UNIVERSITY OF MICHIGAN
UNIVERSITY BULLETIN—NEW SERIES
NEW SERIES, VOL. XXV, NO. 44. MAY 3, 1924

# COLLEGES OF ENGINEERING AND ARCHITECTURE

## GENERAL ANNOUNCEMENT

## 1924 - 1925

ANN ARBOR
PUBLISHED BY THE UNIVERSITY
1924

# UNIVERSITY OF MICHIGAN

MARION LEROY BURTON, PH.D., LL.D.,
*President*

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

(Admission Officers: The Dean, for advanced standing; Registrar Arthur G. Hall, for freshmen.)

Many literary and scientific courses. Special four-year curricula in classical and modern languages, journalism, social science, municipal administration, business administration, accounting, banking, insurance, railway administration, physics, chemistry, geology, landscape design, and forestry. Pre-professional programs. Combined curricula with business administration, law, medicine, dentistry, and nursing.

**Colleges of Engineering and Architecture,** MORTIMER E. COOLEY, *Dean.*

(Admission Officers: Assistant Dean George W. Patterson, for Engineering; Professor Emil Lorch, for Architecture.)

Four and five year curricula in civil, mechanical, electrical, marine and aeronautical engineering, geodesy and surveying, architecture and architectural engineering. 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 with business administration.

**Medical School,** HUGH CABOT, *Dean.*

(Admission Officer: The Dean.)

Two years of collegiate preparation required. Four-year graded professional curriculum. Modern laboratories. Ample clinical facilities in hospitals under University control. Elective work in Homœopathic medicine, with special laboratories and hospital wards. Three-year curriculum in Nurses' Training.

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

(Admission Officer: The Dean.)

Two years of collegiate preparation required. Three and four-year curricula, with graduate year. Instruction in all branches of our system of law, including pleading and practice; also in international law and jurisprudence. Library of 60,000 volumes.

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

(Admission Officer: Professor Clifford C. Glover.

Three and four-year curricula. Fully equipped laboratories Pharmacy experience in health service and hospitals. Training for prescription service, manufacturing pharmacy, food and drug inspection, analysis, and clinical technology.

(*Continued on inside page of back cover.*)

WEST ENGINEERING BUILDING

UNIVERSITY OF MICHIGAN

# COLLEGES OF ENGINEERING AND ARCHITECTURE

GENERAL ANNOUNCEMENT

1924-1925

ANN ARBOR
PUBLISHED BY THE UNIVERSITY
1924

# Announcements

| | | |
|---|---|---|
| 1924 | | |
| June | 4 | Semester Examinations Begin. |
| June | 16 | COMMENCEMENT. |
| June 23 to Aug. | 15 | Summer Session. |
| June | 26-28 | *Examinations for Admission.* |
| September | 19 | Applicants for Admission Present Themselves. |
| Sept. 15 to Sept. | 19 | *Examinations for Admission.* |
| September 17, 18, | 19 | Examinations for the Removal of Conditions. |
| September | 20-22 | Classification of All Students. |
| September | 23 | FIRST SEMESTER BEGINS. |
| November | 27 | Thanksgiving Day. |
| December | 19 | (Evening) Holiday Vacation Begins. |
| 1925 | | |
| January | 6 | (Morning) Exercises Resumed. |
| January | 27 | Semester Examinations Begin. |
| February | 6 | (Evening) First Semester Closes. |
| February | 5-7 | *Examinations for Admission.* |
| February | 9 | SECOND SEMESTER BEGINS. |
| February | 22 | Washington's Birthday. |
| April | 10 | (Evening) Recess Begins, Ending April 20 (Evening). |
| May | 30 | Holiday, Memorial Day. |
| June | 2 | Semester Examinations Begin. |
| June | 15 | COMMENCEMENT. |
| June | 22 | Summer Session Begins. |
| June | 25-27 | *Examinations for Admission.* |
| August | 14 | Summer Session Closes. |
| September | 14-18 | *Examinations for Admission.* |
| September | 22 | FIRST SEMESTER BEGINS. |

# 1924

### JANUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | **1** | **2** | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | 31 | .. | .. |

### FEBRUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | .. | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | **9** |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | .. |
| .. | .. | .. | .. | .. | .. | .. |

### MARCH

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | .. | .. | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | 31 | .. | .. | .. | .. | .. |

### APRIL

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | **12** |
| **13** | **14** | **15** | **16** | **17** | **18** | **19** |
| **20** | **21** | 22 | 23 | 24 | 25 | 26 |
| **27** | 28 | 29 | 30 | .. | .. | .. |

### MAY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | **30** | 31 |
| .. | .. | .. | .. | .. | .. | .. |

### JUNE

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| **1** | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | **17** | **18** | **19** | **20** | **21** |
| **22** | **23** | **24** | **25** | **26** | **27** | **28** |
| **29** | **30** | .. | .. | .. | .. | .. |

### JULY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | **1** | **2** | **3** | **4** | **5** |
| 6 | 7 | 8 | 9 | **10** | **11** | **12** |
| **13** | **14** | **15** | **16** | **17** | **18** | **19** |
| **20** | **21** | **22** | **23** | **24** | **25** | **26** |
| **27** | **28** | **29** | **30** | **31** | .. | .. |

### AUGUST

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | .. | **1** | **2** |
| **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| **17** | **18** | **19** | **20** | **21** | **22** | **23** |
| **24** | **25** | **26** | **27** | **28** | **29** | **30** |
| **31** | .. | .. | .. | .. | .. | .. |

### SEPTEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | **1** | **2** | **3** | **4** | **5** | **6** |
| **7** | **8** | **9** | **10** | **11** | **12** | **13** |
| **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **21** | **22** | 23 | 24 | 25 | 26 | 27 |
| **28** | 29 | 30 | .. | .. | .. | .. |
| .. | .. | .. | .. | .. | .. | .. |

### OCTOBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | 1 | 2 | 3 | 4 |
| **5** | 6 | 7 | 8 | 9 | 10 | 11 |
| **12** | 13 | 14 | 15 | 16 | 17 | 18 |
| **19** | 20 | 21 | 22 | 23 | 24 | 25 |
| **26** | 27 | 28 | 29 | 30 | 31 | .. |

### NOVEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | .. | .. | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **16** | 17 | 18 | 19 | 20 | 21 | 22 |
| **23** | 24 | 25 | 26 | **27** | 28 | 29 |
| **30** | .. | .. | .. | .. | .. | .. |

### DECEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | 1 | 2 | 3 | 4 | 5 | 6 |
| **7** | 8 | 9 | 10 | 11 | 12 | 13 |
| **14** | 15 | 16 | 17 | 18 | 19 | **20** |
| **21** | **22** | **23** | **24** | **25** | **26** | **27** |
| **28** | **29** | **30** | **31** | .. | .. | .. |

# 1925

### JANUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | **1** | **2** | **3** |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |

### FEBRUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| **1** | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| .. | .. | .. | .. | .. | .. | .. |
| .. | .. | .. | .. | .. | .. | .. |

### MARCH

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| **1** | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | .. | .. | .. | .. |
| .. | .. | .. | .. | .. | .. | .. |

### APRIL

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | **11** |
| **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| **19** | **20** | 21 | 22 | 23 | 24 | 25 |
| **26** | 27 | 28 | 29 | 30 | .. | .. |

### MAY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | .. | 1 | 2 |
| **3** | 4 | 5 | 6 | 7 | 8 | 9 |
| **10** | 11 | 12 | 13 | 14 | 15 | 16 |
| **17** | 18 | 19 | 20 | 21 | 22 | 23 |
| **24** | 25 | 26 | 27 | 28 | 29 | **30** |
| **31** | .. | .. | .. | .. | .. | .. |

### JUNE

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | **16** | **17** | **18** | **19** | **20** |
| **21** | **22** | **23** | **24** | **25** | **26** | 27 |
| 28 | **29** | **30** | .. | .. | .. | .. |

### JULY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | 1 | 2 | 3 | 4 |
| **5** | 6 | 7 | 8 | 9 | 10 | 11 |
| **12** | **13** | 14 | 15 | 16 | 17 | 18 |
| **19** | **20** | 21 | 22 | 23 | 24 | 25 |
| **26** | **27** | 28 | 29 | 30 | 31 | .. |

### AUGUST

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | .. | .. | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **9** | **10** | **11** | **12** | **13** | **14** | **15** |
| **16** | **17** | **18** | **19** | **20** | **21** | **22** |
| **23** | **24** | **25** | **26** | **27** | **28** | **29** |
| **30** | **31** | .. | .. | .. | .. | .. |

### SEPTEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | **9** | **10** | **11** | **12** |
| **13** | **14** | **15** | **16** | **17** | **18** | **19** |
| **20** | **21** | 22 | 23 | 24 | 25 | 26 |
| **27** | 28 | 29 | 30 | .. | .. | .. |
| .. | .. | .. | .. | .. | .. | .. |

### OCTOBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | .. | .. | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **11** | 12 | 13 | 14 | 15 | 16 | 17 |
| **18** | 19 | 20 | 21 | 22 | 23 | 24 |
| **25** | 26 | 27 | 28 | 29 | 30 | 31 |

### NOVEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| **1** | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | **9** | 10 | 11 | 12 | 13 | 14 |
| **15** | 16 | 17 | 18 | 19 | 20 | 21 |
| **22** | 23 | 24 | 25 | 26 | 27 | 28 |
| **29** | 30 | .. | .. | .. | .. | .. |
| .. | .. | .. | .. | .. | .. | .. |

### DECEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| .. | .. | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| **13** | 14 | 15 | 16 | 17 | 18 | **19** |
| **20** | **21** | **22** | **23** | **24** | **25** | **26** |
| **27** | **28** | **29** | **30** | **31** | .. | .. |

Days of regular college session are printed in Light face type; Sundays, holidays, and vacation in Dark face.

# Board of Regents

PRESIDENT
MARION LE ROY BURTON, Ph.D., LL.D.

| | TERM EXPIRES |
|---|---|
| HON. WILLIAM L. CLEMENTS, *Bay City* | Dec. 31, 1925 |
| HON. JAMES O. MURFIN, *Detroit* | Dec. 31, 1925 |
| HON. BENJAMIN S. HANCHETT, *Grand Rapids* | Dec. 31, 1927 |
| HON. LUCIUS L. HUBBARD, *Houghton* | Dec. 31, 1927 |
| HON. WALTER H. SAWYER, *Hillsdale* | Dec. 31, 1929 |
| HON. VICTOR M. GORE, *Benton Harbor* | Dec. 31, 1929 |
| HON. JUNIUS E. BEAL, *Ann Arbor* | Dec. 31, 1931 |
| HON. RALPH STONE, *Detroit* | Dec. 31, 1931 |

HON. THOMAS E. JOHNSON, *Lansing*,
SUPERINTENDENT OF PUBLIC INSTRUCTION

SHIRLEY W. SMITH,
SECRETARY OF THE BOARD

ROBERT A. CAMPBELL
TREASURER OF THE BOARD

# Colleges of Engineering and Architecture

MORTIMER ELWYN COOLEY, M.E., LL.D., Eng.D., D.Sc., *Dean.* 1405 Hill Street.

GEORGE WASHINGTON PATTERSON, Ph.D., S.B., *Assistant Dean, College of Engineering.* 2101 Hill Street.

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

LOUIS ALLEN HOPKINS, Ph.D., *Secretary.* 1517 South University Avenue.

ALBERT EASTON WHITE, A.B., *Director, Department of Engineering Research.* 1417 South University Avenue.

# Members of the Faculty and Other Officers*

MARION LE ROY BURTON, Ph.D., LL.D., PRESIDENT.
Campus.

HARRY BURNS HUTCHINS, LL.D., PRESIDENT EMERITUS.
508 Monroe Street.

MORTIMER ELWYN COOLEY, M.E., LL.D., Eng.D., D.Sc., *Professor of Mechanical Engineering and Dean of the Colleges of Engineering and Architecture.* 1405 Hill Street.

ROBERT MARK WENLEY, D.Phil., Sc.D., Litt.D., LL.D., D.C.L., *Professor of Philosophy.* 509 East Madison Street.

FRED NEWTON SCOTT, Ph.D., *Professor of Rhetoric and Journalism.* 538 Church Street.

EDWARD DEMILLE CAMPBELL, B.S., *Professor of Chemistry and Metallurgy and Director of the Chemical Laboratory.* 1555 Washtenaw Avenue.

FILIBERT ROTH, B.S., *Professor Emeritus of Forestry.*
730 South State Street.

FRED MANVILLE TAYLOR, Ph.D., *Professor of Political Economy and Finance.* 527 Church Street.

ALEXANDER ZIWET, C.E., *Professor of Mathematics in the Colleges of Engineering and Architecture.* 532 Packard Street.

HERBERT CHARLES SADLER, Sc.D., *Professor of Naval Architecture and Marine Engineering.* 1510 Hill Street.

MOSES GOMBERG, Sc.D., *Professor of Organic Chemistry.*
725 Oxford Road.

WILLIAM JOSEPH HUSSEY, Sc.D., *Professor of Astronomy, and Director of the Observatory.* The Observatory.

---

* In this list are included the names of instructors with whom engineering students may take courses in other colleges.

GEORGE WASHINGTON PATTERSON, Ph.D., S.B., *Professor of Engineering Mechanics, and Assistant Dean, College of Engineering.* 2101 Hill Street.

EMIL LORCH, A.M., *Professor of Architecture.* 718 Church Street.

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

SAMUEL LAWRENCE BIGELOW, Ph.D., *Professor of General and Physical Chemistry.* 1520 Hill Street.

EDWARD HENRY KRAUS, Ph.D., Sc.D., *Professor of Crystallography and Mineralogy, and Director of the Mineralogical Laboratory, Dean of the College of Pharmacy, and Dean of the Summer Session.* 722 Church Street.

CLARENCE THOMAS JOHNSTON, C.E., *Professor of Geodesy and Surveying, Custodian of the Bogardus Tract, and Director of Camp Davis.* 1335 Hill Street.

ALFRED HOLMES WHITE, A.B., B.S., *Professor of Chemical Engineering.* 514 Forest Avenue.

HENRY EARLE RIGGS, A.B., C.E., *Professor of Civil Engineering.* 1319 Cambridge Road.

HORACE WILLIAMS KING, B.S., *Professor of Hydraulic Engineering.* 1203 Oakland Avenue.

HENRY CLAY ANDERSON, B.M.E., *Professor of Mechanical Engineering.* 1610 Washtenaw Avenue.

ERMINE COWLES CASE, Ph.D., *Professor of Historical Geology and Paleontology, and Curator of the Paleontological Collection.* 1609 South University Avenue.

WILLIAM CHRISTIAN HOAD, B.S., *Professor of Sanitary and Municipal Engineering.* 1028 Martin Place.

LEWIS MERRITT GRAM, B.S., *Professor of Structural Engineering.* 912 Oakland Avenue.

†LOUIS HOLMES BOYNTON, *Professor of Architecture.* 1007 Forest Avenue.

HENRY HAROLD HIGBIE, E.E., *Professor of Electrical Engineering.* 2401 Geddes Avenue.

† Died, April 19, 1924.

BENJAMIN FRANKLIN BAILEY, Ph.D., *Professor of Electrical Engineering.* 1019 Baldwin Avenue.

WILLIAM WARNER BISHOP, A.M., *Librarian.* 715 Church Street.

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

EDWARD MILTON BRAGG, B.S., *Professor of Marine Engineering and Naval Architecture.* 1056 Ferdon Road.

JOSEPH JOACHIM ALBERT ROUSSEAU, *Professor of Architecture.* 319 East Jefferson Street.

JOSEPH ALDRICH BURSLEY, B.S., *Professor of Mechanical Engineering, and Dean of Students.* 2107 Hill Street.

ARTHUR JAMES DECKER, B.S. (C.E.), *Professor of Sanitary Engineering.* 2014 Geddes Avenue.

RALPH HAMILTON CURTISS, Ph.D., *Professor of Astronomy, and Assistant Director of the Observatory.* 910 East Huron Street.

JOHN EDWARD EMSWILER, B.S. (M.E.), *Professor of Mechanical Engineering.* 1303 Granger Avenue.

WALTER LUCIUS BADGER, M.S., *Professor of Chemical Engineering.* 917 Church Street.

CLYDE ELMORE WILSON, M.S.E., *Professor of Mechanical Engineering.* 522 Linden Street.

ALFRED HENRY LOVELL, M.S.E., *Professor of Electrical Engineering.* 3000 Geddes Avenue.

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

WILLIAM D. HENDERSON, Ph.D., *Director of the Division of University Extension.* 1001 Forest Avenue.

CHARLES HORACE FESSENDEN, M.E., *Professor of Mechanical Engineering.* 932 Greenwood Avenue.

ALBERT EASTON WHITE, A.B., *Professor of Metallurgical Engineering, and Director of the Department of Engineering Research.* 1417 South University Avenue.

*NEIL HOOKER WILLIAMS, Ph.D., *Professor of Physics.* 1020 Olivia Avenue.

WALTER FRANCIS COLBY, Ph.D., *Professor of Physics.* 322 North State Street.

*JOHN AIREY, D.I.C., *Professor of Engineering Mechanics, and Director of the Engineering Shops.* 608 Woodmere Place.

PETER FIELD, Ph.D., *Professor of Mathematics.* 904 Olivia Avenue.

ARTHUR HORACE BLANCHARD, C.E., A.M., *Professor of Highway Engineering and Highway Transport.* 224 South Thayer Street.

ROBERT ARTHUR, Major, U. S. A., *Professor of Military Science and Tactics.* 509 Cheever Court.

WILLIAM HENRY BUTTS, Ph.D., *Professor Emeritus of Mathematics.* 1122 Hill Street.

THEODORE RUDOLPH RUNNING, Ph.D., *Professor of Mathematics.* 1019 Michigan Avenue.

JOSEPH HENDERSON CANNON, B.S. (E.E.), *Professor of Electrical Engineering.* 528 Walnut Street.

RANSOM SMITH HAWLEY, M.E., *Professor of Mechanical Engineering.* 1228 Prospect Street.

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

WALTER FRED HUNT, Ph.D., *Professor of Petrology.* 1030 Baldwin Avenue.

JOSEPH RALEIGH NELSON, A.M., *Professor of English.* 927 Forest Avenue.

FELIX WLADYSLAW PAWLOWSKI, M.S., *Professor of Aeronautical Engineering.* 1004 Forest Avenue.

JEAN HAMILTON, A.M., *Dean of Women.* 1722 Cambridge Road.

JOHN STEPHEN WORLEY, M.S., *Professor of Transportation Engineering.* 619 East University Avenue.

ARTHUR WHITMORE SMITH, Ph.D., *Professor of Physics.* 1008 Oakland Avenue.

* Absent on leave, 1923-1924.

HOBART HURD WILLARD, Ph.D., *Professor of Analytical Chemistry.* 904 Oakland Avenue.

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

EUGENE HENDRICKS LESLIE, Ph.D., *Professor of Chemical Engineering.* Traver Road.

WILLIAM THOMAS CARPENTER, M.E., Major, U. S. A., *Professor of Military Science and Tactics.* 520 Walnut Street.

EMIL SAARINEN, *Visiting Professor of Architecture.*

WILLIAM HENRY WAIT, Ph.D., *Associate Professor of Modern Languages.* 1706 Cambridge Road.

HERBERT J. GOULDING, B.S., *Associate Professor of Mechanism and Engineering Drawing.* 719 Arbor Street.

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

WILLIAM GABB SMEATON, A.B., *Associate Professor of General and Physical Chemistry.* 1331 Washtenaw Avenue.

HOWARD B. MERRICK, C.E., *Associate Professor of Surveying.* 928 Church Street.

GEORGE McDONALD McCONKEY, B.A.E., *Associate Professor of Architecture.* 1925 Berkshire Road.

FLOYD EARL BARTELL, Ph.D., *Associate Professor of General and Physical Chemistry.* 523 Linden Street.

JAMES HARLAN CISSEL, B.S. (C.E.), *Associate Professor of Structural Engineering.* 1111 Packard Street.

ALFRED OUGHTON LEE, M.D., *Associate Professor of Modern Languages.* 814 Hill Street.

IRVING DAY SCOTT, Ph.D., *Associate Professor of Physiographical Geology.* 1043 Olivia Avenue.

CLYDE ELTON LOVE, Ph.D., *Associate Professor of Mathematics.* 1527 South University Avenue.

LEIGH JARVIS YOUNG, A.B., M.S.E., *Associate Professor of Forestry.* 911 Forest Avenue.

CLIFTON O'NEAL CAREY, C.E., *Associate Professor of Surveying.* Geddes Road.

CHARLES WILFORD COOK, Ph.D., *Associate Professor of Economic Geology.* 1506 Granger Avenue.

JOHN A. VAN DEN BROEK, Ph.D., *Associate Professor of Engineering Mechanics.* 819 South State Street.

EDWARD LARRABEE ADAMS, Ph.D., *Associate Professor of Romance Languages.* 1850 Washtenaw Avenue.

CHESTER OWEN WISLER, M.S., *Associate Professor of Civil Engineering.* 810 Arch Street.

HERBERT ALDEN KENYON, A.M., *Associate Professor of French and Spanish.* 1103 Ferdon Road.

WALTER EDWIN LAY, B.M.E., *Associate Professor of Mechanical Engineering.* 936 Dewey Avenue.

ALLEN FIRMAN SHERZER, B.S. (M.E.), *Associate Professor of Mechanical Engineering.* 1213 Ferdon Road.

JOHN H. BATEMAN, B.C.E., *Associate Professor of Highway Engineering and Director of the Highway Laboratory.* 309 East Madison Street.

ALEXANDER LINN TROUT, A.B., B.Ch.E., *Associate Professor of Architecture.* 1333 Wilmot Street.

FRANK RICHARD FINCH, Ph.B., *Assistant Professor of Mechanism and Engineering Drawing.* 1619 South University Avenue.

FRANK HOWARD STEVENS, B.S., *Assistant Professor of Engineering Mechanics.* 1125 Lincoln Avenue.

HUGH BRODIE, C.E., *Assistant Professor of Surveying.* 611 Forest Avenue.

ROBERT JOHN CARNEY, Ph.D., *Assistant Professor of Analytical Chemistry.* 519 Lawrence Street.

DANIEL LESLIE RICH, Ph.D., *Assistant Professor of Physics.* 1205 Forest Avenue.

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

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

WILLIAM PLATT WOOD, M.S.E., *Assistant Professor of Metallurgical Engineering.* 1348 Wilmot Street.

WILLIAM WARNER SLEATOR, Ph.D., *Assistant Professor of Physics.* R. R. No. 5, 2503 Geddes Avenue.

ROY STANLEY SWINTON, M.S.E., *Assistant Professor of Engineering Mechanics.* 1114 Woodlawn Avenue.

EDMUND WILD, M.S., *Assistant Professor of Modern Languages.* 532 Walnut Street.

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

WELLS IRA BENNETT, M.S., *Assistant Professor of Architectural Drawing.* 2047 Geddes Avenue.

FRANK ALEXANDER MICKLE, M.E., *Assistant Professor of Mechanical Engineering.* 1053 Olivia Avenue.

HARRY BOUCHARD, B.C.E., *Assistant Professor of Surveying.* 1407 South State Street.

CLAIR UPTHEGROVE, B.Ch.E., *Assistant Professor of Metallurgical Engineering.* 1340 Wilmot Street.

*MARTIN J. ORBECK, M.S.E., C.E., *Assistant Professor of Mechanism and Engineering Drawing.*

CLIFFORD CYRILLE MELOCHE, Ph.D., *Assistant Professor of Analytical Chemistry.* 525 Linden Street.

CHESTER SEITZ SCHOEPFLE, Sc.D., *Assistant Professor of Organic Chemistry.* 1102 Forest Avenue.

LOUIS JOSEPH ROUSE, Ph.D., *Assistant Professor of Mathematics.* 1137 Michigan Avenue.

GEORGE ALLAN LINDSAY, Ph.D., *Assistant Professor of Physics.* 609 Hill Street.

JESSE EARL THORNTON, A.M., *Assistant Professor of English.* 1311 Wilmot Street.

JULIUS CLARK PALMER, B.S., *Assistant Professor of Mechanism and Engineering Drawing.* 649 Haven Avenue.

ALFRED LEWIS NELSON, Ph.D., *Assistant Professor of Mathematics.* 1208 Olivia Avenue.

* Absent on leave, 1923-1924.

FRANCIS L. SCHNEIDER, A.M., *Assistant Professor of English.* 509 Benjamin Street.

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

JOHN MINERT NICKELSEN, B.S., *Assistant Professor of Mechanical Engineering.* 511 Linden Street.

WILLIAM CARL RUFUS, Ph.D., *Assistant Professor of Astronomy.* 547 Elm Street.

HUGH EDWARD KEELER, M.S.E., *Assistant Professor of Mechanical Engineering.* 1102 Willard Street.

WILLIAM WELLS DENTON, Ph.D., *Assistant Professor of Mathematics.* 1014 Cornwell Place.

EDWIN MYRON BAKER, B.S., *Assistant Professor of Chemical Engineering.* 809 McKinley Street.

ALBERT BECKER PECK, A.M., *Assistant Professor of Mineralogy.* 1916 Wayne Street.

THOMAS JOSEPH MITCHELL, B.C.E., *Assistant Professor of Surveying.* 1129 Granger Avenue.

JAMES BLAINE NEWMAN, B.A.E., *Assistant Professor of Architecture.* 1221 Willard Street.

CHARLES THOMAS OLMSTED, B.S. (C.E.), *Assistant Professor of Engineering Mechanics.* 2007 Washtenaw Avenue.

