, Sculpture | 3 |
| Geometric Relations (D. D. 8) | 3 | Pattern Design (D. D. 9) | 3 |
| Hist. of Applied Art (D. D. 21) | 3 | Color Composition (D. D. 15) | 2 |
| Arch. 13 | 3 | Arch. Design (A. 5) | 4 |
| Free-hand Drawing (Dr. 25) | 2 | Life Drawing (Dr. 27) | 2 |
| Elective | 3 | Elective | 3 |

*For Modern Language requirement see section 51.
†Students who enter without Chemistry must elect Chemistry 3. Those whose entrance credits include one unit of Chemistry may substitute four hours of cultural subjects from the list in section 51.

FOURTH YEAR

GROUP I—MAJOR IN INTERIOR DECORATION

| *First Semester* | | *Second Semester* | |
|---|---|---|---|
| *Courses* | *Hours* | *Courses* | *Hours* |
| Economics | 3 | Hist. of Interiors (D. D. 35) | 1 |
| Advanced Color (D. D. 31) | 4 | Design of Interiors (D. D. 37) | 8 |
| Arch. and Interior Dec. (D. D. 33) | 4 | Museum Research (A. 14d) | 2 |
| Sketch Class (Dr. 38) | 1 | Life Drawing (Dr. 28) | 2 |
| Pictorial Comp. (Dr. 40) | 1 | Elective | 4 |
| Elective | 4 | | |

GROUP II—MAJOR IN STAGE AND COSTUME DESIGN

| | | | |
|---|---|---|---|
| Advanced Color (D.D. 31) | 4 | Costume Design (D.D. 41) | 4 |
| Architecture and Interior Decoration (D.D. 33) | 4 | Stage Craft (D.D. 43) | 3 |
| Museum Research (Arch. 14d) | 2 | Color Lighting (D.D. 45) | 2 |
| Sketch Class (Dr. 38) | 1 | Free-hand Draw. (Dr. 28) | 2 |
| Economics | 3 | Elective | 5 |
| Elective | 3 | | |

GROUP III—MAJOR IN DECORATIVE COMPOSITION

| | | | |
|---|---|---|---|
| Advanced Color (D.D. 31) | 4 | Illustration (D.D. 53) | 6 |
| Costume Design (D.D. 41) | 4 | I. Black and White | |
| Museum Research (Arch. 14d) | 2 | II. Color | |
| Economics | 3 | Pictorial Advertising (D.D. 57) | 3 |
| Sketch Class (Dr. 38) | 1 | Free-hand Draw. (Dr. 28) | 2 |
| Elective | 3 | Elective | 5 |

GROUP IV—MAJOR IN DECORATIVE ART

| | | | |
|---|---|---|---|
| Advanced Color (D.D. 31) | 4 | Design in Crafts (D.D. 65) | 9 |
| Furniture Design (D.D. 61) | 4 | Ceramics | |
| Museum Research (Arch. 14d) | 2 | Metal Work | |
| Economics | 3 | Jewelry | |
| Sketch Class (Dr. 38) | 1 | Textiles | |
| Electives | 3 | Leather | |
| | | Free-hand Draw. (Dr. 28) | 2 |
| | | Electives | 5 |

## 122. DESCRIPTION OF COURSES IN ARCHITECTURE

Professors LORCH, ROUSSEAU, WILBY, TITCOMB, and MCCONKEY; Associate Professor BENNETT; Assistant Professors MARSHALL, SLUSSER, FOWLER, O'DELL, CHAPIN, BARNES, and BRIGHAM; Mr. MATHEWS, Dr. ONDERDONK, Mr. VALERIO, Mr. ALDRICH, Mr. BARNUM, Mr. GAMBLE, Mr. HOWE, Mrs. CRANE, Mr. SLOCUM, Mr. BITTINGER, Mr. TANNER, Mr. GORES, Mr. KRONICK, and Mr. ANGELL.

### ARCHITECTURE

**1. Elements of Architecture.** 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. *Should be accompanied or preceded by Architecture 2 and Free-hand Drawing 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. Four hours credit. Each semester.