FREDERICK WILHELM HOORN, B.S. (E.E.), Captain, U. S. A., *Assistant Professor of Military Science and Tactics.* 718 Onondaga Street.

HARRY LINN CAMPBELL, M.S.Ch.E., *Assistant Professor of Metallurgical Engineering.* 935 Dewey Avenue.

HOLGAR MADS HANSEN, B.C.E., *Assistant Professor of Mechanism and Engineering Drawing.* 704 West Huron Street.

CHARLES FERDINAND MEYER, Ph.D., *Assistant Professor of Physics.* 819 South State Street.

HARRY JAMES WATSON, B.M.E., *Assistant Professor of Mechanical Engineering.* 1510 Morton Avenue.

CHARLES ALBERT LANGWORTHY, Ph.D., *Assistant Professor of English.* 1020 Forest Avenue.

JOSE M. ALBALDEJO, Bachelor Institute Cardinal, *Assistant Professor of Spanish.* 1321 South State Street.

CHARLES BURTON GORDY, A.M., *Assistant Professor of Mechanical Engineering.* 1011 Vaughn Street.

ORLAN WILLIAM BOSTON, M.S., *Assistant Professor of Shop Practice, and Acting Director of Shops.* 1125 Olivia Avenue

ERNEST FRANKLIN BARKER, Ph.D., *Assistant Professor of Physics.* 1603 South University Avenue.

WIHTRED COOK, M.S.E., *Assistant Professor of Mechanism and Engineering Drawing.* 1411 Henry Street.

ROY KENNETH McALPINE, Ph.D., *Assistant Professor of Analytical Chemistry.* 926 Sylvan Street.

JOHN A. BROOKS, JR., Major, U.S.A., *Assistant Professor of Military Science and Tactics* 1205 Olivia Avenue.

FOREST E. COLLINS, Captain, U.S.A., *Assistant Professor of Military Science and Tactics.* 613 Oakland Avenue.

ALFRED LYNN FERGUSON, B.Pd., Ph.D., *Assistant Professor of General and Physical Chemistry.* Packard Road.

RALPH ALANSON SAWYER, Ph.D., *Assistant Professor of Physics* 1132 Michigan Avenue.

BRUCE McNAUGHTON DONALDSON, A.M., *Assistant Professor of Fine Arts.* 716 Forest Avenue.

ARTHUR CHARLES KLOCKSIEM, A.M., *Assistant Professor of English.* 1109 White Street.

JAMES FERDINAND FAIRMAN, M.S., *Assistant Professor of Electrical Engineering.* 528 Walnut Street.

RALPH ALLINGTON HAYWARD, B.S.E., *Assistant Professor of Chemical Engineering.* 1517 Brooklyn Avenue.

RICHARD ALFRED ROSSITER, Ph.D., *Assistant Professor of Astronomy.* 1710 Geddes Avenue.

MYRON LOUIS BEGEMAN, M.S.E., *Assistant Professor of Mechanical Engineering.* 507 Benjamin Street.

GEORGE ALEXANDER MORLEY, B.S. (M.E.), *Assistant Professor of Mechanism and Engineering Drawing.* 1001 Cross Street, Ypsilanti.

PHILIP ORLAND POTTS, B.M.E., *Assistant Professor of Mechanism and Engineering Drawing.* 1133 White Street.

WILLIAM C. LOUISELL, Captain, U.S.A., *Assistant Professor of Military Science and Tactics* 521 South Division Street.

GEORGE W. DUNN, JR., Captain, U.S.A., *Assistant Professor of Military Science and Tactics.* 1828 Vinewood Boulevard.

ROBERT HENRY SHERLOCK, B.S. (C.E.), *Assistant Professor of Civil Engineering.* 1520 Morton Street.

### Instructors

HARRY NEWTON COLE, A.B., M.S., *Instructor in Analytical Chemistry.* 702 Forest Avenue.

WILLIAM HENRY YEATMAN, *Foreman and Instructor of Wood and Pattern Shop.* 210 North Thayer Street.

WILLIAM TELFER, *Instructor in Shop Practice.* Washtenaw Road.

LEON ALEXANDER MAKIELSKI, *Instructor in Architectural Drawing.* R.F.D. No. 5, Geddes Road.

*ERNEST HARRISON BARNES, *Instructor in Architectural Drawing.* 1308 Geddes Avenue.

JAMES HARRY SPIERS, *Instructor in Shop Practice.* 402 Observatory Street.

GLENN L. ALT, B.C.E., *Instructor in Civil Engineering.* 918 Sybil Street.

WILFRED NAPOLEON ST. PETER, A.M., *Instructor in Physics.* 1523 South University Avenue.

PAUL NESTEL BLESSING, A.B., *Instructor in Mathematics,* 520 Onondaga Street.

CHARLES WINFRED GOOD, B.S. (M.E.), *Instructor in Mechanical Engineering.* 1025 Vaughn Street.

*FRANK EDWARD JAGOZINSKI, B.S.E., *Instructor in Mechanical Engineering.*

RICHARD T. LIDDICOAT, B.S.E., *Instructor in Engineering Mechanics.* 605 Mary Court.

* Absent on leave, 1923-1924.

JAMES HALLETT HODGES, Ph.D., *Instructor in General and Physical Chemistry.* 720 Whaley Court.

WILLIAM HENRY EGLY, A.M., *Instructor in English.* 1208 Cambridge Court.

DONAT CONSTANTIN KAZARINOFF, Dipl. de l'Univ., *Instructor in Mathematics* 226 Observatory Street.

ALOYSIUS JOSEPH GAISS, A.M., *Instructor in Modern Languages.* 322 East Ann Street.

IVAN HENRY WALTON, A.M., *Instructor in English.* 1232 Prospect Street.

CHRISTIAN N. WENGER, Ph.D., *Instructor in English.* 1311 Wilmot.

ALBERT LORING CLARK, JR., B.S.E., *Instructor in Mechanism and Engineering Drawing.*

HORACE LUNDH OLSON, Ph.D., *Instructor in Mathematics.* 517 Linden Street.

GRANVILLE D. JONES, A.M., *Instructor in Mathematics.* 12 Huddy Road.

JAMES A. SALLADE, A.B., *Instructor in Mathematics.* 120 North Division Street.

JEAN PAUL COOLEY, Ph.D., *Instructor in Physics.* 820 Arch Street.

JAMES MERLE CORK, Ph.D., *Instructor in Physics.* 1034 East Huron Street.

FREDERICK CHARLES O'DELL, B.S.A., *Instructor in Architectural Drawing.* 1921 Berkshire Road.

ERWIN ERNEST DREESE, M.S., *Instructor in Electrical Engineering.* 1426 Brooklyn Street.

H. H. BRITTON, A.M., *Instructor in Modern Languages.* 1316 Volland Street.

THOMAS ALOYSIUS McGUIRE, A.M., *Instructor in Modern Languages.* 906 East Huron Street.

HARRY ANDREW REA, A.B., *Instructor in Machine Shop Practice.* 1236 Washtenaw Avenue.

ROBERT CARL COLE, B.Pd., A.M., *Instructor in Mechanism and Engineering Drawing.* 507 Walnut Street.

HAROLD J. McFARLAN, B.S.E., *Instructor in Surveying.*
414 Lawrence Street.

LATHROP CARLETON POPE, C.E., *Instructor in Structural Engineering.* 609 West Madison Street.

CARL LEONARD DAHLSTROM, A.M., *Instructor in English.*
1311 Wilmot Street.

JOHN COLLIN GENIESSE, M.S., *Instructor in Chemical Engineering* 323 Packard Street.

GEORGE GRANGER BROWN, M.S.E., *Instructor in Chemical Engineering.* 1057 Lincoln Avenue.

ANTHONY JOSEPH JOBIN, A.B., *Instructor in Modern Languages.* 1104 Prospect Street.

CLARENCE FRANK KESSLER, B.S.E., *Instructor in Mechanical Engineering* 947 Wall.

HAROLD ROBERT SNOW, Ph.D., *Instructor in Organic Chemistry.* 1113 Michigan Avenue.

STEPHEN STANLEY ATTWOOD, M.S.E., *Instructor in Electrical Engineering.* 1520 Cambridge Road.

JULIO BRUNO LUZUNARIS, B.S., *Instructor in Spanish.*
1027 East Huron Street.

EDWARD YOUNG, B.S.E., *Instructor in Surveying.*
414 Benjamin Street.

WILLIAM BIRGER ANDERSON, A.M., *Instructor in Modern Languages.* 1303 Geddes Avenue.

ARTHUR RAYMOND CARR, A.B., M.S.E., *Instructor in Chemical Engineering.* 619 Whaley Court.

DETLEV WULF BRONK, M.S., *Instructor in Physics.*
11 Ridgeway Street.

WENDELL MORRIS COATES, A.B., *Instructor in Mathematics.* 1318 Forest Avenue.

HERBERT ATHERTON FOWLER, (Detroit School of Design), *Instructor in Architectural Design.*
220 North Monroe Street, Dearborn.

LAWRENCE McKINLEY GOULD, A.M., *Instructor in Geology.* 1306 Washtenaw Terrace.

JOHN GRENNAN, *Instructor in Foundry Practice.*
716 West Washington Street.

LEWIS STEPHEN RAMSDELL, M.S., *Instructor in Mineralogy* 618 Church Street.

RUSSELL ALGER DODGE, M.S., (C.E.), *Instructor in Engineering Mechanics.* 333 East Huron Street.

EDWARD FULLER HOLDEN, M.S., *Instructor in Mineralogy.* 914 South State Street.

ANDREW LINCOLN MILLER, B.S.E., *Instructor in Electrical Engineering.* 507 Sauer Court.

EDWARD A. STALKER, M.S., *Instructor in Aeronautical Engineering.* 1103 South University Avenue.

ERNEST WILBY, *Instructor in Architecture.*
13 Cutting Apartment.

RUEL V. CHURCHILL, B.S., *Instructor in Mathematics.*
914 South State Street.

ORA STANLEY DUFFENDACK, Ph.D., *Instructor in Physics.*
1218 Willard Street.

HAL FREDERICK FRUTH, A.M., *Instructor in Physics.*
528 North State Street.

LAURICE LAIRD LOCKROW, A.M., *Instructor in Physics.*
612 Hill Street.

EDWARD JOHN MARTIN, M.S., *Instructor in Physics.*
820 Arch Street.

HEMPSTEAD STRATTON BULL, E.E., *Instructor in Electrical Engineering.* 617 East Liberty.

MAURICE BARKLEY EICHELBERGER, B.S. (M.E.), *Instructor in Mechanism and Engineering Drawing.*
419 Hill Street.

JAMES SHERMAN GAULT, B.S.E., *Instructor in Electrical Engineering.* 715 East Ann Street.

WILLIAM SCRIBNER KIMBALL, Ph.D., *Instructor in Physics.* 1014 Cornwell Place.

AXEL MARIN, B.S., *Instructor in Mechanical Engineering.*
513 East Huron Street.

MELVILLE BIGHAM STOUT, B.S., *Instructor in Electrical Engineering.* 1032 Vaughn Street.

CORNELIUS VAN EENENAAM, B.S.E., *Instructor in Civil Engineering.* 1037 Baldwin Avenue.

ROBERT D. BRACKETT, A.M., *Instructor in English.* 1301 Horman Street.

ROSWELL EARL FRANKLIN, B.S., *Instructor in Engineering Mechanics.* 734 Miller Avenue.

DONALD L. PERKINS, M.S., *Instructor in Shop Practice.* 1104 Forest Avenue.

RAYMOND MATHEWS, B.S.A., *Instructor in Architecture.* 848 Brookwood Place.

GEORGE MOYER BLEEKMAN, M.S.E., *Instructor in Geodesy and Surveying.* 611 Forest Avenue.

OSCAR BENJAMIN KLEIN, Ph.D., *Instructor in Physics.* 417 South Fourth Avenue.

CARLETON WATSON ANGELL, (Chicago Art Inst.), *Instructor in Freehand Drawing.* 627 Oakland Avenue.

FLOYD NEWTON CALHOUN, B.S., *Instructor in Mechanical Engineering.* 1511 Washtenaw Avenue.

LLOYD HAMILTON DONNELL, B.M.E., *Instructor in Engineering Mechanics.* 414 West Summit Street.

BERNARD FRANCIS DOSTAL, A.M., *Instructor in Mathematics.* 618 Church Street.

ALFRED GEORGE PELIKAN, A.B., *Instructor in Drawing.* 403 South Fourth Avenue.

JOHN WILFORD KENNEDY, M.S.E., *Instructor in Chemical Engineering.* 601 Catherine Street.

WILLIAM STUART HOUSEL, B.S., *Instructor in Civil Engineering.* 311 Thompson Street.

### Teaching Assistants

CATHERINE BORTIC HELLER, B.S.A., (Pratt Institute), *Teaching Assistant in Architecture.* 324 East Jefferson Street.

ROSEMARY LAWRENCE, *Teaching Assistant in Freehand Drawing.* Martha Cook Building.

BARRY LEWIS FROST, *Teaching Assistant in Architecture.* 909 East University Avenue.

MARY OLMSTEAD JOHNSON, *Teaching Assistant in Freehand Drawing* 516 Chubb Road.

FRANK CHATFIELD CUTTING, B.S.E. (Ch.E.), *Teaching Assistant in Chemical Engineering.* 727 South State Street.

FRANKLIN DAVIS JOHNSTON, B.S.E., *Teaching Assistant in Electrical Engineering.* 1335 Hill Street.

PETER EDWARD BRENDER, B.C.E., *Teaching Assistant in Mechanical Engineering.* 1327 Geddes Avenue.

WILLIAM FREDERICK MOORE, B.S.E., *Teaching Assistant in Mechanical Engineering.* 8 Geddes Heights.

EDWIN FROST SMELLIE, M.S.E., *Teaching Assistant in Mechanical Engineering.* 212 Summit Street, Ypsilanti.

LEAH JAMES WHITTON, *Assistant in Mechanism and Drawing.* 817 McKinley Avenue.

PAUL ALBERT SMITH, *Teaching Assistant in Geodesy and Surveying.* 410 North Thayer Street.

### Student Assistants

JULIAN ROBERT FELLOWS, *Assistant to the Assistant Dean.* 520 East Liberty.

MILDRED ELIZABETH FELLOWS, *Assistant to the Assistant Dean.* 520 East Liberty Street.

GERTRUDE E. MOHLER, *Assistant to the Secretary.* 1303 Wilmot Street.

EDWARD LAWRENCE KLINE, B.S.A., *Student Assistant in Architecture.* 608 East Madison Street.

GORDON AMMON SHEILL, *Student Assistant in Architecture.* 338 John Street.

RICHARD KIRKBRIDE AKIN, *Student Assistant in Chemical Engineering.* 1341 Wilmot Street.

EARNEST GOTTFRIED BRICK, *Student Assistant in Chemical Engineering.* 722 Monroe Street.

JAMES V. HUNN, *Student Assistant in Chemical Engineering.*

GARBIS PENIAMIN MECHIGIAN, *Student Assistant in Chemical Engineering.*

J. W. HOLLYWOOD MONAWECK, *Student Assistant in Chemical Engineering.* 301 North State Street.

WILLIAM A. MYERS, *Student Assistant in Chemical Engineering.* 727 South State Street.

EDWARD H. POTTHOFF, *Student Assistant in Chemical Engineering.* 1110 South University Avenue.

ELMER W. SCHOEN, *Student Assistant in Chemical Engineering.* 1513 South University Avenue.

RICHARD EMORY TOWNSEND, *Student Assistant in Chemical Engineering.* 715 Oakland Avenue.

ROBERT M. TRUE, *Student Assistant in Chemical Engineering.* 1511 Washtenaw Avenue.

PAUL S. CAULKINS, *Student Assistant in Civil Engineering.*

WILLIAM HARVEY CARY, JR., *Student Assistant in Civil Engineering.* 1106 Lincoln Avenue.

WALTER L. CAUSE, *Student Assistant in Civil Engineering.*

ARTHUR FRANKLIN CLOUD, *Student Assistant in Civil Engineering.* 548 South State Street.

FREDERICK JOHN HILDEBRANDT, *Student Assistant in Civil Engineering.* 721 South State Street.

CLEM GEORGE MERRIMAN, *Student Assistant in Civil Engineering.* 509 Sauer Court.

LLOYD FORREST RADER, *Student Assistant in Civil Engineering.* 519 Linden Street.

RUSSELL HYDER TRITES, *Student Assistant in Civil Engineering.* 807 South State Street.

JAMES E. WARK, *Student Assistant in Civil Engineering.*

JOHN ZIMMERMAN, *Student Assistant in Civil Engineering.* 630 Haven Avenue.

ERNEST JAMES ABBOTT, *Student Assistant in Electrical Engineering.* 1302 Packard Street.

CARL JULIUS ANDERSON, *Student Assistant in Electrical Engineering.* 118 North Ingalls Street.

EVERETT CHAPMAN, *Student Assistant in Electrical Engineering.* 818 Oakland Avenue.

WILLIAM MARTIN BORGMAN, *Student Assistant in Electrical Engineering.* 528 Packard Street.

LEWIS N. HOLLAND, *Student Assistant in Electrical Engineering.* 715 Monroe Street.

BIRDSAL E. BLANCHARD, *Student Assistant in Engineering Mechanics.*

RALPH J DOTY, *Student Assistant in Engineering Mechanics.* 921 Dewey Avenue.

RAYMOND C. GRIFFITH, *Student Assistant in Engineering Mechanics.* 826 Tappan Road.

FRANCIS OLIVER NICKLIN, *Student Assistant in Engineering Mechanics.* 1610 Geddes Avenue.

JOE F. VOTROBECK, *Student Assistant in Engineering Mechanics.*

FRANKLIN LELAND EVERETT, *Student Assistant in Engineering Mechanics.* 610 South Division Street.

THEODORE WILLIAM LEGATSKI, *Student Assistant in Engineering Mechanics.* 410 South Division Street.

WILLETT FRANK WEBER, *Student Assistant in Engineering Mechanics.* 321 South Division Street.

DONALD ALVA ZINN, *Student Assistant in Engineering Mechanics.* 721 South State Street.

FREDERICK LOUIS GREEN, *Student Assistant in Engineering Shops.* 327 South Division Street.

MAURICE CHARLES LIBERT, *Student Assistant in Engineering Shops.* 832 East University Avenue.

WILLIAM ALLEN SPINDLER, *Student Assistant in Engineering Shops.* 730 South Division Street.

CHARLOTTE C. HARRISON, *Student Assistant in English.* Helen Newberry Residence.

FLOYD GIFFORD ECKLES, *Student Assistant in Geodesy and Surveying.* 421 Benjamin Street.

FRED MARQUETTE FREEMAN, *Student Assistant in Geodesy and Surveying.* 1617 Washtenaw Avenue.

CURTIS LE FEVER, *Student Assistant in Geodesy and Surveying.* 1309 South State Street.

ROBYN DEWEY MERRIAM, *Student Assistant in Geodesy and Surveying* 953 Greenwood Avenue.

DANIEL J. MILLER, A.B., *Student Assistant in Geodesy and Surveying.* 818 Lincoln Avenue.

CHARLES ALBERT MILLER, *Student Assistant in Geodesy and Surveying.* 1217 Willard Street.

JOHN RICHARD POLHAMUS, *Student Assistant in Geodesy and Surveying.* 1232 Prospect Street.

WILLIAM KENNON SAUNDERS, *Student Assistant in Geodesy and Surveying.* 722 Dewey Avenue.

RILEY JACOB SIPE, *Student Assistant in Geodesy and Surveying.* 1207 Willard Street.

CHARLES B. COE, *Student Assistant in Marine Engineering.* 809 Kingsley Street.

EARL CLIFFORD FRIEL, *Student Assistant in Marine Engineering.* 408 South Fifth Avenue.

WILLIAM HOWARD AUBREY, *Student Assistant in Mechanical Engineering.* 816 Forest Avenue.

LOUIS GESS, *Student Assistant in Mechanical Engineering.* 712 East Washington Street.

CHESTER WINTHROP HASKINS, *Student Assistant in Mechanical Engineering.* 422 Cross Street.

BASIL RAYMOND KRITZ, *Student Assistant in Mechanical Engineering.* 826 Tappan Street.

PAUL DIXON PARKER, *Student Assistant in Mechanical Engineering.* 1217 Willard Street.

CHARLES FRANK POLLEN, *Student Assistant in Mechanical Engineering.* 301 East Liberty Street.

DEAN CAMPBELL SEITZ, B.S.M.E., *Student Assistant in Mechanical Engineering.* 1023 Oakland Avenue.

MAX ROBERT SCHRAYER, B.S.E., *Student Assistant in Mechanical Engineering.* 2006 Washtenaw Avenue.

CHARLES EDWIN SHEPHERD, *Student Assistant in Mechanical Engineering.* 1351 Washtenaw Avenue.

ARNOLD ELMER STOLL, *Student Assistant in Mechanical Engineering.* 1318 Forest Avenue.

ROBERT HOWLAND WATTLEWORTH, *Student Assistant in Mechanical Engineering.* 1824 Geddes Avenue.

JOHN WYLLIE, JR., *Student Assistant in Mechanical Engineering.* 1217 Willard Street.

GEORGE FRANCIS DURAND, *Student Assistant in Mechanism and Engineering Drawing.* 1010 Forest Avenue.

LAWRENCE STEPHEN FREEMAN, *Student Assistant in Mechanism and Engineering Drawing.* 810 East Washington Street.

VICTOR LEE KIRK, *Student Assistant in Mechanism and Engineering Drawing.* 1133 White Street.

ARTHUR HARRIS LINCE, *Student Assistant in Mechanism and Engineering Drawing.* 822 Arch Street.

EINAR MELVIN ORBECK, *Student Assistant in Mechanism and Engineering Drawing.* 314 East William Street.

LYLE STUART VAN ANTWERP, *Student Assistant in Mechanism and Engineering Drawing.* 606 Packard Street.

## STANDING COMMITTEE

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

## COMMITTEES, COLLEGE OF ENGINEERING

COMMITTEE ON CLASSIFICATION:
PROFESSORS A. J. DECKER, H. H. HIGBIE, C. H. FESSENDEN, H. L. CAMPBELL, C. E. LOVE.

COMMITTEE ON DELINQUENT STUDENTS:
PROFESSORS H. W. KING, L. M. GRAM, T. R. RUNNING.

COMMITTEE ON DISCIPLINE:
PROFESSORS A. H. LOVELL, G. W. PATTERSON, H. B. MERRICK.

COMMITTEE ON EXTENSION OF TIME:
PROFESSORS C. E. LOVE, E. L. ADAMS, ASSISTANT PROFESSOR V. C. POOR.

COMMITTEE ON HOURS:
PROFESSOR T. R. RUNNING, ASSISTANT PROFESSORS F. R. FINCH, O. W. BOSTON.

LIBRARY COMMITTEE:
PROFESSORS A. ZIWET, H. C. SADLER, T. H. HILDEBRANDT.

COMMITTEE ON SUBSTITUTION:
PROFESSORS B. F. BAILEY, E. M. BRAGG, A. O. LEE.

COMMITTEE ON CREDITS FOR MILITARY SERVICE:
PROFESSORS W. C. HOAD, A. H. LOVELL, A. E. WHITE, P. FIELD, G. M. McCONKEY.

# Colleges of Engineering and Architecture

## GENERAL INFORMATION

1. The University of Michigan is a part of the educational system of the State, and derives from the State the greater part of its revenue. The University comprises the Colleges of Literature, Science, and the Arts, of Engineering, of Architecture, of Pharmacy, of Dental Surgery, the Medical School, the Law School, the School of Education, the School of Business Administration, and the Graduate School, each of which publishes a separate annual announcement. The various Faculties include about six hundred officers of instruction, besides nearly one hundred assistants, some of whom participate in the work of teaching. Over 11,000 students, representing all the State and Territories and many foreign countries, are in attendance.

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

Instruction in Architecture was organized as a subdepartment of the College of Engineering in 1906. In

1913 the College of Architecture was given control of its courses of study, and, in general, charged with the administration of its affairs.

There are enrolled at present in the College of Engineering and the Graduate School 1678 students, pursuing work in different engineering lines. In the College of Architecture and the Graduate School there are 250 students of architecture.

The aim of these colleges is to lay a foundation of sound theory, sufficiently broad and deep to enable their graduates to enter understandingly on a further investigation of the several specialties of the engineering and architectural profession; 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 cooperate in every proper manner with the industries of the State.

---

### FIVE-YEAR PROGRAM

2. A fundamental revision of the courses of study in Engineering and Architecture has been considered for several years with the purpose of broadening the pro-

grams during the four undergraduate years and postponing part of the specialization to a fifth year of professional graduate study.

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

---

## THE ACADEMIC YEAR

3. The academic year extends from September 23, 1924, to June 15, 1925. The Summer Session, between the student's first and second, second and third, or third and fourth years, extends eight weeks, from Monday following Commencement, June 23 to August 15, 1924.

Copies of the University Catalogue describing the different Colleges and Schools, will be mailed by the Secretary of the University, on request.

---

## SUGGESTIONS AND DIRECTIONS

4. New students should plan to reach Ann Arbor about September 17, 1924, for the first semester, or about February 5, 1925, for the second semester, in order that such preliminaries as finding a room and boarding place may be settled before the opening of the regular session.

Students on arriving in Ann Arbor can obtain information in regard to rooms and board by calling at the office of Dean Bursley, Room 2, University Hall. His secretaries are actively interested in assisting newcomers

to find rooms and boarding places and conduct free employment bureaus for the benefit of students.

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

---

## ADMISSION

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

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

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.

---

## ADMISSION REQUIREMENTS

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

### Group I. Absolute Requirements—10 Units

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

### Group II. Alternative Requirements—1 1-2 or 2 Units

Chemistry ..... 1 unit
Trigonometry, Plane ..... ½ unit
Greek, Latin, German, French, or Spanish.....1 or 2 units
Manual Training ..... ½ or 1 unit

### Group III. Optional Requirements—3 1-2 or 3 Units

The remaining 3 or 3½ 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 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.

The most favorable combination of courses to offer for admission to the College of Architecture is 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.

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

Some modifications of the language requirement may be allowed in the case of students whose native tongue is other than English. These cases will be considered individually.

Under English are included Grammar, Composition, reading of English Classics, and History of English Literature. The History of English Literature may form part of the work of either the third or fourth year. Four units in English should always be presented whenever it is possible to do so.

Biology is defined at one-half year of Botany and one-half year of Zoölgy: hence Biology cannot be accepted from an applicant who offers at the same time a unit in either, or both, of those subjects.

## VOCATIONAL UNITS

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

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

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

**Drawing.**—1. *Free-hand Drawing.*—One-half unit allowed. The student should show that he can represent correctly in outline and in light and shade, geometric and simple natural or decorative form. Accuracy of proportion and perspective are essential. The pencil, charcoal, or brush may be used.

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

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

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

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

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

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

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

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

2. Forging, chipping and filing, sheet-metal construction, tool making, turning and spinning in metals.

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

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

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

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

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

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

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

---

## ADMISSION ON CERTIFICATE

8. Applicants presenting graduate certificates from any of the schools officially approved by the Committee

on Diploma Schools will be admitted without examination to the Colleges of Engineering and Architecture, if they are recommended by the principal of the school in the units required for admission.

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

It is recommended that graduates from preparatory schools enter at once. If they do not, they must present evidence that they are, at the time of admission, prepared to do the work of the Colleges. They must show satisfactory preparation especially in mathematics, in English, and in the modern language presented for admission. This preparation may be shown by certificates of work done since graduation, by examinations at Ann Arbor, September 15 to 19, 1924, or by attendance at the Summer Session, June 23 to August 15, 1924, with a satisfactory record in eight hours of work, a part of which must be mathematics.

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

Students, who for any reason have failed to secure certificate of graduation from an approved school and their principal's recommendation, will be required to pass the regular examinations for entrance in all subjects.

Those desiring to enter on certificate should present their credentials at Room 255, or for Architecture at Room 209, Engineering Building, not later than September 17, if desiring to enter the first semester, or February 5, if desiring to enter the second semester. It is better to mail the credentials, as long before these dates as practicable, for Engineering, to the Assistant Dean, or, for Architecture, to Professor E. Lorch. They will be examined, placed on file, and the applicant will be informed whether they satisfy the requirements or not. Certificates from schools other than those officially approved by the University do not excuse an applicant from the admission examinations.

---

### ADMISSION BY EXAMINATION

9. Before entering upon the examination, each applicant must present his credentials to the Assistant Dean of the College of Engineering at his office, Room 255, or, for Architecture, to Professor Lorch, Room 209, in the Engineering Building.

Specimen entrance examination questions are not furnished.

Fifteen units are required for admission. Eleven and one-half or twelve units are prescribed. The other three and one-half or three units may be presented in the subjects mentioned in § 6. In general, applicants will not be admitted with deficiencies in more than one and one-half of the prescribed units.

An outline of the preparatory work which a student should cover before presenting himself for examination in any one of these subjects is given at length in the University Catalogue. This will be mailed upon application to the Secretary of the University.

## EXAMINATIONS FOR ADMISSION

10. All examinations are held at the University. The principal examinations for admission to the Colleges of Engineering and Architecture will be held June 24-26, 1924, and September 15-19, 1924. Another opportunity is offered on February 5-7, 1925. Applicants will not be examined at any other time except on payment of a special fee of *five dollars* for examination in one or more subjects.

It is necessary for all applicants for admission on examination to present their credentials a day before the entrance examination to the Assistant Dean of the College, at his office, Room 255, or, for Architecture, to Professor Lorch, Room 209, in the Engineering Building, between the hours of 9 and 4, and receive from him papers admitting to 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.

*SCHEDULE OF EXAMINATIONS FOR ADMISSION, SEPTEMBER, 1924*

| | Monday Sept. 15 | Tuesday Sept. 16 | Wednesday Sept. 17 | Thursday Sept. 18 | Friday Sept. 19 |
|---|---|---|---|---|---|
| 8-11 | | Geometry | Algebra | History | English Composition |
| 1-3:30 | English Literature | Physics | Greek<br>German | French<br>Spanish | Botany |
| 3:30-6 | Zoology | Physiography<br>Geology | Latin<br>Physiology | Trigonometry<br>Introductory Science | Chemistry<br>Astronomy |

*SCHEDULE OF EXAMINATIONS FOR ADMISSION, FEBRUARY, 1925*

| | Thursday, Feb. 5 | Friday, Feb. 6 | Saturday, Feb. 7 |
|---|---|---|---|
| 8-10 | English Composition | Algebra<br>Trigonometry | Geometry |
| 10-12 | Botany | Physiography<br>Geology | Chemistry |
| 2-4 | History | Physics<br>Introductory Science | Latin<br>Greek |
| 4-6 | Physiology | French<br>German<br>Spanish | English Literature<br>Zoology |

The examinations June 24-26, 1924, will be given in the same order as in the February Schedule.

All examinations are held in Room 203, Tappan Hall.

## ADMISSION TO ADVANCED STANDING

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

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

The remaining requirements for students of Engineering can usually be completed in two years, if the student takes as electives, while an undergraduate,* the mathe-

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

matics 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 4a, 5a, 21, 22, and 23, and Architecture 1, 4, 5, 6, and 21.

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

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

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

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

An applicant must present a letter of honorable dismissal from college, an official copy of his college record, and an official record of his preparatory studies, similar to those required of students admitted on certificate. (See § 8.)

*c.* A student who has not completed a year's college work in an approved college, but before entering these colleges of the University has pursued studies beyond those required for admission, may be admitted to advanced standing. Entrance requirements in such cases may be satisfied by complying with the conditions stated in either § 8 or § 9.

*d.* All advanced credits are adjusted by the assistant dean 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 received for work done elsewhere or what class a student may enter after having attended another college for a specified time.

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

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

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

Applicants should apply in person at Room 255, for Engineering, and at Room 209, for Architecture, Engineering Building, upon entrance. It is desirable that credentials should be sent on in advance as much before these dates as practicable. Students desiring advanced standing in drawing must bring all drawings completed previous to entrance.

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

### ADMISSION FROM ALBION AND OLIVET COLLEGES

12. A combined course with Albion College has been arranged whereby a student may obtain the degree of Bachelor of Arts from that institution and the degree of Bachelor of Science in Engineering from the College of Engineering. The required work, covering a period of five years, is outlined in § 154. Students entering from Albion College will present a statement of their preparatory work, as well as a transcript of credits from that institution. Similar arrangements have recently been made with Olivet College. See § 155.

---

### ADMISSION AS GRADUATE STUDENTS

13. Higher degrees in Engineering and in Architecture are conferred in the Graduate School of the University. See University Catalogue and special announcement of the Graduate School.

---

### ADMISSION AS SPECIAL STUDENTS

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

Students over twenty-one years of age who wish to pursue particular studies in Engineering or Architecture, and who show by examination or by the presentation of satisfactory certificates that they are prepared to do good work in the selected courses, may be admitted as special students on the recommendation of the heads of the departments of instruction in which they wish to study. The object of this rule is to enable young men who are beyond the high-school age to secure technical training

along special lines when they are properly prepared for the work. Two or more years of successful experience as teacher, draftsman, surveyor, engineer, or operative in engineering works 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 letter 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 21 years of age; must have had two or more years of experience in architects' offices, or its equivalent, and must have a practical knowledge of architectural drawing. Special students who wish to pursue courses in advanced building construction must present the regular entrance requirements in mathematics.

Students who desire to pursue a special course in Architecture should write to Professor E. Lorch as early as possible in order to learn how best to prepare for the work they may wish to do here. They should spend some time in study parallel with their office work before taking up university work, thus to review or master essential preparatory subjects and again to acquire the habit of study, the loss of which in certain subjects is often a serious handicap to capable draftsmen otherwise well prepared to profit by some of the academic work. In general, a working knowledge of English, algebra, plane and solid geometry is required. Advanced credit can often be given such students for work done in the field and in offices.

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

Candidates for admission as specials 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 § 5 and § 6.)

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

---

## SUMMER SESSION

15. The Summer Session of the University of Michigan will open June 23, 1924. Work will be given in the Colleges of Literature, Science, and the Arts, of Engineering, of Architecture, in the Medical School, and in the Law School. The session will close August 15. A special Announcement can be had by addressing the Secretary of the University.

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

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

*Courses Offered.*—In the College of Literature, Science, and the Arts, the Summer Session affords opportunity for study in languages, history, mathematics, and the sciences. In the Colleges of Engineering and Architecture all of the courses in shop practice are offered, and a part only of those in English, modern language, mathematics, physics, chemistry, drawing, surveying, mechanics, civil engineering, mechanical engineering, electrical engineering, chemical engineering, and architecture. Students who wish to review studies or make up deficiencies, preparatory to presenting themselves for admission to the Colleges, will find courses directly adapted to meet their wants. Those with deficiencies are strongly urged to make them up before entrance, in order to be able to pursue the regular course.

*Courses Required.*—Regular students in the Colleges of Engineering and Architecture find it necessary to take certain prescribed courses during one Summer Session in order to complete the prescribed work in four years.

*Tuition Fees.*—In the Colleges of Literature, Science, and the Arts, of Engineering and Architecture, the tuition fee is $30, including fee for medical services. There is also in Surveying 3 a camp fee of $10.

## FEES AND EXPENSES

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

17. ANNUAL FEE.—In addition to the matriculation fee every student has to pay an annual fee for incidental expenses. For men, the annual fee in the Colleges of Engineering and Architecture is, for Michigan students, one hundred dollars; for all others, one hundred twenty-five dollars. For women these fees are five dollars less.

The fee for the second semester is sixty per cent of that for the entire year.

These fees cover class instruction, use of libraries, outdoor physical education and admission to all athletic events on Ferry Field, membership in the Michigan Union or Woman's League, as well as medical attention from the University health service and dispensary.

PART TIME FEE.—(*a*) Persons whose occupations are such as to afford them only a limited part of their time for study, but who are duly accredited for admission to any College or School of the University and who also give evidence of an interest in study wholly accordant with the purpose of the College or School to which they are accredited, may be admitted and may elect not more than five hours in any semester upon the payment of an annual fee of $25.

(*b*) Such students, if entering the University for the first time, must also pay the usual matriculation fee and they must understand that the part-time fee of $25 covers only the usual privileges of study and tuition. Michigan Union or Women's League membership, Outdoor Physical Education, and Health Service are not included.

A by-law of the Board of Regents provides that no student or graduate shall be allowed to enjoy the privilege of the University until he has paid all fees that are due.

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

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

19. GRADUATION FEE.—The fee for graduation is ten dollars, and the by-laws of the Board of Regents pre-

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

20. LABORATORY FEES.—Laboratory fees are abolished, but students in laboratory courses must make a cash deposit to pay for materials used and for breakage. *Camp Fee.*—A fee of *ten dollars,* in addition to the regular tuition for the Summer Session, is required of students who take Course 3 in Surveying. See § 15.

21. OTHER EXPENSES.—There are no dormitories for men and no commons connected with the University. Students obtain board and lodging in private families. Room rent varies from three to five dollars a week for each student. Board varies from five to six dollars a week.

22. ANNUAL EXPENSES.—The annual expenses of students, including clothing and incidentals, are, *on the average,* about seven hundred dollars. By the practice of strict economy, it is possible to complete the four-year course for two thousand dollars. Many students are enabled to complete their course by withdrawing for a year or two to earn money to carry them though the remaining years.

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

## REFUNDING OF FEES

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

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

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

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

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

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

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

---

## STUDENT EMPLOYMENT

24. The University does not undertake to furnish manual labor to students; yet a considerable number find

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

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

---

## FELLOWSHIPS AND SCHOLARSHIPS

25. There are several fellowships and scholarships in the Colleges of Engineering and Architecture. For details see §§ 132, 133, and 186.

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

---

## RELATION TO STUDENTS TO THE CIVIL AUTHORITIES

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

## THE MICHIGAN UNION

27. The University of Michigan Union was organized and incorporated under the laws of the State of Michigan in 1904, to establish a University social and recreational center; to provide a meeting place for faculty, alumni, former students and resident students of the University; to furnish a home for alumni when in Ann Arbor, and a place for wholesome relaxation for students, so that their leisure time, their amusements, and their student interests, through the medium of the University atmosphere of the Union, might become a component part of their education. The Union, furthermore, seeks to inculcate educational ideals through its student activities, for as a social center it encourages and stimulates activities that are for the welfare and enjoyment of the student body, and the result is a richer, more intense University life, a product of the students' own work. This develops group spirit, a sense of loyalty to the community served, pride in work accomplished, a widened circle of friends, and broadened experience and viewpoint in life. The Union, in emphasizing the social values of education, complements the work of the University in its endeavor to graduate broadly educated men and citizens.

The Union Building is exceptionally well appointed. Among its many attractions, the building provides 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 accommodating sixty-eight persons for the alumni and guests of members. The building is the headquarters and gathering place for students, alumni, former students and faculty.

The student annual membership fee is $6, fixed by the Board of Directors and by resolution of the Board of Regents adopted June 28, 1921. This fee is incorporated in the annual tuition of every man student of the University.

---

## UNIVERSITY HEALTH SERVICE

28. The University of Michigan is fundamentally interested in the health and physical welfare of its students. Adequate provisions are made for the care of ill students at the University Health Service which now occupies the annex to the Homœopathic Hospital. It is open at all hours of the day and night. The telephone number is 166 University Exchange.

**Dispensary.**—The Dispensary is open daily and students may receive free office medical attention and ordinary medicines. A student may consult any physician of the Health Service Staff at choice. Prescriptions are filled at the Health Service Pharmacy. If a student receives attention of a Health Service physician at his room, a charge of $1.00 for a day call and $2.00 for a night call is made. The corps of physicians in the Medical School co-operate with the Health Service whenever students need the attention of specialists. The Health Service is open to all students of the Summer Session, and for those remaining during the regular vacations.

**Dental Clinic.**—The dental clinic is open to students; the only charge benig for material used. Students are advised to have their teeth examined at least once a year.

**Hospital Care.**—Twenty-five beds are provided at the Health Service for the care and treatment of students who are ill, and for them hospital service is entirely free.

---

## FACILITIES FOR PHYSICAL EDUCATION

29. The University is provided with excellent gymnasiums. The Waterman Gymnasium for men has cost about $130,000. The main floor, which is a rectangle with truncated corners and dimensions of 246 by 90 feet, is well equipped with the various kinds of apparatus usually found in the best modern gymnasiums. A number of smaller rooms are devoted to administration, fencing, boxing, and other special purposes, while the basement is given up to baths, lockers, handball, and boxing. The main hall is lighted in the daytime by means of a large skylight 60 feet above the floor, and in the evening by electricity. A gallery makes room for an elliptical running track, ten laps to the mile, making it one of the largest gallery running tracks in the country.

All men entering the University for the first time are given a thorough medical and physical examination before University fees are paid. At this time also a measurement of various parts of the body is taken and plotted on an Anthropometric Chart, a comparison with the average measurements can be made in this way, and any existing abnormalities corrected. A second measurement is taken after class work is finished, in order to note what changes have taken place. Abnormal posture conditions are corrected, and special exercises for strengthening weak parts are given. Realizing the fact that most college men have inferior chest development, the character of the class work is arranged to overcome this condition. A mixture of both athletic and gymnastic

work is given, however, in order to produce variety and enthusiasm for exercise. An excellent outdoor elliptical board track, adjacent to the Gymnasium, has recently been installed, in order that outdoor exercise can be taken, especially during the periods when classes are being held, whenever weather conditions permit. Men qualifying for All-Fresh football, cross-country, hockey, track, basketball, and wrestling teams are given gymnasium credit, while these sports are in progress, after which they are transferred to the regular gymnasium classes. Arrangements for the exchange of this work must be made with the Director of the Gymnasium, otherwise no credit will be given.

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. Attendance twice a week is required of all first-year students of these Colleges. Classes begin the third Monday in October.

The Athletic Field, known as Ferry Field, comprising seventy-eight acres of land, has been set apart and equipped for outdoor sports of every kind. Several football fields and baseball diamonds, running tracks, soccer fields, indoor baseball diamonds, tennis courts and space for numerous other games afford possibilities for complete programs of Intramural and Intercollegiate Athletics. In addition to the playing fields there are a football stadium seating 42,000, a baseball stand accommodating 8,000, an excellent club house, and an indoor playground known as Yost Field House.

The Yost Field House provides accommodations for all kinds of athletics during the winter months when they cannot be conducted out of doors. The building is 342 feet long by 165 feet wide. It contains locker and shower facilities for 4200 and seats 12,500 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, several basketball courts and provisions for indoor practice in football and baseball. There are also provisions for handball and wrestling. All of which gives to Michigan a complete athletic plant that functions the year around.

---

## MILITARY SCIENCE AND TACTICS

30. 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 military forces of the United States. Courses are offered in Coast Artillery, in Infantry, in Ordnance, and in Signal Corps, 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.

The courses of the first four semesters of each unit comprise the Basic Group, and the courses of the last four semesters comprise the Advanced Group. Elections are for a period of four semesters; that is, for a complete Basic or Advanced Group. Once elected, a course becomes a prerequisite to graduation unless the student is formally discharged from this obligation. During the Advanced Course members of the R. O. T. C. receive payment of commutation of subsistence from the Government.

In each course, Basic and Advanced, there is summer camp of six weeks' duration. Attendance at the Basic Camp is optional, but 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. Arrangements have been made whereby a student of Aeronautical Engineering may take the regular course in any one of the units, except that, if physically qualified, he may take the advanced Air Service camp instead of the advanced camp of his own unit.

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

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

---

### THE ASSEMBLY AND MENTOR SYSTEM

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

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

As soon as a student enters the College of Engineering he is assigned to a mentor who is to be his faculty adviser throughout his college course, and definite arrangements are made for him to meet his mentor directly after the first assembley. Both socially and in his advisory capacity, moreover, the mentor is the personal representative of the Dean, so that each student may feel free to call on his mentor at any time with reference to any subject relating to his college life.

---

## THE HONOR SYSTEM

32. 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 the rules governing the system. 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, which 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. 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."

## WOMEN STUDENTS

33. All questions relating to the living conditions of undergraduate women students enrolled in the Colleges of Engineering and Architecture come under the jurisdiction of the Dean of Women of the University. Matters of scholarship and attendance are handled by Assistant Dean Patterson for Engineering and Professor Lorch for Architecture. Assistant Secretary Green acts as mentor for the women in Engineering and Architecture.

All women students of the University must make arrangements for their rooms through the office of the Dean of Women from which a list of approved houses may be obtained at any time.

---

## RULES GOVERNING ELECTION OF STUDIES

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

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

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

(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.

(i) Students 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.

---

**RULES RELATING TO EXAMINATIONS AND CONDITIONS**

35. The work of students must be arranged in conformity with the following conditions:

Examinations for admission are held before the beginning of each semester. (See § 9.)

An applicant who fails in some part of the admission examination may, at the discretion of the Faculty, be admitted conditionally, but the removal of entrance conditions shall take precedence of all other work. Any condition so imposed must be removed at one of the next two regular examinations for admission, but the Classification Committee is empowered and instructed to see to it that the students entering this college with conditions remove the same during the first semester of residence as far as possible.

No student who has an admission condition outstanding at the beginning of his second year of residence will be allowed to enter his classes until such condition 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.

36. At the end of each semester the quality of the work of every student in any course is reported by the instructor as A (excellent), B (good), C (satisfactory), D (passing), E (not passed), I (incomplete), or X (absent from examination).

The following regulations with respect to grades were adopted by the faculty of the Colleges of Engineering and Architecture April 3, 1922:

(a) That average semester grades and general average grades shall be computed for each student at the end of each semester and that these average grades shall be made a part of his permanent record.

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

(c) That the average grade shall be 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 of the courses considered.

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

(e) That when the average semester grade of a student falls below 1.6 he be automatically placed on probation.

(f) That students on probation may not elect less than 12 hours work.

(g) That when the average semester grade of a student on probation becomes 2.0 or more he be automatically removed from probation.

(h) That when the average semester grades of a student on probation falls below 2.0 he be automatically placed on the home list.

(i) That 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) That students having an average grade of less than 3.0 may not elect extra hours but students having an average of 3.0 or more may elect extra hours; the number of extra hours which such students may elect to be determined by the classifier.

(k) That insofar as practicable the average semester grades and general average grades of all students in the College be computed before the beginning of the College year 1922-1923.

(l) That this resolution shall become effective at the beginning of the College year 1922-1923 except that Article (d) shall apply

only to such students as matriculate subsequent to the date of passage of this resolution and be effective* with the class of June, 1926.

On January 25, 1923, it was ordered that for all work elected during the second semester of the college year 1922-1923 and thereafter the grade of D be considered a passing grade, the significance of the various grades becoming: A, excellent; B, good; C, satisfactory; D, passing; E, failure.

These changes in regulations as to grades do not affect grades of D (deficient) received in earlier semesters, and they remain subject to the regulations printed in the Announcement for 1922-1923. Deficiencies (D) incurred in February, 1923, must be removed before the beginning of the first semester of the year 1923-1924, otherwise the record is changed to E (not passed).

Students desiring to remove an entrance or other condition or to make up for absence from a semester examination must make application to the Secretary, who will furnish a blank form for presentation to the Instructor in charge of the examination. The blank when filled out must be deposited by the student with the Secretary within one week from the date entered upon it by the examiner.

An examiner may, at the supplementary examination, if showing warrants it, give a student an E, thereby making it necessary for the student to pursue the whole course anew.

The supplementary examination will be four hours in length, and will be held three times a year: on the last Thursday, Friday, and Saturday of the Summer vacation, on the first and second Friday afternoons and Saturdays after the Christmas vacation, and on the first and second Friday afternoons and Saturdays after the Spring recess.

* Amendment of April 28, 1924.

37. The regular examination in any course at the end of each semester is an essential part of the work of the course. Absence from examination is reported by the mark X placed before the letter A, B, C, D, or E, marking the grade of the student's work. This mark X means that the credit in the course is temporarily withheld. Any student absent from examination is required to report to his instructor as soon thereafter as possible. If a student presents a valid excuse for his absence, he may take the examination at one of the regular supplementary or semester examinations before the beginning of the next semester after his return. If the excuse is deemed unsatisfactory, the record shall be reported as E.

When a student has been prevented by illness or other cause beyond his control from completing any course, the mark I may be placed before the grade to denote that fact. This mark is to be removed in the same manner as an absence from examination X.

Students who present themselves for examination in any subject must present to the instructor in charge, at the time of the examination, a supplementary examination slip obtained from the Secretary.

Students having deficiencies in studies which can be taken during the Summer Session are advised to make up those deficiencies at that time and thus be enabled to devote their entire attention to the studies elected during the regular session.

---

## UNSATISFACTORY SCHOLARSHIP

38. The normal number of hours that students should carry each semester is between sixteen and eighteen. Students who have to do outside work to assist themselves through the University, are strongly recommended to elect a smaller number of hours than those above. In the

event that a student's grade for the semester is below 1.6, he will usually be put on probation. This means that his next semester's grade must be at least 2 or he must leave the University. Students who have been on probation twice, and subsequently fail to do satisfactory work, may be asked to leave the University, even though they have not been on probation for the semester immediately preceding. In all cases where failures occur which involve the penalties mentioned the student is given an opportunity to appear before the Committee on Delinquent Students to show cause why such action should not be taken.

---

## WITHDRAWAL FROM THE COLLEGES

39. 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.

# COLLEGE OF ENGINEERING

## DEPARTMENTS OF ENGINEERING

40. 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 wastes 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.

**Civil Engineering** deals especially with the design of static or stationary structures and is divided into several groups which take up the different classes of problems. These groups are:

*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, 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 and other forms of transportation; the location, construction, maintenance, operation, and also the history and economics of transportation systems.

*Sanitary Engineering,* which deals with the design and construction of water works, sewers, water purification and sewage disposal works and with all matters related to public sanitation. It offers many opportunities for advanced work and research along the line of prevention of disease by the proper construction and operation of engineering structures.

*Municipal Engineering,* which deals with the design, construction, and maintenance of paving, sewers, sidewalks, street drainage, waterworks, and other municipal public works, the laws controlling their construction and operation, the proper design and laying out of cities and villages, and the construction and regulation of street railways and other utilities.

*Highway Engineering and Highway Transport,* which deal with the administration, organization, and financing of highway improvements; the economics, design, construction, and maintenance of highways, roads, and pave-

ments; the properties and methods of testing of road and paving materials; and the economics, management, regulation, and methods of highway transport.

**Mechanical Engineering** is the branch of engineering which treats of heat, power, design of machinery, and the problems of the manufacturer. This field of engineering has developed very rapidly in recent years because of the growth of our manufacturing industries. Mechanical Engineering may be divided into the following groups:

*Steam Power Engineering* deals with the design, construction, and operation of the various forms of prime movers using steam as the motive power, and their application in the modern power house.