**3. Architectural Drawing.** Advanced projections and stereotomy; application to arch and vaulting problems; architectural, isometric and perspective drawing, and modeling. Two hours credit. First semester.

**3d. Perspective Drawing for Students in Decorative Design.** *Prerequisite: Architecture 2d.* One hour credit. Second semester.

### COURSES IN 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, and training 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. *Prerequisites*: *Architecture* 1 *and* 2, *and Free-hand Drawing* 21. Three hours credit. Each semester.

**5. Architectural Design.** The small ensemble. *Prerequisites*: *Architecture* 4 *and* 21, *and Free-hand Drawing* 22. Four hours credit. Each semester.

**6. Architectural Design.** A continuation of Course 5. Four hours credit. Each 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. Each semester.

**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.

### COURSES IN 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 Free-hand 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 countries, 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. *Prerequisite*: *Architecture* 12 *and* 13 *and two years of architectural design.* Two hours credit. Each semester.

14d. **Museum Research for Students of Decorative Design.** A study of some type of architectural decoration and the preparation of an illustrated report or thesis. *Prerequisite*: *Architecture* 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.

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* 3, *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. *Prerequisites*: *Architecture* 1 *and* 2. Two hours credit. Second semester.

21d. **Wood Construction for Students in Decorative Design.** Lectures, conferences, and drawing. Surface materials and building processes used by the decorator. Sketches and working drawings. *Prerequisites*: *Architecture* 1 *and* 2d. Two hours credit. Second semester.

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. *Prerequisites*: *Architecture* 19 *and* 20. Three hours credit. Each 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. *Prerequisites*: *E. M.* 1 *and* 2. Three hours credit. Each semester.

23. **Structural Design: Steel.** Working drawings and details of structures. *Must be preceded or accompanied by Architecture 22.* Two hours credit. Each 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. *Prerequisites*: *Architecture* 19 *and* 20. Two hours credit. Each semester.

27. **Structural Design: Masonry.** The design of foundations, columns, slabs, beams, and girders of various types, as used in buildings. *Must be preceded or accompanied by Architecture* 26. Two hours credit. Each 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. *Prerequisites*: *Architecture 22a and a course in reinforced concrete.* Four hours credit. Second semester.

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* 35*a*. Two hours credit. Second semester.

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* 2, *and preceded or accompanied by Architecture 22a.* Three hours credit. Each semester.

PRIMARILY FOR GRADUATES

30. **Architectural Design.** Special problems in planning and design. *Prerequisite*: *Architecture* 10 *or equivalent.*

33. **Architectural History.** A thesis on the architectural work of a period or on a particular monument. *Prerequisite*: *Architecture* 12, 13, *and* 14 *or equivalent.*

**38. Structural Design.** Special problems in building construction. *Prerequisite*: *Architecture* 35*a or equivalent.* Credit to be arranged.

DECORATIVE DESIGN

**2. Principles of Design.** An introductory study of the theory of design. Lectures and short problems in design. (Formerly Arch. 17.) *Prerequisites*: *Drawing* 21 *and* 22. *Architectural students should have completed Architecture* 5, *and* 12 *or* 13. Three hours credit. Each semester.

**3. Lettering.** Free-hand problems in basic letter forms, and lettering design. One hour credit. Each semester.

**4. Theory of Color.** A systematic and intensive study of color and its application in design. Lectures and problems in color and design worked out in the drafting room. (Formerly Arch. 17*a*.) Three hours credit. Each semester.

**6. Nature and Design.** Design with elements derived from nature. Lectures and design problems. (Formerly Arch. 17*b*.) *Prerequisites*: *Decorative Design* 2 *and* 4. Three hours credit. Each semester.

**8. Geometric Relations.** A study in the use of various geometric systems in design. (Formerly Arch. 17*c*.) *Prerequisites*: *Decorative Design* 2 *and* 4. Three hours credit. First semester.

**9. Pattern Design.** The making of patterns appropriate to various purposes and materials. Lectures, drawing, and research. (Formerly Arch. 17*d*.) *Prerequisite*: *Decorative Design* 8. Three hours credit. Second semester.