*Internal Combustion Engineering* considers the application of the gas, oil, and gasoline engine in the development of power. It includes the design, construction, and operation of the various forms of internal combustion engines, also the use of the various types of gas producers.

*Hydro-Mechanical Engineering* deals with the design, construction, and installation of the various forms of water turbines and pumping machinery.

*Heating, Ventilating, and Refrigerating Engineering.*—As the problems of heating and refrigerating are much the same, these are included under one head. This group of studies deals with the theory, design, and operation of heating, ventilating, and refrigerating plants. Special stress is laid upon the applications of heating and ventilation in architectural work.

*Automobile Engineering.*—The University of Michigan has a strategic location at the center of the automobile industry in this country, and a special group of

nine courses is offered in Automobile Engineering. These courses cover the general principles of operation, the theory and design of the engine and the other chassis units, and laboratory and road tests of the various component parts of the automobile or of the complete automobile itself. An exceptionally complete Automobile Laboratory offers opportunity for advanced Research Work.

*Industrial Engineering.*—This group of studies is provided for those who wish to prepare themselves for the business side of the manufacturing plant or who wish to follow the profession of production engineers.

*Machine Design.*—This group of courses is arranged for those students who desire to enter the general field of machine design either as technical designers or as manufacturers of general machinery.

**Electrical Engineering** is sub-divided as follows:

*Electrical Power Engineering* deals with the theoretical and practical phases of power generation, distribution, and utilization, together with the design and construction features of the apparatus applicable thereto, and among other specific applications is studied in its relations to electric railways, lighting, power plants, generators and motors, and the service of the public in its economic and ethical aspects. This training in the knowledge of the art enables men with engineering ability to profit by later experience, thus leading them to executive and technical positions in manufacturing and service corporations, to technical sales work and other kindred vocations.

*Electrical Communication,* dealing with the transmission of signals and of speech by electrical means with and without wires, includes telephony, telegraphy, electrical signalling, and radio communication. The training in

this branch consists in the application of fundamental principles to the problems of these specific branches, its object being to fit the student for ultimate success in technical or executive work. Graduates find a broad field of opportunity with the numerous operating and manufacturing companies of the communication industries.

*Illumination Engineering* 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 undergraduates in this branch of electrical engineering 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.

*Electrical Engineering Design* involves the use of fundamental theory as modified by the practical considerations of cost and properties of materials. The character of the work in the design courses is such that the student gets a good idea of the methods of attack used by designers. The intimate knowledge of the details of electrical apparatus gained in design work serves well to supplement the work of other branches of Electrical Engineering.

**Chemical Engineering** treats of the operations of those industries whose technology is based largely, or in part, on chemical processes. It arose as a separate division of engineering with the growth of the strictly chemical industries, as electrical engineering developed over a generation ago when electricity became industrially important. It is now recognized as one of the important

divisions of engineering. Some, among the many industries with which chemical engineering is concerned, are those producing iron and steel, copper, lead, aluminum, zinc, and other non-ferrous metals, alloys, graphite, carborundum and other electric furnace products, Portland cement, lime, gypsum plastics, heavy chemicals such as sulphuric, hydrochloric, and nitric acids, salt, soda, chlorine and bleaching powder, fuel gases, gasoline, lubricating oils and greases, vegetable and animal oils, soaps, paints and varnishes, tires and other rubber articles, glue, leather, starch, sugar, corn products, industrial alcohol, explosives, pyrexylin plastics, artificial leathers and silks, food products, paper, textiles, and other products too numerous to mention. Many manufacturing operations in industries not ordinarily considered as involving chemical processes fall within the field of the chemical engineer. The combustion of fuels, the heat treatment of metals and alloys, the preparation of water for potable and industrial use, and the inspection and control of numerous important raw materials are examples. The Chemical Engineer must be able to select special materials for his apparatus, to design equipment, to assemble equipment to form a plant, or to operate the finished plant. He must have a strong background of both chemistry and mechanical engineering. He is primarily a man who is concerned with the equipment, operation, or development of processes.

**Marine Engineering** embraces the design, construction, and operation of ships and other floating structures, and the machinery appertaining thereto, and to the auxiliary construction of drydocks and wharves.

**Aeronautical Engineering** embraces the general theory of aero-dynamics, the design and construction of airplanes, balloons, etc., and questions relating to engines and propellers for aircraft.

**Surveying,** broadly speaking, is the applied science which relates to the measurement of distance and the determination of direction for the purpose of establishing the relative position of points and places on or near the surface of the earth. Surveying was practiced in an elementary form before historical records were kept.

**Geodesy** connects surveying with astronomy. The word signifies the measurement of the earth. This is accomplished by combining astronomical and terrestrial measurements. Careful base-line measurement, extensive systems of triangulation, precise level circuits, and a study of topography and densities of earth masses, hydrography, tides and currents are all involved in a fundamental way. Geodetic experiments to determine the shape of the earth were made as early as 276 B. C. Geodesy, as we know it today, owes much to Newton, Laplace, Legendre, Gauss, and other mathematicians and scientists of the past few centuries.

There are four great branches of surveying. The first concerns those operations which underlie construction. Surveys of some kind must be made in connection with every building enterprise. In laying out extensive structures, such as long bridges, and in comprehensive municipal surveys a knowledge of geodetic methods is essential. Some acquaintance with the law is necessary where rights of way are to be determined or property boundaries defined.

Topographic surveying, the second branch, is a great independent field, although local topography must be determined preliminary to many kinds of development. Extensive topographic work is performed by the United States Geological Survey, the United States Coast and Geodetic Survey, and by the Corps of Engineers of the Army. Many municipalities are now interested in topo-

graphic surveys. Where such surveys cover a large area, geodetic principles must be applied.

The third branch of surveying concerns the legal and administrative principles relating to boundary surveying, the registration of land titles, land laws, and riparian boundaries.

The fourth, and probably the most universal branch of surveying, is that which relates to the location of boundaries, the placing of monuments, and the filing of permanent records, with notes, computations, maps, and diagrams. This kind of surveying is still in its infancy in our country. It is closely allied to the administrative or legal branch and must ultimately be supported by geodetic work. Every owner of land and every political division of the nation has an interest in boundary surveying. Many re-surveys must be made to correct errors that have accumulated in the past, and many others to restore monuments that have become obliterated.

**The Department of Engineering Research** was established by an act of the Regents in October, 1920. The purpose of this act was to establish a point of contact between the University and the technical and industrial interests in the State in the field of research.

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

---

## THE WORK OF THE COLLEGE OF ENGINEERING

41. The studies pursued in the earlier part of the course are practically the same for all engineering students. They comprise, in *Mathematics,* advanced algebra,

analytical geometry, and the elements of the differential and integral calculus; in *German, French,* and *Spanish,* the grammar, and reading of narrative prose and current scientific literature; in *English,* courses in literature, composition, and rhetoric; in *Physics,* mechanics, sound, light, heat, electricity, and magnetism; in *Chemistry,* the principles of inorganic chemistry; in *Drawing,* descriptive geometry; in *Shop Practice,* carpentry, pattern-making, and forging.

The more technical subjects follow in the latter part of the course. Some of these are of equal value to all engineering students, such as theoretical and applied mechanics, and the strength and resistance of materials. Other subjects are adapted to the special requirements of the several courses.

The general scope of the courses offered is shown in the following:

42. **English.**—The work in English is based on the assumption that the student of engineering and architecture needs to be able to speak and to write. It is further assumed that he needs, as a means of wholesome and sensible enjoyment, as well as a means of extending his fund of ideas, a real and intelligent interest in reading. The general courses have, therefore, naturally grouped themselves under two heads: those which aim to develop the student's ability to express himself (Courses 1, 1*a*, 2, 2*a*, and 3); and those which aim to deepen his natural interest in books, and to make him more discriminating and critical. The latter include Courses 14, 21, 22, 23, 24, 29, studies in prose fiction; Courses 25 and 26, studies in the drama; and Courses 27 and 28, reading in scientific literature.

There are, in addition to these general courses, a number of technical and special courses (Courses 4, 5, 6, 7, 8, 9, 10, 12), which have been designed to meet the particular needs of the engineering student, and Courses 16 and 17, which have been planned to aid the foreign student in his special problem.

43. **English for Foreign Students.**—Students whose native language is other than English are given special help in overcoming the handicap which their inexperience with the vernacular often puts upon them. All such students have laid out for them such a course in English, French, German, or Spanish as shall justify the modern language requirements for graduation. In the case of a foreign

student, English may be substituted for another modern language, the maximum assignment being 17 hours, and it is understood that English shall be continued until the English faculty is satisfied that a good working knowledge is possessed of both written and spoken English. The two special courses outlined in § 204 for foreign students can be taken throughout the first year, the work being specially planned to meet the requirements of individual cases. If on completing any of these special courses the student can satisfy the English department as to his pronunciation, his written idiom, and his ability to take dictation with reasonable accuracy, and if he is no longer hampered by his difficulties with English, he may be excused from the remaining special courses, provided that he take instead one of the regular composition courses offered for American students. This plan aims to economize the time and effort of the foreign student and to make sure that on graduation from an American university he may have a reasonable command of English.

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

The 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. This reading covers a large range of scientific subjects, such as chemistry, physics, geology, and mineralogy, as well as articles on more technical subjects, dealing with the various branches of engineering and architecture. Many students read, besides the work assigned for the classroom, scientific articles in the numerous German and French periodicals to be found in the University Library. This is of value to the student in the prosecution 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 are offered for the accommodation and benefit of students who have the time and inclination to carry their language work beyond the limits of the required courses.

The courses in Spanish are largely conversational, and some are specifically arranged to meet the demands of students looking forward to a professional career in countries where Spanish is the prevailing medium of communication, as in the Philippine Islands, the West Indies, Mexico, and the countries of Central and South America.

These courses include considerable practice in business forms and commercial correspondence. Opportunity for advanced work in Spanish is offered to students who desire to make themselves specially proficient in this language.

45. **Mathematics.**—The required work is the same for all students of engineering, except students of chemical engineering, and extends throughout the first two or three years.

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

The first year is devoted to trigonometry, advanced algebra, plane and solid analytic geometry, the second to differential and integral calculus, including an introduction to the solution of differential equations.

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.

46. **Physics.**—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 magnetism, 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.

47. **Chemistry.**—Engineering students who present an approved unit of chemistry for entrance are required to take only one course in chemistry. An examination for admission to advanced standing will be required of all students who present admission units derived three or more years prior to the date at which admission is sought and in other doubtful cases. This course covers briefly, by lectures with demonstrations, recitations, and laboratory exercises, the important facts regarding the metallic and non-metallic elements. Due regard is given to the theory of chemistry and the method of scientific reasoning. In the course some of the methods of qualitative analysis are developed. Additional courses in analytical, theoretical, and organic chemistry are required of chemical engineering students and may be elected by other engineering students.

48. **Astronomy.**—A short course is required of civil engineering students, including the elements of General and Spherical Astronomy. Special attention is given to the use of the Ephemeris, to the conversion of time, and to the theory of the problems which occur in engineering practice, such as determination of time, latitude, longitude, and azimuth.

Other elective courses provide for Observatory work with the sextant, transit, meridian circle, equatorial, and other instruments, in which students make complete series of observations and reduce their own data. There are also advanced courses in Practical Astronomy, Theoretical Astronomy, Celestial Mechanics, and Astrophysics.

A course in Navigation is also given in Astronomy 22.

49. **Geology.**—The civil engineering students are required to take a brief course in Physical Geology. This course is given under the title of Geology 3 and is a general course leading to an understanding of the principles of Physical Geology. This course is given each semester.

50. **Drawing.**—Courses 1, 2, 3, and 4 carry the student through the subjects of elementary mechanical and machine drawing, descriptive geometry, drafting room practice, and mechanism. The course Drawing 1 is in advance of high school drawing and is intended to acquaint the student more thoroughly with the principles of orthographic projection, the making and reading of simple and elaborate drawings, the theory of proper dimensioning and sectioning, the making of tracings, and the photographic reproduction of pencil and ink drawings and tracings. Some manual facility is acquired in this course, but this is not its primary purpose.

Drawing 2, Descriptive Geometry, is a course dealing with problems on the point, line and plane, surfaces and solids, is given in the second semester, and has for its purpose the development of that capacity essential in an engineer for visualizing objects undesigned, unmade, or not at hand, and the ability to reason clearly and logically, another absolute essential to an engineer.

Drawing 3, Mechanism and Sketching, is a course in sketching where some attention is paid to the mechanisms, etc., peculiar to the various subdivisions of the profession of engineering; that is, civil, electrical, mechanical, etc. This course includes likewise training and instruction in isometric and oblique or cabinet perspective and further work in the rapid and accurate reading of drawings.

Drawing 4, which has for its prerequisites Courses 1, 2, and 3, covers the elements of mechanism. This includes instruction in the principles and elements of mechanism, the geometric analysis of mechanisms, the history of the development of the various elementary mechanisms, and finally the synthesis of mechanisms. The purpose of

this course is to acquaint the student first with the elementary principles over which machines are properly designed, the purposes of the various elementary mechanisms, for example, cams, gears, levers, etc., how to analyze existing compound mechanisms or combinations of simple mechanisms in the form of machines, tracing the transmission of power and motion from the driver to the driven or to the ultimate accomplishment of the machine, and finally, the development, at least to a certain degree, of some ingenuity in combining the various elementary mechanisms into a machine for the accomplishment of a certain purpose.

These four courses have been arranged for the first four semesters of the four-year curriculum in order that they may form a continuous chain of instruction that will, first, be of the maximum assistance to that large percentage of students who do not continue longer than from one to two years, and second, will 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.

Instruction is also given in free-hand drawing, topographical drawing, statistical charting, patent office drawing, and the application of descriptive geometry to the solution of problems in shades, shadow, and linear perspective and stone cutting. A long sought aim of the Department has been realized in the last year in the reduction of its classes to 15 men or less. This gives the opportunity of that personal contact and acquaintance between the instructor and his students that is of so great value. The work is conduced in well-lighted and well-equipped drafting rooms, and all accessory facilities essential to the proper teaching of the subjects named are available.

51. **Shop Practice.**—During the last two years the various courses in shop work have been completely revised. At the present time there are courses in the specific subjects for the students of the Colleges of Engineering, and Dental Surgery and the School of Education. Each of these courses is designed to serve the individual school or college.

The object of the courses for engineering students is primarily to acquaint them with modern methods, appliances and fundamental principles. This has very largely supplanted the idea of manual training. The courses of instruction are divided into classroom or recitation periods in which texts, notes, lectures, lantern slides, etc., are used, and laboratory periods which begin with a series of standard exercises, designed to give familiarity with the common tools and machines used in the particular branch of work being pursued. The student thus becomes fitted to execute an ordinary piece of mechanical work by making applications of the principles discussed in

the classroom and at the same time acquires familiarity with sources of information bearing upon such work.

As occasion permits trips through industrial plants supplement laboratory work to acquaint the students with the commercial application of the courses.

*Wood Shop Practice.* After the preliminary series of graded exercises involving wood, wood-working tools and machines is completed, the student is assigned elementary pattern work. Special emphasis is placed on this part of the course which consists of about three-fifths of the semester. The student shapes, forms and builds up patterns for castings in iron and brass, also core boxes, and is made as familiar as possible, in the time allowed, with all the details of the practice. Pattern making and its relation to foundry practice is studied further in the foundry.

*Metal Working.* The instruction given in the Forge Shop consists of a study of the principles applied to the hot and cold working of metals, the heat-treatment of steel, the welding and cutting of metals; and the application of these principles through exercises. Demonstrations are given by the instructors on the practice which is under consideration. In addition to the class room work, the students become acquainted with the properties of metals by performing the various operations on the work assigned.

*Foundry.* In the foundry course a study is made of the processes for producing gray iron castings, malleable iron castings, steel castings, copper castings, aluminum castings and other non ferrous castings. Special consideration is given to the principles involved in the melting processes, the mixing of metals, the compositions and properties of cast metals, the making of cores and molding practice. The work which is done in the foundry is arranged to demonstrate the principles which are considered during the class periods. The castings which are produced are used in different departments of the University. In this course, the engineer learns that foundry practice is one of the important factors to be considered in the design of metal castings. A well equipped metallurgical laboratory is provided for control and research purposes.

*Advanced Foundry.* For those students who are especially interested in the foundry branch of engineering, advanced foundry instruction is offered on special research problems. This subject may be elected as Shop 3*a* for two or more hours.

*Machine Shop Practice.* This course embraces machine shop practice and elements of production. There are class periods and laboratory periods, the former devoted to assignments from a text and manual, illustrated lectures and discussions. The class periods

treat of industrial organization and its object, general and cost accounting and how they serve manufacturing divisions, stock or material control from the rough through the production departments to the finished product, standardization of labor, machines, tools, etc., including time study and wage payment plans. They also cover principles underlying the cutting of metals in the various types of machines and include forms of tools, heat treatment, speeds, feeds, lubricants, etc.; also machines and processes such as lathes, millers, drill presses, broachers, grinders, gear cutters, automatics, die casting, punch presses, etc., and the use of each type, as well as jigs and fixtures, measuring instruments and gages, etc.

The standard exercises, making tools or repair parts involving turning, boring, drilling, reaming, cutting tapers, cutting gears, broaching, etc., come under the first part, while the manufacture of several complete articles in quantities under standardized conditions is the second part, the purpose of which is to give the student a comprehensive conception of the manufacture of complete units by the modern method. This involves the work-ticket, stock-records which are kept by students, time- and motion-study, jigs, fixtures, gages, etc., and a form of planning department.

*Advanced Machine Shop Practice* (*Course 4a*) may be elected to suit individual requirements. In this course special topics incidental to machine shop practice, such as shop administration, technique of processes or advanced tool room work are included. The new shops and equipment offer excellent opportunities for those interested in research.

*Pattern Making.* In this course is taught the shaping and construction of wood and metal patterns for both iron and non-ferrous metals. Shrinkage and its prevention, draft, shape, partings, straining of molds, etc., are treated.

*Jig and Fixture Design.* This course consists of drawing periods, supplemented by assignments treating of the principles underlying the design, construction and application of such accessories to manufacture. Frequent trips to manufacturing plants are included.

*Foundry Costs and Organization.* Study is made of cost systems used in the casting industry. The use of standard instructions and records in the foundry are considered.

*Standardization of Labor.* This course treats of employment, wage payment in relation to standardized conditions and the position of labor in manufacture.

A description of the engineering shops is given in section 112, and of the shop courses in section 220.

## 52. Geodesy and Surveying.

GROUP I. ELEMENTARY SURVEYING.

Surveying 1 and 2 are prescribed for students of Geodesy and Surveying, Civil Engineering and Landscape Design. Courses 1 and 2 are given on the campus, while Course 3, which follows in sequence, is conducted at Camp Davis during the Summer Session.

Surveying 1 and 2 cover the fundamental theory, with sufficient field work to illustrate lectures and text and to familiarize students with the common surveying instruments. The subjects covered by Courses 1 and 2 are given in logical sequence. Particular attention is given to neat, full, and accurate field notes and to their orderly reduction.

Surveying 3, at Camp Davis, gives students opportunity to engage in more extensive surveys and to become accustomed to field conditions. The equipment for Course 3, in addition to transits, levels, and the usual accessories, includes a mean time chronometer, sextants, triangulation transits, instruments for use in making adjustments, invar tapes, a launch and a number of row-boats. Office buildings are provided for housing field data, for mapping and for computations.

Surveying 4 is required of all students of engineering excepting those pursuing work in Geodesy and Surveying and Civil Engineering. The student is given an elementary introduction to the use of the transit and level, brief instruction in fundamental theory and in the keeping and reduction of simple field notes.

Surveying 5 embraces the theory of least squares as applied in geodetic and surveying enterprises. The theory is applied to problems that are familiar to the student.

Surveying 7, Municipal Surveying, is offered as an advanced course for all students who have completed Courses 1, 2, and 3. It comprises lectures, text, field and drawing room work, street surveys for the following purposes: location, fixing grades, paving, sewers, curbs, and minor details, the location of property lines and the planning and laying out of new subdivisions and additions. Special attention is given to the state laws governing surveys of this nature.

Surveying 9, Railway Surveying, may be elected by students who have completed Courses 1, 2, and 3. The course embraces the theory and practice of easement curves, turnouts, track problems, with exercises in location and re-location.

Surveying 12 and 13 run parallel with Courses 1 and 2, excepting that they cover slightly more ground. They are designed especially for students of Forestry.

GROUP II. TOPOGRAPHY.

Surveying 21, Photography and Camera Surveying, embraces a brief history of photography, the design of the dark room and its equipment, the testing of lenses and cameras, developing plates, making prints, lantern slides and enlargements. Students are given a brief introduction into the application of photography in topographic surveying. The prerequisites are Courses 1 and 2 or 12 and 13 in surveying.

Surveying 22. Advanced Topographic Surveying, introduces topography as a special field. The methods of several branches of the government service are followed. The purposes for which topographic surveys are made are analyzed and special attention is given to uniform scale of maps, and connection with existing land surveys and triangulation stations. The course connects fundamental theories and processes covered in more elementary courses.

Surveying 23, Map Projections and Sketching, deals with the various systems employed in the preparation of maps by several departments of government service. Special attention is given to the polyconic system of projection. Topographic sketching is included in this course.

GROUP III. ADMINISTRATIVE.

Surveying 31, History and Organization of Administrative Departments. This course deals with the history, organization and policies of several branches of the National Government which have been and are responsible for extensive surveys.

Surveying 32, Land Law, relates particularly to the elementary phases of the Common Law defining property interests in real estate.

Surveying 33, Land Law, is a continuation of Course 32.

Surveying 34, Registration of Land Titles, deals with such legislation as the Torrens Act and various modifications thereof.

Surveying 35, Boundary Surveys, deals with the detail problems of the man in the field, such as directions, monuments, witnesses, bearing marks, old boundary lines, re-surveys, meander posts; also the interpretation of real property descriptions in deeds and public records. Special consideration is given the modern methods pursued by the General Land Office in re-surveys.

Surveying 36, Riparian Boundaries, deals with the boundary lines where lakes and rivers intervene. The Common Law Rules are compared with the principles in force in countries which have developed different regulations relating to water and land boundaries.

GROUP IV. GEODESY.

Geodesy 1 relates to the history of the science, its application to determine the shape of the earth, and its value in connection with extensive surveys.

Geodesy 2 is largely a reading course covering the operations of the Coast and Geodetic Survey and like surveys authorized by other governments.

**53. Military science.—**

MILITARY SCIENCE—COAST ARTILLERY. The first year, which is common to all branches, includes an average of one hour's drill per week, and either two hours' practical instruction in rifle marksmanship or an hour's recitation on elementary military subjects. The last three years include both theoretical and practical work which will enable a student to became proficient in operating heavy artillery and in handling men.

MILITARY SCIENCE—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.

MILITARY SCIENCE—ORDNANCE. After the first year, which is common to all branches, the student receives instruction in all types of artillery and ammunition. 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.

MILITARY SCIENCE—SIGNAL CORPS. After the first year, the student receives such instruction as will tend to make him expert primarily in communication work.

**54. Engineering Mechanics.**—A course of four recitations a week is devoted to the elements of applied mechanics and is required of all students in Engineering. Thorough drill is given in the fundamental principles of mechanics, especially statics, by analytical and graphical methods, centers of gravity, moments of inertia, friction, shear and bending-moment.

This general course is followed by three courses along special lines of mechanics—(1) dynamics of moving bodies and machinery, including practical illustrations with apparatus in vibration, balancing and gyroscopy. (2) Strength and elasticity of materials with laboratory illustrations. (3) Hydromechanics with a demonstration room, in which are shown the fundamental principles of flow in channels, through pipes and orifices; preparing the student for further study of the science of hydraulics in its application to water-power development and hydraulic machinery.

For students who wish to do further work in engineering mechanics other courses of a more advanced nature are offered as electives.

**Testing of Materials.**— The courses in testing of materials include the use of the laboratory and the testing machines for commercial and other tests of cement, concrete, wood, steel, and other structural materials. Special stress is laid on the importance of careful study and full written discussion of results of all tests, and much time is spent in studying the published results of other investigators. Tests made for private individuals, in reinforced concrete, steel and special alloys, afford occasional opportunities for research along these lines. The course affords the student an opportunity to learn the use of instruments for measuring the strain in any type or part of a structure, from which computations of stress can be made.

Advanced courses, primarily for graduates, are given in Engineering Mechanics, particularly in research work. (See Announcement of Graduate School.)

55. **Structural Engineering.**—Course 2, Theory of Structures; Course *2a*, Elementary Design of Structures; Course 3, Masonry including reinforced concrete, are fundamental courses required of all civil engineering students. They cover the theory, design and construction of the simpler types of structures.

Advanced courses covering the theory, design and construction of the more complicated structures are offered in Course 4, Advanced Theory of Structures; Course 5, Design of Structures; Course 7, Advanced Design of Structures. These courses are open only to senior and fifth-year students.

Course 65, Structural Engineering Research, is open to graduate students and fifth-year students who have taken prescribed courses in the structural group.

Courses in testing materials, metallography, and political economy are open to students electing the structural group.

56. **Hydraulic Engineering.**—Course 10, which is required of all Civil Engineering students, includes three or four exercises in gauging the flow of the Huron River and practical problems in preparing continuous records of stream discharge. It also covers the theory of the measurement of water, the relation of precipitation to run-off; the effect of seepage, evaporation, and temperature on run-off; fluctuations in discharge of streams; the storage of water; the mass curve; and the study of floods. Course 11, an advanced course in hydraulics, is required only of students taking the hydraulic group.

These fundamental courses are followed by Course 12, Development of Water Power; Course 14, Irrigation and Drainage; Course 16, Design of Hydraulic Structures; and Course 18, Rivers and Harbors.

Fourth and Fifth-year students electing these courses may, if they have completed the prerequisites, elect work in the Mechanical and Electrical Departments dealing with water turbines, pumps, and electrical machinery.

Special courses for graduate students are offered as follows: Course 61, Irrigation and Drainage; Course 62, Advanced Hydraulic Design, and Course 64, Hydraulic Engineering Research. Considerable latitude in the line of investigation to be followed is allowed in these courses.

57. **Transportation Engineering.**—Course 20, Railroad Location, and Course 23, Railroad Design, are open only to students of the College of Engineering. Course 21, Railroad Engineering, is designed for both students of the College of Engineering and students in the Railroad Administration Course in the Department of Economics, and takes up the subjects of location, design, construction, and maintenance of track and structures in a less technical way.

Course 22, Transportation, is designed for both students of the College of Engineering and students of the Railroad Administration course and treats of the history and economics of the various methods of transportation.

None of the work in the Railroad Transportation group is required of all students.

58. **Sanitary and Municipal Engineering.**—Course 30, Water Works, deals with the general problem of supplying water of suitable quality and sufficient in quantity for all the various municipal uses, and is required to be taken by all Civil Engineering students. It is logically followed by Course 31, Water Purification, which treats fully of acceptable methods and devices for improving the quality of waters intended for municipal supplies.

Course 32, a first course in sewerage, deals with the general problem of the sewerage and drainage of urban areas, and is a required course for all Civil Engineering students; while Course 33, Sewage Disposal, treats of proper methods of disposal and deals with various processes and devices for the purification of sewage.

In Course 35, Sanitary Engineering Design, the classroom courses are supplemented by lectures and problems and drawing-board work in the designing of structures related to sanitary engineering. Course 34, Municipal and Industrial Sanitation, considers briefly the great body of observed data and other facts upon which the practice of public sanitation is based. Course 36, Municipal Engineering, covers the subjects of street cleaning, the collection and disposal of garbage and other city wastes, and certain other administrative problems properly belonging to the city engineering office. Course 26, Engineering Contracts and specifications, rounds out the program with a consideration of the duties and responsibilities of the city engineer in his relation to public works contracts.

Opportunities for graduate study in the purification of water and sewage and in certain other lines of investigation related to public sanitation are afforded by the Sanitary Experiment Station and the facilities offered in the Engineering Library. § 200.

**59. Highway Engineering and Highway Transport.**—Course 40, Highway Engineering, which treats of the fundamentals of economics, administration, legislation, preliminary investigations, highway transport surveys, economic design of highways, and the construction and maintenance of the different types of roads and pavements, is required to be taken by all Civil Engineering students. Course 41, Highway Engineering Theory and Economics and Highway Transport Surveys, is the theory course in this group. In Course 42, Highway Engineering Laboratory, the various non-bituminous and bituminous materials used in the construction and maintenance of roads and pavements are studied in the laboratory. Course 43, Highway Engineering Design, covers design problems pertaining to roads and streets and discussions of field methods of reconnoisance and surveying, and office methods used in mapping, estimating, and recording. Course 44, Highway Transport Economics, Methods, Legislation, and Management, treats of the fundamentals of the transportation of passengers and commodities over highways.

Students electing the highway engineering and highway transport group in the senior year are advised to elect, in addition to the above courses, as many courses as practicable from the following group: Civil Engineering 22, Transportation; Civil Engineering 26, Specifications and Contracts; Civil Engineering 27, Public Utility Problems; Mechanical Engineering 29, Automobiles and Motor Trucks; English 6, Report Writing; Political Economy 1E, Elements of Economics. Students electing the highway engineering and highway transport group, and who have obtained the written approval of the Professor of Highway Engineering and Highway Transport, may elect for credit not more than two of the graduate short period courses.

Special opportunities for graduate work in highway engineering and highway transport are offered through the medium of Civil Engineering 66, Highway Engineering and Highway Transport Research, and the graduate short period courses in highway engineering and highway transport, Civil Engineering 67 to 83, and Mechanical Engineering 40, which are given during the months of December to March, inclusive.

**60. Steam Power Engineering.**—Course 9 is required of all mechanical engineers, and includes lectures and text-book work covering the theory, economics, design, and construction of steam power plants. This course is followed by Course 9*a*, in which the student designs a power plant to fit the need of a special problem assigned to him. In this group are included Courses 11 and 11*a* in the design and construction of steam boilers; Course 12 and 12*a* in the design of reciprocating engines, and Course 13 in steam turbines. Courses 20 and 20*a* consider the problems involved in the handling of coal and ashes in power house design.

Special courses are offered in the laboratory in the experimental examination of power plant equipment to determine its operating efficiency.

61. **Internal Combustion Engineering.**—All Mechanical Engineering students are required to take Course 5, which deals with the laws of thermodynamics underlying the principles of the internal combustion engine as a heat engine, and Courses 2 and 6, in which are taken up the fundamental laws of the design of machine parts. This is followed by Course 15, which covers the theory, design, and construction of various types of gas, oil, and gasoline engines, and their auxiliaries; and by Course 15*a*, in which the student designs a standard type of internal combustion engine. The methods of testing of internal combustion engines are studied in Courses 7 and 8. The theory, design, and testing of automobile gas engines are taken up in Courses 29, 30, 30*a*, and 32.

Students, especially graduates, engineers with several years of experience, and officers of the army or navy who desire to do research work in any branch of internal combustion engineering are offered an opportunity in Courses 37, 38, and 39.

62. **Hydro-Mechanical Engineering.**—Course 4, which is required of all students of Mechanical Engineering, takes up in a general way the theory, design, and operation of all principal hydraulic machines, particularly water turbines, centrifugal pumps, and reciprocating pumps.

Course 4 may be followed by Course 17, in which the complete theory of reciprocating and centrifugal pumps is given. In Course 17*a* the student may design either a centrifugal pump or a reciprocating pump.

Course 16 covers the theory of water turbines. In conjunction with 16, students may take 16*a*, in which they design a water turbine.

Course 23 offers the students an opportunity for advanced laboratory work and post-graduate students a chance for research work in hydro-mechanical engineering.

Students who desire to specialize further in hydro-mechanical engineering can take suitable courses in hydraulic engineering offered in the department of Civil Engineering, and also courses in Electrical Engineering.

63. **Heating, Ventilating, and Refrigerating Engineering.**—Course 25 is a general course in heating and ventilation in which the design, construction, and operation of the various types of heating and ventilating plants are considered. Course 25*a* takes up the design and construction of complete heating systems.

The laboratories are equipped with special machines for the investigation of some of the more important problems in heating and ventilation.

The theory and construction of refrigerating plants is given in Course 19. The laboratory is equipped for special research work in refrigeration.

64. **Automobile Engineering.**—A series of eight courses is given in Automobile Engineering: One general course, five design courses, and two laboratory and road testing courses. Course 29 is a general course covering the fundamental principles of automobile operation and design, and their application in current automobile practice. This is followed by Courses 30 and 30*a*, which cover the theory and design of the engine, and Courses 31 and 31*a*, which cover the theory and design of the automobile chassis. In these courses the students make calculations and complete designs for the principal automobile units. Course 32 includes experimental laboratory and road study of modern automobiles and their component parts, including engine tests, transmission tests, and road tests upon the complete automobile. Course 33 is an advanced course in automobile testing and research, covering special problems involved in some automobile unit or in the complete automobile. Course 34 affords an opportunity for advanced design and research upon special critical problems in the design of some automobile unit or of the complete automobile or motor truck. Course 41 is seminar work taking up current topics.

65. **Industrial Engineering.**—The general subject of shop management is given in Course 35. This course includes both the theory of the subject and experimental work in the University shops, including motion study. Course 36 is a continuation of Course 35, and may be followed by a research course 42. Courses 20 and 20*a* on material handling machinery, and Course 43 on factory transportation may be elected in this group. There are also special courses in the Economics department in Business Administration which are closely associated with the engineering courses, and these courses are taken by students doing special work in these lines.

66. **Dynamo-Electric Circuits and Apparatus.**—Five courses are offered, three of them designed for students who are candidates for a degree in Electrical Engineering, and two for other students. Courses 2, 3, and 4 are required for candidates for the electrical degree and cover, respectively, the principles and practical calculations of circuits and machines using direct-current electricity, the principles and practical calculation of circuits carrying alternating current electricity, and the operating characteristics of alternating current machinery. These courses in fundamental principles are followed for students in electrical engineering by more advanced courses, some required and some elective. Courses 2, 3, and 4 form a close knit group and should be taken in close sequence. Courses 2*a* and 3*a*, the former prescribed and the latter elective for students other than candidates for a degree in electrical engineering cover together in a brief fashion about the same ground as Courses 2, 3, and 4, the

emphasis being placed perhaps more on the applications than on theory. Course *2a* covers circuits and machines using direct current and circuits carrying alternating current, together with a brief study of the characteristics and applications of alternating current machines. Course *3a* is devoted to a more thorough study of characteristics and applications of machines using alternating current. A non-electrical student thus receives thorough but by no means exhaustive instruction which should equip him with at least rudimentary training in the application of electrical principles to his specialty.

67. **Design of Electrical Machinery.**—Two courses in electrical design are offered. It is not possible nor is it desirable to try in these courses to turn out finished professional designers. The courses are intended to do two things: First, to clarify and fix the student's knowledge of dynamo machinery by means of calculations applied to actual machines. Second, to induce him to think as an engineer, rather than as a physicist, by imposing upon him the limitations encountered in practical work, by making him consider factors of cost of materials, possibility of economical manufacture, physical limitations of the materials used, the possibility of selling the machines at a profit, etc. Course 5 deals primarily with direct-current apparatus, Course 6 with alternating-current machinery.

68. **Power Generation, Transmission, and Distribution.**—In courses 11, 19, and 20 effort is made to apply fundamental economic principles to the selection and location of standard apparatus, including the financial phases of design, and to cultivate an analytic engineering judgment through the study of the operative functions of generating and transmitting devices.

69. **Electrical Communication.**—In this subject the principles developed in the preceding courses are studied from a new point of view. The aim is to broaden the student's electrical training by applying these principles to new apparatus and circuits. Many new ideas are introduced, such as the simultaneous transmission of several telephone or telegraph currents over the same conductor, the production and detection of electro-magnetic waves, the electron theory in its application to the electron tube used in the telephone repeater and in radio apparatus.

The work is divided into three courses and prepares the student for the opportunities of the communication industry or strengthens him for work in other electrical industries as a result of his broadened perspective and better grasp of fundamentals.

70. **Illumination and Photometry.**—The courses offered in this subject are designed to familiarize the student with the fundamental principles of generation and control of light as a commodity and to that end the significance and use of photometric quantities, and the methods of measuring them are thoroughly treated.

71. **Advanced Theory of Electrical Machinery and Circuits.**—A limited number of problems in connection with rotating magnetic fields, electrical oscillations, the propagation of electric waves along wires and in free space, etc., are taken up and studied in detail from the mathematical standpoint. The emphasis is placed upon the formation of the equations representing electrical and mechanical phenomena and upon the interpretation of the results arrived at by the mathematical analysis. An effort is made to get the student to see the theoretical and practical advantages of mathematical analysis, to give him some added facility in the application of mathematics to practical problems, and to inspire him to continue his development along theoretical lines.

72. **Applied Electrical Engineering.**—Courses 8, 11, 33 and 36 in Industrial, Railway and Rate Engineering lay particular stress on the use of engineering judgment and the application to engineering problems of the principles of economics.

73. **Advanced Courses** are described under "Courses of Instruction—Electrical Engineering" and include seminary and research work under the direction of various members of the staff, the problems assigned being such as will develop initiative and analytic power and at the same time contribute to the advancement of the electric art. The student's own desires determine to a large degree the nature of the work undertaken. In addition, there are courses of recitations and lectures on the existing advanced theory.

74. **Chemical Engineering.**—Under this head are grouped the courses which treat of the technical operation and control of the important manufacturing industries in which chemical processes play an important part. The course of study leading to a degree in Chemical Engineering is detailed in § 151. The students are trained in chemistry so that they may understand the chemical side of the processes and act as their own chemist if necessary. They are taught mechanism, the operation of machinery and Chemical Engineering that they may understand the problems involved in designing equipment and carrying out processes on the manufacturing scale and be fitted, after proper experience and further study, to fill executive positions. Further description of specific lines of work in Chemical Engineering is given in succeeding paragraphs.

75. **Engineering Materials.**—A general course is given to all students in the Engineering College. It discusses the properties of the important manufactured materials used in engineering structures. The processes of manufacture are only studied as throwing light upon the properties of the materials. The course includes: iron and steel, copper, zinc, aluminum and their important alloys, hydraulic cements, brick and other clay products, fuels and water-softening, glass, and protective coatings.

76. **Fuel and Furnaces.**—A study of the preparation, combustion, and utilization of fuels, including measurement of temperatures, analysis of gases, determination of heating values, and computation of heat balances, maximum temperatures, furnace efficiencies, and relative costs. § 198.

77. **Chemical Technology.**—The field of chemical technology is divided into inorganic and organic technology. These are treated in separate courses. The important industries based on inorganic technology are the manufacture of sulfuric, hydrochloric, and nitric acids, the fixation of atmospheric nitrogen, the production of caustic soda, soda ash, chlorine, bleaching powder, bromine, graphite, carborundum, and aluminum, and the recovery from natural sources of salt, potash, nitrates, borax, and sulfur. The important industries based on organic technology are the manufacture of wood products, coal-gas, water-gas, petroleum products, coal tar products, purified fats and oils, soaps, glycerine, paints and varnishes, rubber products, glue, leather, starch and dextrines, corn products and glucose, sugar, industrial alcohol, pyroxylin plastics, artificial leather and silk, explosives, paper, textiles, dyes, and dyestuff intermediates.

The principles underlying the manufacture of these products are outlined and the development of plant methods studied. Subsequent courses allow a more specialized study of many of these industries.

78. **Iron and Steel.**—General courses are given which cover, by means of lectures and recitations the manufacture, physical properties and uses of iron and steel.

Advanced courses afford opportunities both in the class-room and laboratory for a detailed study of the effects of heat treatment and mechanical work upon the properties of steel. The correlation of the foundry and forge shop with the metallurgical laboratories furnishes unusual opportunities. Excellent facilities are provided for heat treatment, physical and microscopic examinations of specimens.

79. **Metallurgy of Non-Ferrous Metals.**—A course in the metallurgy of copper, lead, zinc, and other non-ferrous metals is given. Consideration is also given in this course to the preparation, properties and uses of the common non-ferrous alloys. An advanced lecture and laboratory course dealing with structure, properties and heat treatment of non-ferrous alloys is offered Opportunity for practical alloy work is provided in the foundry.

80. **Gas and Fuel Testing.**—This is a combined class and laboratory course involving the ordinary methods of technical gas analysis, and the determination of the heating value of solid fuel and of gas.

81. **Portland Cement and Concrete.**—The changes which Portland cement undergoes as it sets and hardens are studied microscop-

ically and also by delicate measurements of change of volume. Especial attention is paid to the causes of disintegration of concrete and to the efficiency of protective coatings and waterproofing compounds. The effects of variations in temperature of burning and in the composition of cement are studied on products made in a small rotary kiln installed in the laboratory where temperatures may be accurately controlled.

82. **Paint and Varnish Technology.**—Research work is offered on the technology of manufacture and application of protective coatings. Students desiring work in these fields should have adequate preparation in organic chemistry and technology.

83. **Chemical Engineering Machinery.**—Several courses are devoted to a study of the mechanical operations involved in the chemical industries and of the particular types of machines adapted to the work. These are followed by advanced courses in which the student may take some piece of chemical machinery and design it in detail; or take a process and select the types and sizes of machinery for carrying it out. Extensive laboratory study is made of the principles involved in the design of various types of apparatus.

Through the generosity of the Swenson Evaporator Company of Chicago, there has been established a laboratory for the study of evaporators, one of the principal representatives of the special apparatus used in chemical industries. Studies are made of the effect on the rate of heat transmission of all the factors involved in evaporating surfaces, differences in steam pressure, etc. The great variety of problems arising in the design of film evaporators are the subject of other lines of investigation. Experiments on the manufacture of particular products on the factory scale are also carried out. The principles underlying other types of apparatus, such as filters, sprays, cooling systems, etc., are also under investigation. Advanced research courses are offered in this laboratory for graduate students.

84. **Explosives and Pyrotechnics.**—This course was established at the request of the Post Graduate school of the U. S. Naval Academy at Annapolis. The course consists of a study of the methods of manufacture and properties of explosives and pyrotechnics. No laboratory work is connected with this course.

85. **Gas Engineering.**—The generation of gas from coal either in the producer or retort, its purification, distribution, and utilization for heating furnaces, or in gas engines, demand a very considerable special training in chemical engineering and mechanical engineering. The course in Chemical Engineering is sufficiently flexible to allow the desired specialization.

86. **Gasoline and Other Petroleum Products.**—Fundamental studies of the production and utilization of gasoline, other motor

fuels, and lubricants, are of great importance to the automotive and petroleum industries. Work is offered to familiarize the student with the technology of manufacture and utilization of these products and opportunity is given for special studies in these fields.

ADVANCED COURSES, PRIMARILY FOR GRADUATES, are given in Chemical Engineering, and include seminary and research work. (See Announcement of Graduate School.)

87. **Marine Engineering and Naval Architecture** are subdivided as follows:

STRUCTURAL ARRANGEMENTS OF SHIPS.—This course is devoted to the discussion of the practical details relating to the various parts of a ship's structure, such as keels, framing, plating, preparation of working drawings, ordering material, general methods of construction, and Classification Societies' rules.

88. **Ship Calculations.**—This course consists of a series of lectures and recitations upon the displacement and buoyancy of ships, and includes discussions of rules for determining areas, volumes, center of buoyancy, metacenters, change of trim, tonnage, freeboard, etc. The theory and use of the planimeter and integrator are also discussed.

This course also includes a general discussion upon the question of strength and resistance of materials, methods of obtaining curves of weights, buoyancy, shearing force, and bending moment upon ships under various conditions of wave support; general and local stresses, and strength of riveted joints.

89. **Stability of Ships.**—A series of lectures and recitations is devoted to the various methods of obtaining curves of stability, statical and dynamical, of vessels of different types under varying conditions. The geometrical properties of the surface of buoyancy, flotation, etc., are discussed, together with problems relating to the rolling of vessels in still water and in waves. Methods of reducing rolling are illustrated by methods in the experimental tank.

A part of the time of this course is devoted to the problems relating to the preliminary design of ships.

90. **Resistance and Propulsion of Ships.**—Under this heading are treated all questions relating to the resistance of vessels to motion. Surface friction, wave making, eddy resistance, Froude's law of comparison, progressive trials, etc., are discussed and illustrated in the experimental tank. Investigations of the action and design of various forms of propellers and the analysis of their effect upon the resistance of the vessel are also discussed.

91. **Ship and Engine Specifications.**—A series of lectures is given which embraces a general discussion of the preparation of spec-

ifications. Methods of estimating weights and costs; arrangements of pumping, heating, and ventilation; auxiliary machinery, etc., are also included. In connection with the design of a ship or machinery installation each student is required to prepare a general specification.

92. **Marine Boiler Design.**—This course covers a general discussion of all details relating to the design, construction, and economy of marine boilers, together with the consideration of various kinds of fuels.

In the drawing course connected with the above, the student designs a marine boiler and all the necessary details.

93. **Marine Engine Design.**—Courses in this subject include all problems relating to the design and economy of multiple expansion marine engines. The detail design of the various parts, including condensers, air and feed pumps, balancing, etc., is also discussed.

In the drawing course connected with the above, the student designs a marine engine and all the necessary details.

94. **Steam Turbines, Gas, and Oil Engines.**—Courses in these subjects, which are accepted in Marine Engineering, are given by the department of Mechanical Engineering.

95. **Ship Drawing and Design.**—The above courses are accompanied by work in the drawing room, which include: Laying off and fairing a set of lines from given offsets; calculations of displacement, center of buoyancy, etc., and plotting results; construction of capacity curves; calculation of change of trim and curves connected therewith; of launching; of strength and determination of curves of weight, buoyancy, shearing forces, and bending moments; calculation of stresses; of curves of stability.

Later the student works out a design for a vessel to fulfill given conditions, as, for instance, a fast passenger or cargo steamer, or steam yacht, and prepares the lines, general arrangement, midship section, and all calculations connected with the above, and, if time permit, complete set of working plans, together with an order form and specifications.

96. **Experimental Tank Work.**—Students are given an opportunity of assisting in the moulding and preparation of the various models, and afterwards testing the same.

Experiments on ships' forms are conducted in a systematic manner, and the results of such experiments will give the student an intelligent idea as to the capabilities of any given form.

The action of the bilge keels upon the rolling of vessels, and upon the speed, are also subject to investigation.

For description of Experimental Tank, see § 123.

*Advanced Work.*—Advenced courses, primarily for graduates, are given in Naval Architecture and Marine Engineering, and include seminary, design, and research work. (See Announcement of Graduate School.)

97. **Aerodynamics.**—Starting with the fundamental laws of motion of fluids, this subject is developed primarily as an experimental science based on data from aerodynamic research in the world laboratories.

98. **Mechanics of Flight.**—This subject treats the motion of the aircraft, in such manœuvres as straight, circular, and climbing, gliding and diving flight. A complete performance analysis of the aircraft is made which indicates the radius of action, ceiling, rate of climb, speeds at all altitudes and the revolutions of the propeller under the same conditions.

99. **Theory and Design of Propellers.**—For given conditions a complete propeller design is prepared. The theory used is that of Drzewiecki and the investigation of performance and stresses is carried out both analytically and graphically, so that the student becomes familiar by the latter method with the very effective means of handling mathematical functions which have no analytic form. Eiffel's method of interpretation of propeller performances are studied, so that the construction and use of his logarithmic charts are clear.

100. **Airplane Design.**—This course entails the design of an airplane from a chosen set of conditions, and the student investigates the aerodynamic and strength properties of the airplane.

101. **Aeronautical Motors.**—In this course only problems peculiar to aircraft motors are studied, the general problem of the theory and design of internal combustion engines having been studied in the Mechanical Engineering Department. The means of balancing and of lessening the engine vibrations are examined and a more refined method of cam design is applied to the actual design of a motor.

102. **Balloons and Dirigibles.**—The study of these two types of aircraft is conducted by means of seminars and lead from the general theories of sustentation and stability to the design, Aerodynamic and strength calculations of any of the types such as non-rigid, semi-rigid or rigid, are investigated.

103. **Experimental and Research Work.**—Experimental work which aims to familiarize the student with the types of dynamometers and instruments used in various research laboratories is provided. The courses also involve the interpretation of results of experiments on aircraft and their parts to determine the lift, resistance and the stability, and on propellers to determine their performance.

Research work of the highest quality is possible in the new wind tunnel and every student is encouraged to undertake some original investigation.

104. **Stability.**—This course is devoted to the study of the stability of aircraft, particularly airplanes according to the mathematical treatment due to G. H. Byran; the experimental derivatives and coefficients for the treatment are introduced after the method of L. Bairstow.

## FACILITIES FOR INSTRUCTION

105. While 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 have selected the instructing staff from among those qualified both by technical training and practical experience, nevertheless extensive use is made of the ordinary supplementary aids.

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

At Detroit there is much of interest to students of electrical engineering, including the main power house and substations of the Detroit Edison Company, and of the Detroit United 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 the new power plants, and recently forty seniors spent four days on the tests of one of the largest plants in the state. The managements of the companies operating these plants are all in hearty sympathy and accord with the College of Engineering and afford the students every opportunity for inspection of the plants.

There are within forty miles two of the most complete modern classification yards in the United States, illustrating all types of humps and other modern sorting, the New York Central freight terminals at Toledo and the Michigan Central passenger terminals at Detroit. The Detroit River tunnel and the street railway properties in both cities afford exceptional opportunities for the inspection of important work. The coöperation of railways with the work of the

department extends not only to giving students access to the properties but to giving freely to the University plans of all standard and special structures, for illustrative material, as well as courses of lectures by officers of the companies.

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

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

107. **Physical Laboratory.**—The first floor of the physical laboratory is devoted to experimental work in electricity and magnetism, and to research. It contains about 8,000 square feet and is divided into fourteen rooms, including a battery room, an instrument shop, a large room for electrical measurements, and a smaller one for photometry. Two rooms are used for elementary instruction in direct and alternating current machinery and the theory and use of vacuum tubes and are equipped with various types of apparatus and machines in common use, with the necessary instruments for testing. The rest of the rooms are used for research.

The battery room contains two storage batteries; one, consisting of one hundred twenty cells, of ten ampere capacity, and one, consisting of eighteen cells, of twenty-five ampere capacity. A switchboard, wired to all parts of the building, serves for the distribution of current from the batteries as well as the 220 and 110 volt direct current from the University power house and the 110 volt alternating current from the city lines. Compressed air is also available in several rooms.

On the second floor are two lecture rooms, one seating one hundred twenty and the other four hundred students. An apparatus room is adjacent to each lecture room. This floor contains, in addition, a large laboratory for beginners, the library, an office, and three research rooms.

The third floor contains eleven rooms, the two largest of which are used as laboratories for beginners. Two rooms are used as classrooms and the rest for the advanced work in heat and for research. On account of the crowded condition of the Physics building

two rooms in the basement of Tappan Hall have recently been assigned to the Physics department. They are equipped for laboratory work in sound and light and for research.