**15. Color Composition.** Batik; decorative panels and murals. (Formerly Arch. 17*e*.) *Prerequisites*: *Decorative Design* 2 *and* 4. Two hours credit. Second semester.

**21. History of Applied Arts.** Lectures and research. Three hours credit.

**31. Advanced Color.** Color as applied to various phases of interior problems. (Formerly Arch. 17*f*.) *Prerequisite*: *Decorative Design* 4. Four hours credit.

**33. Architecture and Interior Decoration.** Lectures and drafting room problems. (Formerly Arch. 6*d*.) Four hours credit.

**35. History of Interiors.** Lectures and library study on the historical development of the design of interiors. One hour credit.

**37. Design of Interiors.** Lectures, drafting room problems, and research dealing with the interior design of important rooms. Eight hours credit.

**41. Costume Design.** History of costume periods. Practical problems in designing costumes. The use of materials; dyeing, painting, and stencil in costume. Four hours credit.

**43. Stagecraft.** The design of stage sets. Rendering in models; scenery, costumes, lighting, and properties. Three hours credit.

**45. Color Lighting.** Theory of color and light. Psychology of color. Practical problems in lighting. Two hours credit.

**53. Illustration.** Illustration in black and white and in color. Six hours credit.

**57. Pictorial Advertising.** Poster work. Newspaper, magazine, and booklet advertising. Printing processes; layout problems. Three hours credit.

**61. Furniture Design.** The design of furniture; its construction, carving, and finish. Four hours credit.

**65. Design in Crafts.** Practical work in ceramics, metal work, jewelry design, textiles, and leather. Nine hours credit.

FREE-HAND DRAWING, PAINTING, AND MODELING

The following courses are open to others as well as students in Architecture. The courses are to be elected as Free-hand 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 is done 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 students in Architecture, 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 in drawing from antique casts (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. *Prerequisite*: *Free-hand Drawing* 21. Two hours credit.

23. **Free-hand Drawing.** Drawing from architectural ornament in pencil. *Prerequisite*: *Free-hand Drawing* 22. Two hours credit.

24. **Water-Color Painting.** Painting from still life. *Prerequisites*: *Free-hand 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*: *Free-hand Drawing* 24. Two hours credit.

31. **Pastel Drawing and Painting.** Drawing and painting from still life in pastel. *Prerequisite*: *Free-hand Drawing* 21 *or equivalent*. Two hours credit.

32. **Painting in Oil.** Painting from still life in oil. *Prerequisite*: *Free-hand 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.

**40. Pictorial Composition.** The principles of design as applied to illustration, painting, and mural decoration, in black-and-white and in color. 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:

1. *Introductory Course to the Field of Design.* Drawing exercises, modeling, and lectures. Three hours credit.

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 Free-hand Drawing 24. *Prerequisite: Free-hand Drawing 21 or equivalent.* Two hours credit.

# SUMMARY OF STUDENTS

1929-1930

## COLLEGE OF ENGINEERING

| | 1st Yr. | 2nd Yr. | 3rd Yr. | 4th Yr. | 5th Yr. | Specials | Total |
|---|---|---|---|---|---|---|---|
| Civil Engineering | | 61 | 69 | 69 | | 3 | 202 |
| Mechanical Engineering | | 76 | 66 | 65 | | 3 | 210 |
| Electrical Engineering | | 59 | 82 | 69 | | 2 | 212 |
| Chemical Engineering | | 61 | 49 | 36 | | 7 | 153 |
| Marine Engineering | | 8 | 3 | 6 | | 2 | 19 |
| Aeronautical Engineering | | 108 | 82 | 61 | | 3 | 254 |
| Geodesy and Surveying | | 2 | | 1 | | | 3 |
| Mathematics | | 1 | 14 | 4 | | | 19 |
| Physics | | 2 | 2 | | | | 4 |
| Engineering Mechanics | | | | 1 | | | 1 |
| Mechanical and Industrial | | | 5 | 3 | 1 | | 9 |
| Electrical and Industrial | | | | 2 | | | 2 |
| Chemical and Industrial | | 1 | 4 | 1 | 1 | | 7 |
| Engineering and Law | | | 2 | | | | 2 |
| Unclassified, 1st year | 413 | | | | | | 413 |
| Unclassified, part-time | | | | | | 11 | 11 |
| Grand Total | 413 | 379 | 378 | 318 | 2 | 31 | 1,521 |
| Counted more than once | | | | | | | 36 |
| Net Total, Engineering | | | | | | | 1,485 |

## COLLEGE OF ARCHITECTURE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Architecture I | 32 | 12 | 26 | 22 | | | 92 |
| Architecture II | 42 | 39 | 36 | 33 | | | 150 |
| Architectural Engineering | 33 | 11 | 9 | 5 | | | 58 |
| Decorative Design | 8 | 17 | 13 | 7 | | | 45 |
| Special students | | | | | | 11 | 11 |
| Part-time students | | | | | | 14 | 14 |
| Grand Total | 115 | 79 | 84 | 67 | | 25 | 370 |
| Counted more than once | | | | | | | 5 |
| Net Total, Architecture | | | | | | | 365 |

| | |
|---|---|
| Undergraduates, College of Engineering | 1,485 |
| Undergraduates, College of Architecture | 365 |
| Students in Colleges of Engineering and Architecture enrolled in the Summer Session of 1929 | 342 |
| Students in Engineering enrolled in the Graduate School | 125 |
| Students in Architecture enrolled in the Graduate School | 3 |
| Students enrolled in Engineering Extension courses | 205 |
| Students enrolled in Architectural Extension courses | 28 |
| Number of Students in Engineering and Architecture, net | 2,288 |

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### UNIVERSITY BUILDINGS

1. University Hall; Mason Hall; South Wing
2. James B. Angell Hall
3. Romance Language Building
4. Alumni Memorial Hall
5. Tappan Hall
6. President's Residence
7. Wm. L. Clements Library
8. West Physics Building
9. West Engineering Annex
10. West Engineering Building
11. R. O. T. C. Headquarters
12. East Physics Building
13. Economics Building and Pharmacology Building
14. West Medical Building
15. Power Substation
16. Waterman and Barbour Gymnasiums
17. Chemistry and Pharmacy Building
18. Natural Science Building
19. Law Building
20. Library, General
21. Hill Auditorium
22. Michigan League Building
23. Dental Building
24. South Department, University Hospital
25. Health Service, University
26. Storehouse and Shops
27. Laundry Building
28. Heating and Power Plant
29. Women's Athletic Building
30. Palmer Field House
31. Nurses' Central Residence
32. Observatory Buildings
33. Simpson Memorial Institute
34. Hospital, University
35. State Psychopathic Hospital
36. Convalescent Hospital
37. Wood Utilization Lab.
38. Museum Dove Lofts
39. Nurses' Dormitory
40. Contagious Disease Hospital
41. Animal House
42. Gauging Station
43. Hydraulic Testing Flume
44. Nurses' Residences
46. School of Music
47. Betsy Barbour House
48. Helen Newberry Residence
50. Morris Hall
51. Laboratory Theater
52. Michigan Union
53. Adelia Cheever Residence Hall and Cottage
54. Lawyers' Club
55. Martha Cook Building
56. Architecture Building
57. High School; Nursery School; Elementary School
58. East Engineering Building
59. East Hall
60. East Medical Building
61. Museums, University
62. Alumnae House
63. Nichols Arboretum Greenhouse
64. Coliseum Building
65. Intramural Sports Building
66. Ferry Field Administration Building
67. South Stand
68. Yost Field House
69. Baseball Stand
70. Stadium
71. Newberry Hall
72. Student Christian Association (Lane Hall)
73. Student Publications Office
74. Botanical Gardens Greenhouse

### PUBLIC BUILDINGS

90. U. S. Post Office
90A. Substation No. 1
90B. Substation No. 2
90C. Substation No. 3
91. Court House
92. City Hall
93. Armory
94. Fire Department
95. Carnegie Library
96. Y.M.C.A., City
97. Y.W.C.A., City
98. Chamber of Commerce
99. County Jail
100. Boy Scouts of America
101. St. Joseph's Hospital