The laboratory is well supplied with apparatus from the best European and American Makers, and the annual budget allows the addition each year of apparatus needed for the work of graduate students and for the illustration of recent advances in physics.

108. **The New Physics Laboratory.**—Beginning with the second semester of the University year of 1923-24 the Department of Physics will come into possession of that portion of its new laboratory which is devoted to advanced work and research. This is now known as the first unit of the projected laboratory. The second unit, when built, will contain the large lecture rooms, laboratories, class and consultation rooms required for the elementary classes. In the meantime the old laboratory will be used for the elementary courses. Relieved by the removal of the advanced work, the laboratories and class rooms devoted to general physics will be expanded and the bad congestions under which the large classes have been carried on will be relieved. This laboratory also contains the two largest lecture rooms of the Department, the main instrument shop, and the liquid air plant.

The new laboratory is in the form of an L, the two long sides having lengths of 144 ft. and 132 ft. respectively, while the width of either part is 60 ft. It is of reinforced concrete construction with specially deadened floors. There are four floors above the basement, and both a first sub-basement and a second sub-basement. The first sub-basement has a little more than one half the area of the basement, while the second sub-basement is about one fourth as large.

Several considerations have led to this unusual type of laboratory. The location of the Physics Laboratory in the center of the group of buildings devoted to the various sciences and scientific professions was the chief consideration. The space available here, however, was so limited that additional floors were necessary. The fact that for several hundred feet below the building there is dry gravel made it possible to get the necessary space by using sub-basements. In constructing these sub-basement rooms special care has been taken to secure uniformity of temperature and freedom from vibration. An elevator connects the seven floors.

The building has laboratories for electrical measurements, heat, sound, light, radio activity, mechanics, applied optics, high temperature measurements, vacuum tubes and wireless. These laboratories are provided with apparatus rooms, adjacent research rooms and consultation rooms. In addition there are special rooms for research in several subjects.

Sound is provided with a sound proof two story building extending through the first sub-basement and the basement. This structure, entirely disconnected from the walls of the building which

contains it, is designed through the type of its construction, its division into rooms and its equipment, to meet very adequately the requirements of certain kinds of sound problems. X-Ray research has ample quarters in the basement and first sub-basement. The necessary high potential generators are housed in a two story room which permits ready distribution of power to a number of research rooms adjacent to it on the two floors.

Spectroscopy both of the photographic and infra-red regions has a series of laboratories and rooms designed to meet its particular needs.

In addition there are single unit research rooms available for any purpose. A single unit research room is 24 ft. by 12 ft. The larger rooms are multiples of this unit. Each such unit whether it forms a single research room or is a part of a larger room is provided with numerous storage battery connections as well as the University power circuits, both the 110 v. A.C. and 220 v. D.C. Water, gas, and compressed air are also available. In certain rooms brine circuits from the refrigerating plant of the neighboring medical building permit maintenance of low temperatures and the removal of moisture by freezing.

There are three storage battery rooms conveniently situated on different floors. The switch boards in adjacent rooms make possible the universal distribution of battery power. These batteries contain altogether 640 cells. Motor generators in the switch board rooms provide power for special purposes. Permanent vertical and horizontal ducts have been installed which make it possible to connect any two rooms with wiring or piping. In addition to the battery rooms there are two small instrument shops, a wood shop, a glass blowing room, and general apparatus rooms. The building contains the necessary offices, four small rooms for lectures and classes in advanced courses, a library, and a faculty room.

The Laboratory will be provided with adequate equipment and apparatus, which the annual budget of the Department makes it possible to maintain.

109. **Chemistry Building.**—The Chemistry building provides for the teaching of chemistry to students in all the schools and colleges of the University and for the technical work in the College of Pharmacy. This building, which was especially designed for the purpose, was erected in 1909 at a cost of approximately $300,000. It is rectangular in shape, 230 x 130 feet, with two central courts, and is four stories high. It contains 125 rooms and has a total floor area of 104,500 square feet. Besides having excellent hood facilities, hydrogen sulphide, high pressure steam, compressed air, and distilled water are piped to the laboratories needing them, and special electric circuits have been freely provided. In addition to a full supply of routine materials and apparatus for work in general, analytical, organic, physical, pharmaceutical, and certain lines of

technological chemistry, facilities are offered for advanced study in each of these fields.

The library occupies the center of the south side of the building and is a handsomely finished room with shelf capacity for ten thousand books, and seats for eighty-five readers. The chemical library contains about eight thousand volumes and is especially rich in complete sets of journals. Over ninety journals are currently received.

110. **Equipment for Surveying.**—The equipment for surveying includes transits, levels, rods, tapes, etc., in sufficient number to supply two hundred students. Special equipment is provided for triangulation work. A launch and sounding apparatus is provided for the work in the summer camp. Current meters, barometers, hand levels, sextants, cameras for surveying and engineering photography, plane tables for topographic work, and numerous other small engineering and surveying instruments are provided.

111. **Camp Davis.**—In 1908 the Regents of the University came into possession of about 1,600 acres of land, lying between Burt and Douglas Lake, Cheboygan County, Michigan. Nearly half of this area came as a gift from Colonel Charles Bogardus and his wife, Hannah W. Bogardus. In recognition of their kindly interest, the entire area now owned by the University in this locality,—increased by purchase since 1908 to 3,200 acres,—is called the Bogardus Tract.

The camp of the Department of Geodesy and Surveying is called "Camp Davis," in memory of the late Professor Joseph Baker Davis, who established it in 1874 and conducted it for over thirty years. Until 1909 the camp moved from place to place as Professor Davis found land he could use. Permanent improvements were impossible during its early migratory years.

Camp Davis is situated on the south shore of South Fishtail Bay, Douglas Lake, six miles east of Pellston on the Grand Rapids and Indiana Railway, thirteen miles west and slightly south of Cheboygan and eight miles northwest of Topinabee. Douglas Lake is about 4½ miles long, east and west, and from a mile to two miles wide, north and south. Burt Lake lies 1¾ miles south of, and at an elevation of 118 feet below Douglas Lake.

The camp consists chiefly of fifty residence buildings of galvanized sheet steel, 14 feet square, with concrete floors, arranged in a double row running parallel with the lake shore. The street, 70 feet wide between the buildings, has been improved by the application of gravel in 1916 and 1918. Concrete sidewalks, four feet wide, have been laid through the greater part of the camp. In addition to the residence buildings, the camp boasts of the following improvements: Two concrete buildings used for storing supplies and as a central

power station, erected in 1912 and 1913; a harbor excavated in 1912 and remodeled with harbor building in 1921; a kitchen; dining rooms; complete sanitary system with septic tank, built in 1915; a combined ice house and refrigerator, a cube of 17 feet, was erected in 1922; a water system with concrete reservoir built in 1912; an instrument room, 14 x 28 feet, erected in 1917; one steel office building erected in 1921 and a second completed during the summer of 1922; a concrete platform, 20 x 30 feet, for adjusting instruments, built in 1912; and two sextant piers, built in 1913.

While the camp has had an independent power plant, which has operated pumps and a small generator since 1914, this is not used at the present time except when power is interrupted from the high tension line of the Cheboygan Electric Light and Power Company which was connected with the camp circuits in 1921.

In the way of transportation facilities the camp has acquired a tractor and lumber wagon, a small truck and a light touring car. A shelter for this equipment was built early in June, 1922.

The Bogardus Tract has a varied topography. While most of the valuable timber was removed prior to 1908, a second growth has since sprung up. The tract has been well protected from fire, under University management.

A small store has been maintained at the camp for some years. This includes, also, a telephone booth, a post office, a local bank, and headquarters for the mess accountant.

Students have laid out an athletic field and horseshoe links. They maintain a diving tower and other facilities for bathing and swimming.

A physician from the University Health Service is in attendance each year.

The camp is generally reached by way of Cheboygan, which is also the address for mail (Camp Davis, Route No. 1), freight and express.

112. **Engineering Shops.**—The Engineering Shops occupy most of the south wing in the East Engineering Building. One shop on each of the four floors, with storage room for raw materials, oil, unused machinery, etc., in the basement. All equipment is of the best or latest types, a large part of which is new. All layouts have been carefully made to give the best results for routine instructional and research work.

Electric power is used throughout, machines being driven in groups rather than individually. The power transmission has been standardized as to size and speed and is so arranged that maximum flexibility is available.

The general shop offices and drawing room are located on the southwest corner of the second floor. Class rooms are placed adjacent to each laboratory.

THE WOOD AND PATTERN SHOP, 45 by 60 feet, is located on the second floor and is well equipped with a good assortment of tools and machinery. The north side of the shop contains the work benches and portable power tools needed for hand woodwork, together with the tools necessary for pattern making. On the south side carefully arranged are a variety of woodworking machines, making the wood shop a very complete unit. Adjoining the wood shop on the west side is a pattern loft and a wood storage room.

THE FORGE SHOP, 60 by 100 feet, is located on the third floor. The equipment consists of 40 forges with all necessary tools, a belt hammer, lathes, shapers, planers, grinders and drilling machines. In the heat treating department are furnaces and quenching tanks for all types of heat-treating. An acetylene welding outfit is provided.

THE FOUNDRY, 60 by 100 feet, is located on the fourth floor. A 32-inch cupola and a crucible furnace is provided for melting metals. A core department is equipped with ovens, racks and benches. Four types of molding machines are used. The cleaning equipment consists of a sand blast machine, tumbling barrels and grinding stands. An elevator is provided for raising the metals to the charging level and an electric travelling crane serves the molding floor.

THE MACHINE SHOP, 60 by 130 feet, is located on the first floor and has been very carefully arranged to demonstrate the two types of Machine Shop methods, tool room and production. One part of the shop contains one or more of each of the principal types of machine tools, such as various types of lathes, planers, shapers, drilling, milling and broaching machines, also others of more special types, together with a great variety of tool room equipment.

In another part of the shop the machines are arranged to give the student a perspective of the machines, tools, and methods used in the manufacture of an article in production.

A third part of the shop is occupied by a grinding room which contains grinding machines and auxiliary equipment. Centrally located is a well organized tool crib, 25 by 36 feet, under the supervision of an attendant, containing quite a complete equipment of small tools for machine and hand use. Adjoining this tool crib and under the same supervision is a production room, 12 by 25 feet.

113. **The Mechanical Engineering Laboratory** is located in the West Engineering building and has a floor space of approximately 13,000 square feet. It is devoted to experimental work in connection with the testing of engines, boilers, pumps, fans, air compressors, hydraulic machinery, and automobile engines. The very complete and modern Washington Street plant of the University is available

for use, and a test of this plant constitutes a regular part of the second course in Mechanical Laboratory. Occasionally tests are made of outside plants in the vicinity of Ann Arbor.

The laboratory, as a whole, comprises all the equipment utilized for illustration of the theory involved in Mechanical Engineering and for experimental work of both standard and research nature. Separate laboratory instruction is given along the lines of hydraulic machinery and automobiles, and those parts of the equipment applying especially to these divisions are segregated as far as possible to form the Hydro-Mechanical Laboratory and the Automobile Laboratory. The general laboratory is well equipped with power machines of all kinds, which furnish the means of instruction in the principles of testing.

114. **The Hydro-Mechanical Laboratory** is equipped with a pair of 600-cubic-foot tanks on scales, a large Duplex pump, a Francis turbine, a Doble tangential water wheel, two Rees Roturbo pumps, two three-inch single-stage centrifugal pumps, one 50-h.p. Sprague electric dynamometer arranged for direct connection to centrifugal pumps, and all necessary accessories for testing.

115. **The Automobile Laboratory** consists of an engine testing section, a dynamometer room, and a section for the display and demonstration of automobiles, motor trucks, and their component parts. The engine testing section contains a complete equipment of engines, selected with a view to affording the student experience with various typical successful types. This section is equipped with prony brakes, water dynamometers, and one fan dynamometer. The dynamometer room contains a complete Diehl electric dynamometer and a 100-h.p. Sprague electric dynamometer, together with special fuel measuring devices, tachometers, air meters, pyrometers, gas analysis apparatus, manograph, and complete accessories necessary for instructional testing and advance research work. In the display and demonstration section are gathered together complete operating and cut-out chassis, various types of engines, cut-out transmissions, rear axles, differentials, clutches, carburetors, ignition systems, and other automobile parts and equipment. This apparatus is especially mounted to show its operation and design, and is used as demonstration study and test equipment for the regular automobile courses. It further serves as a permanent educational exhibit open to the public.

116. **The Physical Testing Laboratory** occupies two adjoining rooms, 29 by 54 feet and 27 by 54 feet, respectively, on the ground floor of the south wing of the building, and is equipped with apparatus especially designed for testing the strength of materials used in engineering work. This equipment includes a 100,000-pound Olsen testing machine and one of 200,000 pounds capacity built by Riehle

Brothers. Both of these machines are adapted to tensil, compressive, and transverse tests, and are run by direct-connected electric motors. An Olsen torsion machine of 240,000 inch-pounds capacity, also equipped with direct-connected motor, is used in determining the torsional strength of shafts and axles. Impact tests are made on an Olsen impact machine and an Upton Lewis toughness testing machine is used for endurance tests. The cement testing laboratory is equipped for making the ordinary tests of cement and concrete. In addition to scales, sieves, briquet moulds, and accessories, there are two briquet testing machines made by Olsen, and a uniform load beam testing machine, especially designed for the University of Michigan, with a capacity of 85 tons, and adapted to beams of reinforced concrete, wood, or steel of any span up to 12 feet.

117. **Highway Laboratories.**—Through a cooperative 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 new laboratories in the East Engineering Building are in all respects complete and fully equipped for all kinds of work on road materials. 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.

118. **The Sanitary Experiment Station.**—This laboratory in sanitary engineering is located near the campus, with thoroughly up-to-date equipment for the study of problems in public sanitation, more especially those relating to stream pollution and sewage disposal.

119. **Hydraulic Experimental Flume.**—Facilities for experimental work in the measurement of flowing water for discharges up to 250 cubic feet per second and 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.

120. **The Electrical Engineering Laboratories** consist of a dynamo laboratory, communication laboratories, and a photometric laboratory.

THE DYNAMO LABORATORY is fully equipped with direct and alternating current apparatus of various types and sizes, representative of the leading American manufacturers.

As in all of the electrical laboratory work, special emphasis is here laid upon the development of the student's ability to analyze

the phenomena which he observes in the operation of electrical machinery. To this end, and with the aim of developing the personal initiative of the student, a large number of moderate sized machines have been provided in order to give each student intimate contact with the apparatus.

The laboratory is fully equipped with meters and instruments of various ranges, types, and makes. For calibration work there are standard resistances, standard cells, a potentiometer, and meters of the precision type. The equipment includes a General Electric oscillograph with all accessories and a portable oscillograph for projecting oscillograms in classrooms for group discussion.

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 several dynamos of very early type which are of historic interest.

THE COMMUNICATION LABORATORIES are unusually well equipped for both practical and theoretical experimental study of communication by electrical means.

The University's private branch exchange of some two hundred lines, adjacently located, together with an automatic and magneto exchange in the laboratory, provides excellent facilities for practical study. As the laboratory is unusually well equipped with special instruments of the highest grade, the facilities for theoretical study are good.

Exceptional facilities are provided for the study of radio communication in the radio laboratory. It is equipped with modern medium sized vacuum tubes for experimental work together with all the necessary auxiliary equipment in the way of transformers, condensers, meters, generating apparatus, and control equipment. Recently a cathode-ray oscillograph for radio-frequently work has been added to the communication laboratories.

A radio telephone set of the modern type is available for experimental use so that students of radio engineering may get first hand knowledge of the design and operation of such a set.

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; four portable photometers for making surveys of illumination; a single-mirror selector for making measurements on large light sources; a 30-inch integrating sphere for small light

sources together with a Macbeth illuminometer; a part-sphere for measuring the reflection coefficient of surfaces in place. The equipment includes, besides standard lamps, a complete and modern collection of lamps and accessories including mercury, magnetic, and carbon arcs, refractors, reflectors of all varieties in glass and metal, and head-light and floor-light projectors.

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 class room work in appropriate courses.

121. **University Power Plant.**—The new University Power Plant, which has recently been completed at a cost of $350,000, is a fine example of modern power plant construction and is available for instruction and for use. There have been installed eight 400 H.P. Wickes water-tube boilers with Murphy stokers, supplying steam at 150 pounds gauge pressure; an Allis-Chalmers cross-compound engine direct connected to a 625 K. V. A. generator producing 3-phase, 60-cycle alternating current at 2,300 volts; a 300 K. V. A. Curtis turbo-generator, equipped with Westinghouse-Le Blanc condenser; a 25 K. W. Allis-Chalmers motor-generator set; a 25 K. W. Allis-Chalmers turbine-driven exciter; a 15-ton engine room crane; a 3½-ton coal-handling crane; a pneumatic ash conveyor; two 2,000 H.P. feed-water heaters; two turbine-driven pumping units; two hot-well pumps; an air compressor; power and lighting transformers; and a distribution system for power and light. It is proposed in the future to obtain a supply of water from the river by means of an electrically-operated pumping station erected near the river. The feed-water heaters supply hot water to the boilers and also for domestic purposes. Coal is brought directly from the Michigan Central Railroad to the plant over an electrically-operated road, delivering the coal to a storage bin; thence, it is taken to a coal-crusher and delivered to the steel bunker above the stoker-hoppers. The ashes are carried by a pneumatic conveyor to a bunker over the track, from which they are loaded directly into the cars. Tunnels are provided for the underground distribution of steam, hot water, and electrical energy. There is available alternating current at 2,300 volts, 220 volts for lighting, and other voltages for power; also direct current at 220 volts and 500 volts; high and low-pressure steam, and hot water.

122. **The General Chemical Engineering Laboratories** occupy 10,500 square feet of floor space in the north wing of the new East Engineering Building. In these laboratories provision is made for the study of the unit operations of chemical engineering, and for the

development of chemical engineering processes. Special facilities are available for particular unit operations as follows:—

EVAPORATION. The evaporator laboratory occupies a space 26 by 69 feet extending from the basement through the first floor. The principal equipment is a set of evaporators and accessories which are the gift of the Swenson Evaporator Company of Harvey, Illinois. It is the most complete and extensive equipment of its kind in the country. The evaporators include a standard vertical tube unit, a standard horizontal tube unit, a semi-film unit, a true film-unit of the Yaryan type, and a special Yaryan apparatus fitted with glass tubes. Each of the three evaporators first mentioned has a maximum evaporation capacity of 4000 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.

DISTILLATION.—Facilities for the study of batch and continuous distillation, and of dephlegmation, are available. The equipment includes a 250 gallon electrically heated still provided with a 20-foot 10-inch packed column, and a bubbler-cap column of the same size. Either column may be operated continuously or as an apparatus of batch type. Suitable condensing, metering, and instrument equipment is available. A 4-inch column and 30 gallon still fitted for continuous distillation and several smaller stills and columns complete the equipment of this division of the laboratory. All of the apparatus is designed with a view to studying the fundamental principles of fractional distillation and fractional condensation.

GAS ABSORPTION.—There is an absorption column which can be filled with various types of tower packing.

FILTRATION.—The present equipment consists of a 24-inch washing plate-and-frame press, with an assortment of special frames. There is also a de Laval centrifugal clarifier and filter; and a 10-inch Weston centrifuge.

CRYSTALLIZING.—For this work there is a standard 20-foot single deck Swenson-Walker continuous crystallizer; and also 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.—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.

Shops and tool room are conveniently located so that students can build new apparatus or make necessary repairs, and the services of skilled mechanics are also always available.

**Metallurgical Laboratories.**—Facilities for heat treating and melting are provided in a large furnace room equipped with standard electric and gas furnaces. A pyrometric control system including automatic regulators is a part of this equipment. Facilities are provided for electro-metallurgical work and experimental electric furnace work in this room. Power is furnished through three 50 K. W. transformers.

For instruction in *metallography* facilities are provided in the way of a large grinding and polishing room, a microscope and camera room, and a well equipped dark room. A smaller room fully equipped with grinding, polishing and microscopic equipment, and special camera and dark rooms, are available for graduate students.

Special *testing equipment* such as the Brinell Hardness machine, Shore Scleroscope, Rockwell Hardness Tester, Lewis Upton Toughness machine, Izod Impact and others are available. Provision has been made for the installation of small rolls and a drawing bench. General physical testing equipment is available in the Engineering Mechanics Laboratory.

Additional facilities for metallurgical work are available in the foundry and forge shop and in the heat treating room of the Engineering Shops.

In the *Pyrometry Laboratory* unusual facilities are provided. This laboratory has desk space sufficient to accommodate 15 students working at the same time. The equipment includes several types of millivoltmeters, indicating and recording potentiometers, a transformation point apparatus, optical and radiation pyrometers, various types of thermocouples, and ample facilities for calibrating and checking pyrometric apparatus. The arrangement and equipment of the laboratory are all aimed to supply the student with information which will enable him to take charge of the installation and control of commercial pyrometric and temperature control systems.

## SPECIAL CHEMICAL ENGINEERING LABORATORIES

In addition to the general laboratories above mentioned, small laboratories are equipped for special work as follows:

THE CEMENT LABORATORY is equipped with a small rotary kiln and accessory apparatus for burning Portland cement under controlled conditions and for testing the properties of cements.

THE CERAMIC LABORATORIES, located on the third floor, consist of a kiln room, preparation room and laboratory. The kiln room covers about 600 square feet and is equipped with oil fired pottery, high temperature, and down draft kilns, an air blower and gas booster for firing with gas, and the necessary pyrometric equipment. A switchboard is provided for connections to apparatus for electrical drying and heating.

THE PREPARATION ROOM includes a dry pan for fine grinding of shales and hard clays, two mixers, a pug mill and extruding machine, glass topped tables, and other equipment used in preparing clays for burning. The laboratory is supplied with a Fairbanks testing machine, a volumeter, and means for analyzing and testing the raw and burned clay.

THE PULP AND PAPER LABORATORY contains small digesters for the manufacture of pulp, a beater, screen, and bleaching apparatus, and screens for making paper by hand.

THE PAINT AND VARNISH LABORATORY contains facilities for the study of problems connected with the manufacturing of paint and varnish and their application. In addition equipment for this work is provided in the general chemical engineering laboratory.

THE PETROLEUM AND MOTOR FUELS LABORATORY has facilities for study and utilization of motor fuels and other petroleum products. These are supplemented by the equipment available in the general chemical engineering laboratory and in the automobile engineering laboratory.

THE DYE, TEXTILE, AND LEATHER LABORATORY has facilities for the study of problems connected with the dye, textile, and leather industries. These are supplemented by additional equipment in the general chemical engineering laboratory.

THE ELECTROCHEMICAL ENGINEERING LABORATORY provides research facilities for electrochemical work. Equipment for the study of electro-thermal and high-temperature electrolytic processes are also available as part of the facilities of the metallurgical laboratories.

THE GAS ENGINEERING LABORATORY contains furnaces for manufacture of gas on a small scale and for measuring and testing the finished product.

THE GAS AND FUEL LABORATORIES occupy three rooms on the fourth floor of the north wing. They contain apparatus for the rou-

tine analysis of flue gases and coal gas; calorimeters for gas and for solid fuels, and equipment for testing boiler water and lubricants.

There are also a number of individual GRADUATE LABORATORIES not specially equipped, which can be used by advanced students who are working on special problems.

123. **Marine Engineering Laboratory.**—On the first floor of the West Engineering building the east wing contains the experimental tank. This tank is 300 feet long, 22 feet wide, with a depth of water of 10 feet. At the south end is a model room and work shop for the purpose of making models of vessels.

The models used in the tank for testing purposes are from 10 to 12 feet, and are made of paraffin wax. A clay mould is first made approximately to the shape desired, and a core inserted. The paraffin is then poured into the mould, and, after cooling, the rough model is taken to the model cutting machine. This machine consists essentially of two moving tables or platforms, upon one of which is placed the model and upon the other the drawing which it is desired to reproduce. The model moves under a pair of rotating cutters, which are made to follow the lines on 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.

124. **Aeronautics Laboratory.**—For students taking aeronautical courses, facilities are provided in various laboratories of the Engineering College for special investigations of strength of materials and parts of aircraft structure, motor testing, comparative study of resistance of bodies in the naval tank; also studies are made of aerodynamical properties of various bodies and aerofoils in an air current, 3 x 3 feet, velocity 40 miles an hour, provided by an air blower, in connection with which two dynamometers are used. One dynamometer is of a type enabling a simultaneous determination of lift, drag, and center of pressure of aerofoils. The other for determination of thrust and torque of 2 feet diameter propeller models.

A new aerodynamic laboratory is under construction comprising a model shop and two new wind tunnels. One tunnel will be 6 feet in diameter for wind velocities up to 80 miles per hour; the other 13 inches in diameter for wind velocities up to 450 miles per hour. The tunnels will be equipped with several dynamometers of different types for various types of aerodynamic research.

125. **Astronomical Observatory.**—The University Observatory was founded in 1852, through the liberality of citizens of Detroit, and on this account was named Detroit Observatory. It is situated about one-half mile northeast from the University Library, at the corner of Ann and Observatory Streets.

Its principal instruments are a reflecting telescope of 37⅜ inches clear aperture, equatorially mounted, and designed especially for photographic and spectroscopic work; a refracting telescope of 12¼ inches aperture, arranged for micrometric work; a six-inch meridian circle; a six-inch refractor with camera attached for celestial photography; a three-inch meridian transit with zenith telescope attached; a comet seeker; mean and sidereal clocks; theodolites; chronometers; chronograph; seismographs; computing machines; sextants, etc.

The meridian circle and a large refractor are installed in the original Observatory building, the west wing of which contains the Observatory Library and connects with the residence of the Director.

A newer building adjoins the original one on the east, and contains the dome of the large reflecting telescope; laboratory, class, and computing rooms; offices, etc. A set of seismographs is installed in the basement of this building.

For many years the Observatory has been receiving the principal astronomical publications and its technical library is reasonably complete. It includes nearly all the printed star catalogues, most of the modern publications of observatories and astronomical societies, and nearly complete files of the astronomical periodicals.

126. **Natural Science Building.**—A four-story fireproof building was erected in 1915 for the use of the departments of botany, forestry, geology, mineralogy, psychology, and zoölogy. The approximate measurements are for the north side 243 feet, for the east side 263 feet, for the west side 150 feet; and the south side, with a series of breaks, is made to conform in general to the diagonal walk and trees. A green-house is located on the south side at the east corner. The building encloses a court 120 feet across. A corridor about 700 feet in length runs through the center of each floor. There is a clear span of approximately 23 feet between the corridor and the exterior walls on both the campus and court sides. The form of construction gives unusually large windows, and these, combined with the light court in the center, allow excellent illumination of all rooms. The corridor floors are finished with terrazzo, the floors of the rooms with cement. The building contains 270 rooms. Each department is given a section from roof to basement. At the southwest corner on the diagonal walk is located a lecture room seating 500, with a preparation room attached. The lecture table is built in sections; each section runs on rollers and can be taken to any part of the building

for the preparation of material. These sections fasten to stanchions set in the concrete floor; at the stanchions all sorts of plumbing and electric supplies are available, including low-voltage storage battery current. An isolated and well-lighted library for all departments in the building is located above the lecture room. This portion of the building is carried on structural steel.

There is a vacuum cleaning system throughout. Alternating current is used for power and lighting and is available everywhere. There is a unit system of distribution and direct current at 220 volts and special outlets for direct current at 75 volts are well distributed. Cistern water and filtered water are available at certain places in the building. The building is well ventilated with a complete air supply and exhaust system. A special separate exhaust is provided for the toilets and certain other rooms. Pneumatic switches and diaphragm motors are used to control ventilation. The temperature is controlled by thermostats.

127. **The Mineralogical Laboratory** comprises 36 rooms located in the northeast portion of the Natural Science building. A suite of five rooms, designed especially for research, are located on the first floor. Three of these rooms have light-tight shutters, and are provided with piers equipped with water, gas, compressed air, and alternating and direct currents. The packing, store, and grinding rooms are also on this floor. The mineral collection, lecture room, model and apparatus rooms, and an office are on the second floor. The laboratories for the courses in general mineralogy, blowpipe methods, and mineral and rock analyses, several offices, and a stock room are on the third floor. On the fourth floor are the laboratories of lithology, petrography, crystal measurements, and physical crystallography, a small lecture room, and offices for the staff and advanced students.

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

128. **The Laboratories for Geology and Geography** are located in the Natural Science building, occupying the northern half of the eastern front and extending through the four floors of the building. They include a general geological laboratory for the work in physical geology, a laboratory for the work in geography and physiography,

a paleontological laboratory, and soil laboratories, beside smaller private working laboratories for members of the staff of the department. In addition, there is the Russell semniary room. In the southwestern corner of the building there is a natural science library room provided for the six science departments which occupy the building.

The several laboratories of the department are equipped with the necessary apparatus, including topographical-geological map models, reference and working map collections, globes, charts, and other accessories for comprehensive studies. For the work on soils there are two connecting laboratories served by adjoining balance and stock rooms which are well equipped for a thorough study of the subject. For the work in vertebrate paleontology there is a large mounting room provided with a preparateur, whose time is given up to the mounting of the specimens for the geological museum.

For the use of assistants in the department and for advanced students, a number of special research rooms have been provided.

129. **The East Engineering Building,** completed in 1923, has a 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 Highway Engineering and Highway Transport, and the Department of Aeronautical Engineering. The building is U-shaped with a head portion 190 by 62 feet and two wings 160 by 66, and 160 by 62 feet respectively. It is constructed of reinforced concrete faced with Bedford limestone and tapestry brick. There are four main floors and a basement. The wings house most of the laboratories while the head of the building contains the libraries, offices, class rooms and some of the smaller laboratories. The main entrance is through a lobby 22 by 60 feet which also serves as a museum.

The wings are separated from the head of the building by a structural joint packed with compressed cork and felt which prevents vibration from travelling from the wings to the head of the building. Ventilation is provided by two sets of fans, those for fresh air being located in the basement and those for the removal of foul air in the attic. A special exhaust fan removes the vapors from the hoods in the chemical engineering laboratories.

The Engineering Shops occupy most of the south wing, Chemical Engineering, Highway Engineering and Highway Transport occupy the north wing and the head of the building is divided among the various departments. Aeronautical Engineering has a testing laboratory and drafting room in the basement of the south wing.

130. **The Libraries.**—A large new library building, erected at the cost of $615,000, was opened in January, 1920. This building has

general and special reading rooms for eight hundred students at one time, and is equipped with modern appliances for the housing and serving of books. The University libraries receive over 2,800 periodicals annually.

The University Library has at present about 560,000 volumes, of which many are of importance to engineers and architects.

THE ENGINEERING LIBRARY, comprising about 20,000 volumes, is housed in the Engineering building. The latest and best books on professional subjects are added yearly to the library, where they are accessible to all; and frequent references are made to them in the classroom as the various subjects are brought forward. Over one-half of the collection consists of files of professional periodicals and proceedings of engineering societies. Funds being now available, extensive additions to the books and periodicals, particularly foreign periodicals, will be made during the coming year. A new Library for Chemical Engineering has been opened in the East Engineering Building (1924), for the convenience of research work and teaching in applied chemistry.

THE DAVIS LIBRARY OF HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT, located in Room 1024 East Engineering building, is the most complete collection of works on highway engineering and highway transport in this country. All the most recent books in English, French, and German have been purchased and, in addition, may old volumes, which are of interest from a historic point of view, have been secured. Town, municipal, county, park, state, and government reports and specifications, many monographs and complete files of trade publications also form an important part of this library. All technical periodicals which contain articles relative to highway engineering and highway transport are on file, hence the latest literature on the science and of highway engineering and highway transport is available.

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

## SOCIETIES

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

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

The general society has as its primary purpose the creating of a broader field of vision for the Engineering student. This it attempts to accomplish by providing the opportunity for closer associations and the promotion of a social spirit among the students of the several departments; by securing as speakers at its meetings engineers of prominence in all fields of the profession; and by the publication of articles of general information to the student. As a further means to this end the society publishes quarterly a journal, called *The Michigan Technic,* which contains papers read before the society, abstracts of theses, contributed articles from the alumni and faculty members, and other matters of interest to the student and the profession. A reading room is also maintained by the society where all the leading magazines and technical papers are accessible.

The sections of the general society are as follows:

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

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

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

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

---

## FELLOWSHIPS

132. **Roy D. Chapin Fellowship in Highway Transport.**—This fellowship is offered to provide for the investigation of an approved subject relative to Highway Transport. It pays the sum of $250 per semester or winter period, December to March, with an allowance of $50 for expenses.

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

**Detroit Edison Fellowships in Highway Engineering.**—Two Fellowships are offered for the investigation of approved subjects relative to moderate-cost country roads. Each Fellowship pays the sum of $250 per semester or winter period, with an allowance of $50 for expenses.

**National Steel Fabric Company's Fellowship in Highway Engineering.**—This fellowship is offered to provide for the investigation of the design of cement-concrete pavements and foundations as structures. It pays the sum of $250 per semester or winter period.

**The Acme White Lead and Color Works Fellowship in Paints.**—This Fellowship in the Department of Engineering Research is offered to provide for the investigation of the Settling of Suspensions. It pays the sum of $1,000 per year, of which sum $750 goes to the holder of the Fellowship.

**The Detroit Edison Fellowship in Metallurgy.**—This Fellowship in the Department of Engineering Research is offered for the investigation of subjects relating to metallurgy.

**Michigan Gas Association Fellowship.**—This Fellowship in the Department of Engineering Research has been maintained continuously since 1900 with the exception of interruptions during the war. It pays the sum of $1,000 per year, of which sum $750 goes to the holder of the Fellowship.

## SCHOLARSHIPS

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

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

## LOAN FUNDS

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

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

**The John Frank Dodge Loan Fund.**—Seniors and Juniors of the College of Engineering may borrow from this $1,000 fund to the amount of one hundred dollars for any one year when their records and needs warrant such a loan. All loans must be paid with five per cent interest two years after graduation, the interest being reckoned from date of graduation.

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

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

**Class Fund of 1917.**—The Class of 1917 contributed $300 to be used as a loan fund for Engineering students.

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

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

**William James Olcott Scholarships.**—In June, 1916, Mr. William J. Olcott of Duluth, Minnesota, gave to the University the sum of five thousand dollars for the establishment of a loan fund open to students in the College of Engineering. The amounts awarded, when repaid, shall accumulate towards the foundation of further scholarships.

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

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

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

---

## GIFTS

135. As large numbers of our students must have financial assistance to enable them to complete their courses, special gifts and bequests for fellowships, scholarships, and loan funds are very valuable contributions to the students and to the College. The following form is suggested for such gifts:

"I give (or bequeath) to the Regents of the University of Michigan ———— dollars (or the following described real estate) to be used for the establishment of loan funds (fellowships or scholarships) in the college of Engineering."

## DEGREES CONFERRED IN THE COLLEGE OF ENGINEERING

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

### Graduate Courses Leading to the Degree of Master of Science in Engineering and to the Degree of Civil Engineer, Mechanical Engineer, Electrical Engineer, Chemical Engineer, Naval Architect, Marine Engineer, Aeronautical Engineer, and Geodetic Engineer.

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

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

---

## REQUIREMENTS FOR GRADUATION

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

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

2. He must complete a sufficient number of group options or other courses of University grade approved by the head of his department to make a total of 140 credit hours with an average grade of 2 or above. See section 36.

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

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

| SUBJECT | Civ. | Mch. | Elec. | Chem. | Mar. | Aero. | Geod. Surv. |
|---|---|---|---|---|---|---|---|
| English | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Language and Groups | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Mathematics | 18 | 18 | 18 | 16 | 18 | 18 | 18 |
| Physics | 10 | 10 | 14 | 10 | 10 | 10 | 10 |
| Chemistry | 5 | 5 | 5 | 28 | 5 | 5 | 5 |
| Astronomy | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Forestry | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Geology | 3 | 0 | 0 | 0 | 0 | 0 | 3 |
| Drawing | 8 | 8 | 8 | 8 | 8 | 8 | 11 |
| Shop Practice | 2 | 10 | 2 | 2 | 2 | 6 | 2 |
| Engineering Mechanics | 12 | 12 | 12 | 7 | 12 | 12 | 12 |
| Civil Engineering | 23 | 3 | 3 | 0 | 3 | 3 | 8 |
| Mechanical Engineering | 4 | 27 | 4 | 7 | 24 or 18 | 22 | 4 |
| Electrical Engineering | 4 | 4 | 33 | 4 | 4 | 4 | 4 |
| Chemical Engineering | 3 | 4 | 3 | 20 | 3 | 3 | 3 |
| Marine Engineering | 0 | 0 | 0 | 0 | 15 or 21 | 0 | 0 |
| Aeronautical Engineering | 0 | 0 | 0 | 0 | 0 | 14 | 0 |
| Geodesy and Surveying | 7 | 2 | 2 | 2 | 2 | 2 | 22 |
| Economics | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Group Options | 7 | 15 | 14 | 11 | 12 | 11 | 0 |
| *Military Science and Tactics | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elective | 12 | 0 | 0 | 0 | 0 | 0 | 9 |
| Total | 140 | 140 | 140 | 140 | 140 | 140 | 140 |

## MODERN LANGUAGES AND CULTURAL ELECTIVES

138. All regular students in the College of Engineering are required to complete the equivalent of Course 4 in French, German, or Spanish, as given in the University, or Course 3 in Spanish if preceded by two years of Latin in the high school. Course 2 in Spanish if preceded by at least three units of Latin or Greek, will satisfy this modern language requirement. After completing this requirement, students must elect courses from the following list, until they have 16 hours of college credit in foreign languages and other cultural studies: English, Foreign Languages, Oratory, History, Political Science, Political Economy, Sociology, Philosophy, Fine Arts, Music. Students whose language is other than English may substitute English for French, German, or Spanish, the maximum amount of English being seventeen hours. Plane Trigonometry and Chemistry 1 or 1*b* will be included in this list when college credit is given in these studies. Advanced courses in Mathematics may be counted

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

as cultural or technical electives, at the discretion of the Head of the Technical Department concerned.

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

English may be substituted for German, French, or Spanish in satisfying the requirements for graduation in the case of students whose native language is other than English. The administration of this rule is left to the professor in charge of English.

Students in the College of Architecture are required to complete Course 3 in French or German.

## 139. PROGRAM I. CIVIL ENGINEERING

### First Year

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

### Second Year

| | | | |
|---|---|---|---|
| *Language | 4 | *Language or †Electives | 4 |
| Calculus I (Math. 3) | 5 | Calculus II (Math. 4) | 5 |
| Mech.,Sound, Heat (Phys. 1E) | .5 | Statics (E.M. 1) | 4 |
| Surveying 1 | 4 or 3 | Surveying 2 | 3 or 4 |
| Total hours | 18 or 17 | Total hours | 16 or 17 |

### Summer Session

†Electives, or required work, or a combination of elective and required work, to a total of 8 hours

### Third Year

| | | | |
|---|---|---|---|
| *Language or †Electives | 4 | Geology 3 | 3 |
| Magn., El., Lt. (Phys. 2E) | 5 | Chem. Eng. 1 | 3 |
| Strength, Elasticity (E.M. 2) | 3 | Dynamics (E.M. 3) | 2 |
| Heat Engines (M.E. 3) | 4 | Hydromechanics (E.M. 4) | 3 |
| Drawing 3 | 2 | Theory of Structures (C.E. 2) | 3 |
| | | El. Design of Struc. (C.E. 2*a*) | 3 |
| Total hours | 18 | Total hours | 17 |

* See Sec. 138.

† These electives are to be chosen by the student from the accompanying list. A total of at least 12 hours is required, to inlude not less than 3 hours in each of the two groups A and B.

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

**Fourth Year**

| | | | |
|---|---|---|---|
| Masonry (C.E. 3) | 4 | Elec. App. and Circ. (E.E. 2*a*) | 4 |
| Hydrology (C.E. 10) | 3 | English 6 | 2 |
| Water Works (C.E. 30) | 3 | Spec. and Contracts (C.E. 26) | 2 |
| Sewerage (C.E. 32) | 2 | ‡Professional Group | 7 |
| Highway Eng. (C.E. 40) | 3 | | |
| Total hours | 15 | Total hours | 15 |

‡This is the present Professional Group requirement reduced from 12 hours to 7 hours. See Sec. 147.

## Electives for Civil Engineering Curriculum

Electives from the following list to a total of at least 12 hours are to be chosen by the student, including not less than 3 hours in each of the two groups A and B.

### Group A

Advanced Courses in Modern Languages.
Economics 1, 1E, 2, 3, 4, 6, 14, 15, 16, 32, 36, 36*a*, 37, 38E.
English (Engineering College): 2, 3, 5, 14, 23, 24, 26, 28.
English (Literary College): 1, 2, 4, 14, 18, 24, 25.
Fine Arts: 1, 8.
History: 1, 2, 1*a*, 2*a*, 14, 15, 16, 17.
Philosophy: 1, 1*s*, 3, 4*x*, 6*a*, 9.
Political Science: 1, 2, 3, 4, 12, 17, 18.
Psychology: 7, 25*m*.
Public Speaking: 1, 2, 5.

### Group B

Astronomy: 1, 2, 2*a*, 3, 3E.
Bacteriology: 3E, 5.
Botany: 1, 3, 12, 13, 14, 18.
Chemistry: 3*a*, 3*b*, 5, 7, 8, 25.
Engineering Mechanics: 2*a*, 5, 6, 9.
Forestry: 1, 3, 4, 13, 14, 21, 23, 24, 24*a*.
Geology: 4*b*, 20, 40, 42*a*.
Hygiene and Public Health: 1.
Mathematics: 33, 35, 37, 57, 58, 73, 74, 75, 76, 80.
Military Science: Basic Group (any Corps), Advanced Group (any Corps).
Mineralogy: 1, 2, 9.
Physics 3, 4, 7.
Surveying: 3, 5, 7, 9, 21.
Zoölogy: 1, 3, 7.

## 140. PROGRAM II. MECHANICAL ENGINEERING

### First Year

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

### Second Year

| | | | |
|---|---|---|---|
| *Language | 4 | *Language | 4 |
| Calculus I (Math. 3) | 5 | Calculus II. (Math. 4) | 5 |
| Mech., Sound, Heat (Phys. 1E) | 5 | Magn., Elect., Lt. (Phys. 2E) | 5 |
| Eng. Materials (Chem. Eng. 1) | 3 | Statics (E.M. 1) | 4 |
| Drawing 3 | 2 | | |
| Total hours | 19 | Total hours | 18 |

### Summer Session

| | |
|---|---|
| Elect. App. and Cir. (E.E. 2*a*) | 4 |
| Foundry and Pattern Shop (3) | 4 |
| Total hours | 8 |

### Third Year

| | | | |
|---|---|---|---|
| Strength, Elasticity (E.M. 2) | 3 | Machine Shop | 4 |
| Dynamics (E.M. 3) | 3 | Hydromechanics (E.M. 4) | 2 |
| El. of Mach. Des. (M.E. 2) | 3 | Thermodynamics (M.E. 5) | 3 |
| Heat Engines (M.E. 3) | 4 | (a) Mach. Design (M.E. 6) | |
| (a) Mech. Lab. (M.E. 7) and Ch.E. 10, or | | (b) Hyd. Mach. and Mech. Lab. (M.E. 4, 8) | 4 or 6 |
| (b) Surveying 4 | 3 or 2 | (a) Surveying 4 or | |
| | | (b) Mech. Lab. (M.E. 7) and Ch.E. 10 | 2 or 3 |
| Total hours | 15 or 16 | Total hours | 15 or 18 |

### Fourth Year

| | | | |
|---|---|---|---|
| (a) Hyd. Mach. & Mech. Lab. or | | Power Plants (M.E. 9) | 3 |
| (b) Machine Des. | 6 or 4 | M.E. 9a, 11a, 12a, 15a, 16a, 17a, 20a, 21a, 25a, 30a, or 31a, | 2 or 3 |
| Machine Movements (M.E. 10) | 2 | Group Options | 12 or 13 |
| M. E. 11, 12, 13, 15, 16, 17, 19, 20, 30, 31, or 35 | 2 or 3 | | |
| English 5, 6, 9, 10, or 14 | 2 | | |
| C.E. 2 | 3 | | |
| Group Options | 2 | | |
| Total hours | 15, 17, or 18 | Total hours | 17, 18, or 19 |

## 141. PROGRAM III. ELECTRICAL ENGINEERING

### First Year

| FIRST SEMESTER | | SECOND SEMESTER | |
|---|---|---|---|
| *Modern Language | 4 | *Modern Language | 4 |
| Gen. Chem. (2E) | 5 | Gen. Chem. (2E) | 5 |
| or Shop 2 and Eng. 1 | 6 | or Shop 2 and Eng. 1 | 6 |
| Alg. and Anal. Geom. (Math. 1) | 4 | Alg. and Anal. Geom. (Math. 2) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Total hours | 17 or 16 | Total hours | 16 or 17 |

### Second Year

| | | | |
|---|---|---|---|
| *Modern Language | 4 | *Modern Language | 4 |
| Calculus I (Math. 3) | 5 | Calculus II (Math. 4) | 5 |
| Mech., Sound, Heat (Phys. 1E) | 5 | Magn., Elect., Lt. (Phys. 2E) | 5 |
| Drawing 3 | 2 | Statics (E.M. 1) | 4 |
| Surveying 4 | 2 | | |
| Total hours | 18 | Total hours | 18 |

### Summer Session

| | |
|---|---|
| Mech. Eng. 3 | 4 |
| D.C. App. and Cir. (E.E. 2) | 4 |
| Total hours | 8 |

### Third Year

| | | | |
|---|---|---|---|
| Strength, Elasticity (E.M. 2) | 3 | Electives | 4 |
| Dynamics (E.M. 3) | 3 | Theory of Structures (C.E. 2) | 3 |
| Hydromechanics (E.M. 4) | 2 | A. C. Apparatus (E.E. 4) | 4 |
| A. C. Circuits (E.E. 3) | 4 | Mechanism of Electrical Machines (E.E. 14) | 3 |
| Flux and Potential (E.E. 16) | 3 | English 5, 6, 9, 10, or 14 | 2 |
| Ch. Eng. 1 | 3 | Illumination and Photometry (E.E. 7) | 2 |
| Total hours | 18 | Total hours | 18 |

### Fourth Year

| | | | |
|---|---|---|---|
| Elec. Measurements (Phys. 5E) | 4 | Electromechanics (E.E. 17) | 4 |
| Design of Elec. Mach. (E.E. 5) | 4 | Electives | 7 |
| Power Plants, Trans. and Distribution (E.E. 11) | 5 | | |
| Electives | 3 | | |
| Total hours | 16 | Total hours | 11 |

## 142. PROGRAM IV. CHEMICAL ENGINEERING

### First Year

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

### Second Year

| | | | |
|---|---|---|---|
| *Modern Language | 4 | *Modern Language | 4 |
| Calculus I (Math. 3) | 5 | Calculus II (Math. 4*a*) | 3 |
| Mech., Sound, Heat (Phys. 1E) | 5 | Magn., Elect., Lt. (Phys. 2E) | 5 |
| Qual. Analysis (Chem. 3) | 5 | Quant. Analysis (Chem. 5) or Chem. Eng. 1, and 2a | 5 or 6 |
| Total hours | 19 | Total hours | 17 or 18 |

### Summer Session

| | |
|---|---|
| Theoretical Chem. 8E | 3 |
| Chemistry 5, or Chem. Eng. 1 and 2*a* | 5 or 6 |
| Total hours | 8 or 9 |

### Third Year

| | | | |
|---|---|---|---|
| Organic Chem. (Chem. 7) | 5 | Organic Chem. (Chem. 7*a*) | 5 |
| Economics 1E | 3 | Strength and Elas.(E.M.2 or 6) | 3 |
| Statics (E.M. 1) | 4 | Drawing 3 | 2 |
| Heat Engines (M.E. 3) | 4 | Inorgan. Tech. (Ch.E. 4) | 2 |
| Metal. of Iron and Steel (Ch.E. 3) | 3 | Group Options | 6 |
| Total hours | 19 | Total hours | 18 |

### Fourth Year

| | | | |
|---|---|---|---|
| Organic Tech. (Ch.E. 5) | 4 | Elect. App. and Cir.(E.E. 2*a*) | 4 |
| Special Problems (Ch.E. 12) | 5 | Surveying 4 | 2 |
| Elem. Mach. Des. (M.E. 2) | 3 | Group Options | 2 |
| English 5, 6, 9, 10, or 14 | 2 | | |
| Group Options | 4 | | |
| Total hours | 18 | Total hours | 8 |

## 143. PROGRAM V. MARINE ENGINEERING

### First Year

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

### Second Year

| | | | |
|---|---|---|---|
| *Modern Language | 4 | *Modern Language | 4 |
| Calculus I (Math. 3) | 5 | Calculus II (Math. 4) | 5 |
| Mech., Sound, Heat (Phys. 1E) | 5 | Magn., Elect., Lt. (Phys. 2E) | 5 |
| Surveying 4 | 2 | Statics (E.M. 1) | 4 |
| Drawing 3 | 2 | | |
| Total hours | 18 | Total hours | 18 |

### Summer Session

| | |
|---|---|
| Elect. App. and Cir. (E.E. 2*a*) | 4 |
| Elective | 4 |
| Total hours | 8 |

### Third Year

| | | | |
|---|---|---|---|
| Strength, Elasticity (E.M. 2) | 3 | Hydromechanics (E.M. 4) | 2 |
| Dynamics (E.M. 3) | 3 | Thermodynamics (M.E. 5) or | |
| El. Mach. Des. (M.E. 2) | 3 | Ship Drawing Design (N.A. 6) | 3 |
| Heat Engines (M.E. 3) | 4 | Machine Design (M.E. 6) | 4 |
| Structural Design (N.A. 1) | 1 | Mech. Laboratory (M.E. 7) | 2 |
| Structural Drawing (N.A. 5) | 2 | Eng. Materials (Ch.E. 1) | 3 |
| | | Ship Calculation (N.A. 2) | 3 |
| Total hours | 16 | Total hours | 17 |

### Fourth Year

| | | | |
|---|---|---|---|
| Hyd. Machinery (M.E. 4) | 3 | English 5, 6, 9, 10, or 14 | 2 |
| Mech. Laboratory (M.E. 8) | 2 | Resistance, Propulsion (N.A. 4) | 3 |
| Internal Com. Eng.(M.E. 15) or | | Marine Engines (Mar.E. 9) | 2 |
| Stability of Ships (N.A. 3) | 3 | Group Options | 8 |
| Marine Boilers (Mar. E. 8) | 1 | | |
| Draw. and Des. (Mar.E. 10) | 3 | | |
| Theory of Structures (C.E. 2) | 3 | | |
| Total hours | 15 | Total hours | 15 |