### HOTELS

110. Allenel Hotel
111. Whitney Hotel
112. American House
113. St. James Hotel
114. Lincoln Hotel
115. Huron Hotel
116. Jennings House

### CHURCHES

120. First Baptist
121. Second Baptist (Colored)
122. St. Thomas' Roman Catholic
123. St. Mary's Catholic Chapel
124. Church of Christ (Disciples)
125. Church of Christ (Scientist)
126. First Congregational
127. St. Andrew's Episcopal
128. Bethlehem Evangelical
129. Calvary Evangelical
130. First Free Methodist
131. St. Paul's Evangelical Lutheran
132. Trinity Lutheran
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136. West Side Methodist Episcopal
137. Pilgrim Holiness
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140. Seventh Day Adventist
141. Unitarian
142. Beth Israel Center
143. Harris Hall
144. Wesley Hall
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161. Henry P. Tappan
162. Eberbach
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165. W. S. Perry
166. Philip Bach
167. Christian Mack
168. Patrick Donovan
169. St. Thomas

### RAILWAY STATIONS

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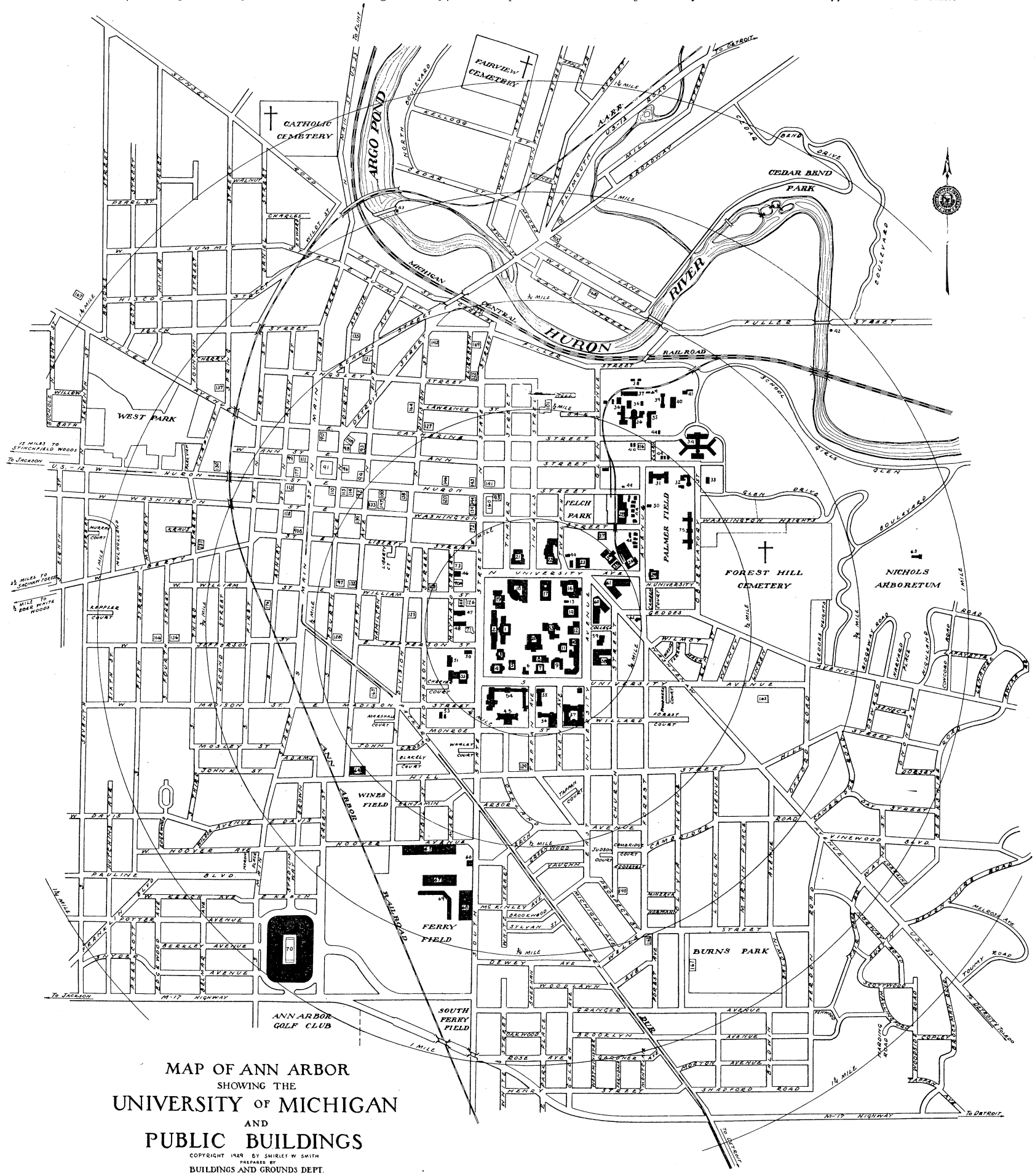


## MAP OF ANN ARBOR
SHOWING THE
## UNIVERSITY OF MICHIGAN
AND
## PUBLIC BUILDINGS

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# UNIVERSITY OF MICHIGAN

*(Continued from inside page of front cover)*

**School of Dentistry,** MARCUS L. WARD, *Dean*

(Admission officers: The Dean, for School of Dentistry; Registrar Ira M. Smith, for Curriculum in Oral Hygiene.)

Two years of collegiate preparation required. Three-year professional curriculum; fourth year optional. Fully equipped modern laboratories and clinic. Abundant clinical material. Graduate work leading to M.S. and D.D.Sc. degrees. One-year curriculum in oral hygiene.

**School of Education,** J. B. EDMONSON, *Dean*

(Admission officers: The Dean, for two-year curricula; Registrar Ira M. Smith, for four-year curricula.)

Two-year curricula (following two years of prerequisite collegiate preparation) leading to Bachelor of Arts (or Science) in Education, with life certificate. Four-year curricula in vocational education, in physical education, athletics, and school health, and in art and design, and a four-year and one-year program in public health nursing.

**School of Business Administration,** CLARE E. GRIFFIN, *Dean*

(Admission officer: The Dean.)

Three years of collegiate preparation required. Two-year professional curriculum leading to the degree of Master of Business Administration (M.B.A.). Comprehensive programs in all important phases of management. Emphasis upon case work and business research. Combined curriculum with letters, and with forestry.

**School of Forestry and Conservation,** S. T. DANA, *Dean*

(Admission officer: The Dean.)

Two years of collegiate preparation required. Two-year curriculum leading to the degree of Bachelor of Forestry or Bachelor of Science in Forestry. Three-year curriculum leading to the degree of Master of Forestry or Master of Science in Forestry. Combined curricula, in forestry and business administration, and in letters and forestry. Ample opportunity for specialization and research leading to higher degrees.

**School of Music,** CHARLES A. SINK, *President*

(Admission officers: Musical Director Earl V. Moore, for advanced standing; Registrar Ira M. Smith, for freshmen.)

Four years of high school preparation required. Four-year curricula leading to the degree of Bachelor of Music or Bachelor of Music in Education with teacher's life certificate. Other four-year curricula leading to diplomas in applied music.

**Graduate School,** G. CARL HUBER, *Dean*

(Admission officer: The Dean.)

Graduate courses in all departments of study. Special curricula leading to higher degrees in professional subjects.

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*For Bulletin of General Information and Announcements, address Mr. Ira M. Smith, Registrar of the University.*

*For general information concerning the University, address Mr. Shirley W. Smith, Vice-President and Secretary of the University, Ann Arbor, Michigan.*

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The prospective student should have, in addition to a copy of the Bulletin of General Information, a copy of one or more of the announcements or bulletins listed under this head. These will be sent, without charge, on request to the Registrar of the University.

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Colleges of Engineering and Architecture
Medical School
Law School
College of Pharmacy
School of Dentistry
School of Education
School of Business Administration
School of Forestry and Conservation
University Hospital School of Nursing
School of Music
Graduate School
Summer Session
Extension Division

Bulletins describing the work of various departments and curricula

### Other Bulletins

The President's Report
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