## 144. PROGRAM VI. AERONAUTICAL ENGINEERING

### First Year

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

### Second Year

| | | | |
|---|---|---|---|
| *Modern Language | 4 | *Modern Language | 4 |
| Calculus I (Math. 3) | 5 | Calculus II (Math. 4) | 5 |
| Mech.,Sound, Heat (Phys. 1E) | 5 | Magn., Elect., Lt. (Phys. 2E) | 5 |
| Surveying 4 | 2 | Statics (E.M. 1) | 4 |
| Drawing 3 | 2 | | |
| Total hours | 18 | Total hours | 18 |

### Summer Session

| | |
|---|---|
| Shop 4 | 4 |
| Elect. App. and Cir. (E.E. 2*a*) | 4 |
| Total hours | 8 |

### Third Year

| | | | |
|---|---|---|---|
| Strength, Elasticity (E.M. 2) | 3 | Hydromechanics (E.M. 4) | 2 |
| Dynamics (E.M. 3) | 3 | Thermodynamics (M.E. 5) | 3 |
| El. Mach. Des. (M.E. 2) | 3 | Machine Design (M.E. 6) | 4 |
| Heat Engines (M.E. 3) | 4 | Eng. Materials (Ch.E. 1) | 3 |
| Mech. Lab. (M. E. 7) | 3 | Theory of Structures (C.E. 2) | 3 |
| General Aeronautics (Aero 1) | 2 | Theory of Aviation (Aero. 2) | 2 |
| Total hours | 18 | Total hours | 17 |

### Fourth Year

| | | | |
|---|---|---|---|
| Internal Com. Eng. (M.E. 15) | 3 | English 5, 6, 9, 10, or 14 | 2 |
| Theory and Design of Propellers (Aero. 3) | 3 | Mech. Laboratory (M.E. 32) | 2 |
| Aeropl. Design (Aero. 4, 4*a*) | 4 | Aerodynam. Lab. (Aero. 5) | 1 |
| Group Options | 6 | Design of Aeronaut. Motors (Aero. 6) | 2 |
| | | Group Options | 5 |
| Total hours | 16 | Total hours | 12 |

## 145. PROGRAM VII. GEODESY AND SURVEYING

### First Year

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

### Second Year

| | | | |
|---|---|---|---|
| *Language | 4 | *Language | 4 |
| Calculus I (Math. 3) | 5 | Calculus II (Math. 4) | 5 |
| Physics 1E | 5 | Physics 2E | 5 |
| Drawing 3 | 2 | Statics (E.M. 1) | 4 |
| Total hours | 16 | Total hours | 18 |

### Third Year

| | | | |
|---|---|---|---|
| Least Squares (Surv. 5) | 2 | Astronomy 3E | 2 |
| Surveying 1 | 3 | Surveying 2 | 4 |
| Strength of Materials (E.M. 2) | 3 | Hydromechanics (E.M. 4) | 2 |
| Geology 3 | 3 | Theory of Design (C.E. 2) | 3 |
| The Solar System (Astron. 1) | 3 | Drawing 4 (Mechanism) | 3 |
| Dynamics (E.M. 3) | 3 | Chem. Eng. 1 | 3 |
| Total hours | 17 | Total hours | 17 |

### Summer Session

Surveying 3 — 8 hours

### Fourth Year

| | | | |
|---|---|---|---|
| Identification Woods (Forestry 24*a*) | 2 | Geodesy 1 | 3 |
| Photography and Camera Surveying (Surv. 21) | 2 | Heat Engines (M.E. 3) | 4 |
| Design of Structures (C.E. 2*a*) | 2 | Electives (English and Science) | 9 |
| Hydrology (C.E. 10) | 3 | | |
| Public Speaking | 2 | | |
| Motors and Gen. (E.E. 2*a*) | 4 | | |
| Total hours | 15 | Total hours | 16 |

## COURSES COMMON TO THE DIFFERENT PROGRAMS IN THE COLLEGE OF ENGINEERING

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

| | |
|---|---|
| English 1, Theme-writing and Oral Expression | 4 hours |
| English 5, 6, 9, 10, or 14 | 2 hours |
| Modern Language and Cultural Electives | 16 hours |
| Mathematics 1, Algebra and Analytic Geometry | 4 hours |
| Mathematics 2, Algebra and Analytic Geometry | 4 hours |
| Mathematics 3, Differential Calculus | 5 hours |
| Mathematics 4a, Integral Calculus | 3 hours |
| Physics 1E, Mechanics, Sound, and Heat | 5 hours |
| Physics 2E, Magnetism, Electricity, and Light | 5 hours |
| Chemistry 2E, General Inorganic Chemistry | 5 hours |
| Drawing 1, 2, 3 | 8 hours |
| Shop 2, Forge Shop | 2 hours |
| Eng. Mech. 1, Statics | 4 hours |
| Eng. Mech. 2, Strength and Elasticity | 3 hours |
| Mech. Eng. 3, Heat Engines | 4 hours |
| Elect. Eng. 2, Electrical Apparatus I (or 2*a*) | 4 hours |
| Chem. Eng. 1, Engineering Materials | 3 hours |
| | 81 hours |

The following studies are common to most of the programs:

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

## THE GROUP SYSTEM OF ELECTIVE STUDIES

147. In July, 1912, there went into effect a complete revision of all the programs in Engineering by which it was made possible for a student in his senior year to have a much wider range of elective work than formerly. The new system provides that of tht 140 hours of credit required for graduation, 125 to 128 hours only are pre-

scribed and 12 to 16 hours may be elected. These elections may be made from the groups of study outlined below 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.

The groups of studies and the scope of the work which they cover are given in the following:

---

### 148. CIVIL ENGINEERING

1. *Outline of Required Courses*

a. Preparatory Courses.

| | |
|---|---|
| English 1 and English 6 | 6 hours |
| Modern Language or Cultural Electives | 16 hours |
| Mathematics 1, 2, 3, 4 | 18 hours |
| Physics 1E, 2E | 10 hours |
| Chemistry 2E | 5 hours |
| Drawing 1, 2, 3 | 8 hours |
| Geology 1 | 3 hours |
| Shop Work 2 | 2 hours |
| | 68 hours |

b. Secondary and Technical Courses.

| | |
|---|---|
| Chem. Eng. 1, Engineering Materials | 3 hours |
| Surveying 1, 2 | 7 hours |
| Eng. Mech. 1, Statics | 4 hours |

| | |
|---|---|
| Eng. Mech. 2, Strength and Elasticity | 3 hours |
| Eng. Mech. 3, Dynamics | 2 hours |
| Eng. Mech. 4, Hydromechanics | 3 hours |
| Civil Eng. 2, Theony and Structures | 3 hours |
| Civil Eng. 2*a*, Elementary Design of Structures | 3 hours |
| Civil Eng. 3, Masonry | 4 hours |
| Civil Eng. 10, Hydrology | 3 hours |
| Civil Engineering 26, Spec. and Contracts | 2 hours |
| Civil Eng. 30, Water Works | 3 hours |
| Civil Eng. 32, Sewerage | 2 hours |
| Civil Eng. 40, Roads and Pavements | 3 hours |
| Mech. Eng. 3, Heat Engines | 4 hours |
| Elec. Eng. 2*a*, Electrical Apparatus I | 4 hours |
| | 53 hours |

Summary:

| | |
|---|---|
| Preparatory Courses | 68 hours |
| Secondary and Technical Courses | 53 hours |
| Group Options | 7 hours |
| Elective | 12 hours |
| Total | 140 hours |

Each student in Civil Engineering must choose one of the group options, and elect 7 hours work from the courses listed under that option, one of the courses elected must be a design course, with its accompanying theory.

Fifth year courses are offered in the Graduate School which permit specialization in any one of the groups, and which offer courses in the School of Business Administration or in the Literary College.

A. Structural Engineering.
B. Hydraulic Engineering.
C. Transportation Engineering.
D. Sanitary and Municipal Engineering.
E. Highway Engineering and Highway Transport.
F. General Engineering Science.

## A. STRUCTURAL ENGINEERING.

| | |
|---|---|
| Civil Eng. 4, Advanced Theory of Structures | 2 hours |
| Civil Eng. 5, Design of Structures | 3 hours |
| Civil Eng. 7, Advanced Design of Structures | |
| a, Bridge Design | 4 hours |
| b, Reinforced Concrete | 3 hours |
| c, Arches | 2 hours |
| d, Timber Construction | 1 hour |
| Civil Eng. 65, Structural Engineering Research | |

Mech. Eng. 20, Mechanical Handling of Materials.....2 hours
Chem. Eng. 6, Iron and Steel..... 2 hours
Chem. Eng. 8, Metallography..... 2 hours

Students electing Group A are required to elect Design Course 5 and Course 4, the accompanying theory course.

B. HYDRAULIC ENGINEERING.

Civil Eng. 11, Hydraulics..... 2 hours
Civil Eng. 12, Development of Water Power..... 3 hours
Civil Eng. 13, Administration of Water Resources.... 2 hours
Civil Eng. 14, Irrigation and Drainage..... 2 hours
Civil Eng. 16, Design of Hydraulic Structures..... 3 hours
Civil Eng. 18, Rivers and Harbors..... 2 hours
Civil Eng. 27, Public Utility Problems..... 2 hours
Civil Eng. 61, Irrigation and Drainage, Advanced.... 2 hours
Civil Eng. 62, Hydraulic Design, Advanced..... 2 hours
Civil Eng. 64, Hydraulic Engineering Research..... ———
Mech. Eng. 4, Hydraulic Machinery..... 3 hours
Mech. Eng. 16, Water Turbines..... 3 hours
Mech. Eng. 20, Mechanical Handling of Materials.... 2 hours
Elec. Eng. 3a, Alternating Current Apparatus..... 4 hours
Elec. Eng. 11, Power Plants, Transmission and Distrib. 5 hours
Elec. Eng. 33, Industrial Electrical Engineering..... 2 hours
Elect. Eng. 36, Rates and Cost Analysis..... 2 hours

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

C. RAILROAD TRANSPORTATION ENGINEERING.

C.E. 20, Railroad Location..... 2 hours
C.E. 21, Railroad Engineering..... 2 hours
C.E. 22, Transportation..... 2 hours
C.E. 23, Railroad Design..... 3 hours
C.E. 27, Public Utility Problems..... 2 hours
E.E. 8, Electric Railways..... 2 hours
E.E. 11, Electric Generating Stations and Substations... 2 hours

Students electing Group C are required to elect Design Course 23 and Course 20 or 21, accompanying theory courses.

D. SANITARY AND MUNICIPAL ENGINEERING.

Civil Eng. 7*a*, Concrete and Steel Highway Bridge Design ..... 3 hours
Civil Eng. 11, Hydraulics..... 2 hours
Civil Eng. 27, Public Utility Problems..... 2 hours
Civil Eng. 31, Water Purification..... 2 hours

Civil Eng. 33, Sewage Disposal..... 2 hours
Civil Eng. 34, Municipal and Industrial Sanitation.... 2 hours
Civil Eng. 35, Sanitary Engineering Design..... 3 hours
Civil Eng. 36, Municipal Engineering..... 2 hours
Civil Eng. 41, Highway Engineering Theory and Economics, and Highway Transport Surveys..... 2 hours
Civil Eng. 42, Highway Engineering Laboratory..... 2 hours
Mech. Eng. 20, Mechanical Handling of Materials.... 2 hours
Mech. Eng. 25, Heating and Ventilation..... 2 hours

Students in Sanitary and Municipal Engineering electing Group D are required to elect Design Course 35 and Courses 31, 33, or 34.

## E. HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT.

Civil Eng. 27, Public Utility Problems..... 2 hours
Civil Eng. 36, Municipal Engineering..... 2 hours
Civil Eng. 41, Highway Engineering Theory and Economics, and Highway Transport Surveys..... 2 hours
Civil Eng. 42, Highway Engineering Laboratory..... 2 hours
Civil Eng. 43, Highway Engineering Design..... 3 hours
Civil Eng. 44, Highway Transport Economics, Methods, Legislation, and Management ..... 2 hours
Mech. Eng. 29, Automobiles and Motor Trucks..... 3 hours

Students electing Group E are required to elect the Theory Course 41 and the accompanying Design Course 43. Students having a conflict of a required course with Civil Engineering 41 may substitute Civil Engineering 44 by obtaining the written approval of the Professor of Highway Engineering and Highway Transport. Students electing Group E may elect for credit, with the written approval of the Professor of Highway Engineering and Highway Transport, not more than two of the graduate short period courses.

## F. GENERAL ENGINEERING SCIENCE.

Physics.
Chemistry.
Astronomy.
Mathematics.
Mechanics.
Mineralogy.
Geology.

This group is arranged to permit students of high scholastic standing to take advanced work in any of the above subjects. Courses elected in this group must be in advance of the last required course in the subject chosen. Students electing twelve hours' work in any one of the subjects will not be required to elect a design course.

Any student electing this group shall indicate the fact not later than the beginning of his junior year and all elections in the chosen

science shall be with the approval of the Head of the Science Department, or a committee chosen by him.

**Graduate Students in Civil Engineering** may specialize in any of the above groups. Such students will ordinarily be required to complete at least 12 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 6 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.

---

## 149. MECHANICAL ENGINEERING

1. *Outline of Required Courses.*

a. Preparatory Courses.

| | |
|---|---|
| English 1, and choice of English 5, 6, 9, 10, or 14 | 6 hours |
| Modern Languages or Cultural Electives | 16 hours |
| Mathematics 1, 2, 3, 4 | 18 hours |
| Physics 1E, 2E | 10 hours |
| Chemistry 2E | 5 hours |
| Drawing and Descriptive Geometry 1, 2, 3 | 8 hours |
| Shop 2, Forge Shop | 2 hours |
| Shop 3, Foundry | 4 hours |
| Shop 4, Machine Shop | 4 hours |
| Total | 73 hours |

b. Secondary and Technical Courses.

| | |
|---|---|
| Surveying 4, Use of Instruments | 2 hours |
| Eng. Mech. 1, Statics | 4 hours |
| Eng. Mech. 2, Strength and Elasticity | 3 hours |
| Eng. Mech. 3, Dynamics | 2 hours |
| Eng. Mech. 4, Hydromechanics | 3 hours |
| Mech. Eng. 2, Elements of Machine Design | 3 hours |
| Mech. Eng. 3, Heat Engines | 4 hours |
| Mech. Eng. 4, Hydraulic Machinery | 3 hours |
| Mech. Eng. 5, Thermodynamics | 3 hours |
| Mech. Eng. 6, Machine Design | 4 hours |
| Mech. Eng. 7, Mechanical Laboratory, First Course | 2 hours |
| Mech. Eng. 8, Mechanical Laboratory, Second Course | 3 hours |
| Mech. Eng. 9, Power Plants | 3 hours |
| Mech. Eng. 10, Theory of Machine Movements | 2 hours |

| | |
|---|---|
| Civil Eng. 2, Theory of Structures | 3 hours |
| Elect. Eng. 2a, D.C. App. and Circ. | 4 hours |
| Chem. Eng. 1, Engineering Materials | 3 hours |
| Chem. Eng. 10, Tech. Examination of Gas and Fuel. | 1 hour |
| Total | 52 hours |

Summary:

| | |
|---|---|
| Preparatory Courses | 73 hours |
| Secondary and Technical Courses | 52 hours |
| Electives | 15 hours |
| Total | 140 hours |

2. *Selection of Elective Courses.*

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

a. Restricted electives.

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

Students electing design courses 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.

b. Free electives.

The remaining elective hours may be filled by courses offered by any department in the Engineering College or by any College or School in the University to which the student is eligible, subject to the approval of the head of the Mechanical Engineering Department.

The following groups of courses are arranged for the purpose of assisting the student in his selection of elective hours. The student is urged, however, to broaden his course by making elections from other departments as well as from the Mechanical Engineering course and in so doing is urged to consult freely with the members of the Mechanical Engineering staff.

## A. STEAM POWER ENGINEERING.

| | |
|---|---|
| Mech. Eng. 9*a*, Design of Power Plants | 3 hours |
| Mech. Eng. 11, Steam Boilers | 3 hours |
| Mech. Eng. 11*a*, Design of Steam Boilers | 3 hours |
| Mech. Eng. 12, Steam Reciprocating Engines | 2 hours |
| Mech. Eng. 12*a*, Design of Steam Reciprocating Engines | 3 hours |
| Mech. Eng. 13, Steam Turbines | 3 hours |
| Mech. Eng. 19, Refrigeration and Compressed Air | 3 hours |

Mech. Eng. 20, Mechanical Handling of Materials.... 2 hours
Mech. Eng. 20*a*, Design of Hoisting and Conveying Machinery ..... 3 hours
Mech. Eng. 22, Research Work in the Mechanical Laboratory ..... 3 hours

B. INTERNAL COMBUSTION ENGINEERING.

Mech. Eng. 9*a*, Design of Power Plants..... 3 hours
Mech. Eng. 15, Internal Combustion Engines and Gas Producers ..... 3 hours
Mech. Eng. 15*a*, Design of Internal Combustion Engines ..... 3 hours
Mech. Eng. 37, Special Topics on the Internal Combustion Engine ..... 2 hours
Mech. Eng. 38, Laboratory Research Work on Internal Combustion Engines ..... 3 hours
Mech. Eng. 39, Research Design of Internal Combustion Engines ..... 3 hours

C. HYDRO-MECHANICAL ENGINEERING.

Mech. Eng. 16, Water Turbines..... 3 hours
Mech. Eng. 16*a*, Design of Water Turbines..... 3 hours
Mech. Eng. 17, Pumping Machinery..... 3 hours
Mech. Eng. 17*a*, Design of Pumping Machinery..... 3 hours
Mech. Eng. 23, Advanced Hydraulic Laboratory..... 3 hours

D. HEATING, VENTILATING, AND REFRIGERATING ENGINEERING.

Mech. Eng. 19, Refrigeration and Compressed Air..... 3 hours
Mech. Eng. 25, Heating and Ventilation..... 2 hours
Mech. Eng. 25*a*, Heating and Ventilation Design..... 3 hours
Mech. Eng. 22, Research Work in Mechanical Laboratory ..... 3 hours

E. AUTOMOBILE ENGINEERING.

Mech. Eng. 29, Automobiles and Motor Trucks..... 3 hours
Mech. Eng. 30, Automobile and Motor Truck Engines.. 3 hours
Mech. Eng. 30*a*, Design of Automobile and Motor Truck Engines ..... 3 hours
Mech. Eng. 31, Automobile and Motor Truck Chassis.. 3 hours
Mech. Eng. 31*a*, Design of Automobile and Motor Truck Chassis ..... 3 hours
Mech. Eng. 32, Automobile Testing..... 2 hours
Mech. Eng. 33, Advanced Automobile Testing and Research ..... 3 hours

Mech. Eng. 34, Advanced Automobile Design and Research ..... Hours arranged
Mech. Eng. 35, Shop Management..... 3 hours
Mech. Eng. 41, Automobile Engineering Seminar..... 1 hour
Mech. Eng. 44, Automotive Electrical Equipment..... 3 hours

F. INDUSTRIAL ENGINEERING.

Mech. Eng. 20, Mechanical Handling of Materials..... 2 hours
Mech. Eng. 20*a*, Design of Hoisting and Conveying Machinery ..... 3 hours
Mech. Eng. 21*a*, Design of Machine Tools ..... 3 hours
Mech. Eng. 25, Heating and Ventilation ..... 2 hours
Mech. Eng. 25*a*, Heating and Ventilating Design..... 3 hours
Mech. Eng. 35, Shop Management..... 3 hours
Mech. Eng. 36, Field Work in Shop Management..2 or 3 hours
Mech. Eng. 43, Factory Internal Transportation..... 3 hours

G. MACHINE DESIGN.

In addition to the regular advanced courses listed in this announcement special machine design courses will be arranged to fit the needs of the student. Courses in other departments of engineering and in the sciences will also be found of particular value.

---

## 150. ELECTRICAL ENGINEERING

1. *Outline of Required Courses.*

a. Preparatory Courses.

English 1, and choice of English 5, 6, 9, 10, or 14.. 6 hours
Modern Language and Cultural Electives..... 16 hours
Mathematics 1, 2, 3, 4..... 18 hours
Physics 1E, 2E ..... 10 hours
Chemistry 2E ..... 5 hours
Drawing 1, 2, 3..... 8 hours
Shop 2, Forge and Machine Shop..... 2 hours

Total ..... 65 hours

b. Secondary and Technical Courses.

Physics 5E, Electrical Measurements..... 4 hours
Surveying 4, Use of Instruments..... 2 hours
Eng. Mech. 1, Statics ..... 4 hours
Eng. Mech. 2, Strength and Elasticity ..... 3 hours
Eng. Mech. 3, Dynamics ..... 2 hours
Eng. Mech. 4, Hydromechanics..... 3 hours
Civil Eng. 2, Theory of Structures ..... 3 hours

| | |
|---|---|
| Mech. Eng. 3, Heat Engines | 4 hours |
| Elec. Eng. 2, D.C. App. and Cir. | 4 hours |
| Elec. Eng. 3, A.C. Circuits | 4 hours |
| Elec. Eng. 4, A.C. Apparatus | 4 hours |
| Elec. Eng. 5, Design of Electrical Machinery | 4 hours |
| Elec. Eng. 7, Illumination and Photometry | 2 hours |
| Elec. Eng. 11, Power Plants, Transmission and Distribution | 5 hours |
| Elec. Eng. 14, Mechanism of Elec. Engines | 3 hours |
| Elec. Eng. 16, Flux and Potential | 3 hours |
| Elec. Eng. 17, Electro-Mechanics | 4 hours |
| Chem. Eng. 1 | 3 hours |
| Total | 61 hours |

Summary:

| | |
|---|---|
| Preparatory Courses | 65 hours |
| Secondary and Technical Courses | 61 hours |
| Elective | 14 hours |
| Total | 140 hours |

## CHOICE OF ELECTIVE WORK

In the selection of his elective work the student will do well to be guided in his choice by the general philosophy controlling the work of the department. The aim of the staff in Electrical Engineering is to help the student toward the development of a sense of proportion, of ability to observe, visualize, and analyze rather than to impart specific and empirical information.

With this aim in view the staff in Electrical Engineering advises the student to choose his elective work from the following classes on the bases indicated.

For the undergraduate, elections in pure science, economics, history, philosophy and the Liberal Arts are urged in the belief that such broad elections will fit the engineering graduate to take his place in organized society and will aid him to an unusually broad perspective of his profession and life. It is the belief of the staff that such preparations should fit the student for an ultimate position of leadership in his profession.

Next in importance after the above class of subjects come fundamental courses in other branches of engineering or in engineering science. It is felt that a broad election in the engineering field is to be preferred to too narrow specialization during the undergraduate course.

The specialized and advanced courses in Electrical Engineering are particularly designed for graduate or fifth year work and every strong student is urged to stay for such a fifth year leading to an advanced degree. It is felt however that this work should be preceded by the work outlined above.

## 151. CHEMICAL ENGINEERING

1. *Outline of Required Courses.*

a. Preparatory Courses.

| | |
|---|---|
| English 1, and choice of English 5, 6, 9, 10, or 14 | 6 hours |
| Modern Language and Cultural Electives | 16 hours |
| Mathematics 1, 2, 3, 4*a* | 16 hours |
| Physics 1E, 2E | 10 hours |
| Chemistry 2E, 3 | 10 hours |
| Drawing 1, 2, 3 | 8 hours |
| Shop 2, Forge Shop | 2 hours |
| Total | 68 hours |

b. Secondary and Technical Courses.

| | |
|---|---|
| Chemistry 5, Quantitative Analysis | 5 hours |
| Chemistry 7, Organic Chemistry | 5 hours |
| Chemistry 7*a*, Organic Chemistry | 5 hours |
| Chemistry 8E, Theoretical Chemistry | 3 hours |
| Economics 1E | 3 hours |
| Surveying 4, Use of Instruments | 2 hours |
| Eng. Mech. 1, Statics | 4 hours |
| Eng. Mech. 2, Strength and Elasticity, or Eng. Mech. 6, Strength of Materials | 3 hours |
| Mech. Eng. 2, Elements of Machine Design | 3 hours |
| Mech. Eng. 3, Heat Engines | 4 hours |
| Elec. Eng. 2*a*, Elec. App. and Circ | 4 hours |
| Chem. Eng. 1, Engineering Materials | 3 hours |
| Chem. Eng. 2*a*, Technology of Fuels | 3 hours |
| Chem. Eng. 3, Metallurgy | 3 hours |
| Chem. Eng. 4, Inorganic Technology | 2 hours |
| Chem. Eng. 5, Organic Technology | 4 hours |
| Chem. Eng. 12, Special Problems | 5 hours |
| Total | 61 hours |

Summary:

| | |
|---|---|
| Preparatory Courses | 68 hours |
| Secondary and Technical Courses | 61 hours |
| Group Options | 11 hours |
| Total | 140 hours |

2. *Outline of Group Options.*

The following courses listed under the various optional groups are intended to be suggestive. A student may make up a list of his own entirely outside of these groups and if the choice seems to be reasonable it will be approved.

A. Metallurgical Group.
B. Gas Engineering Group.
C. Organic Industrial Group.
D. General Manufacturing Group.
E. Pulp and Paper Manufacturing Group.

## A. METALLURGICAL GROUP.

| | |
|---|---|
| Mineralogy 1, Elements of Mineralogy | 2 hours |
| Geology 1, Elements of Geology | 3 hours |
| Geology 16, Economic Geology | 3 hours |
| Geology 17, Metamorphosis and Ore Deposits | 2 hours |
| C. E. 26, Specifications and Contracts | 1 hour |
| E. M. 5, Testing Materials | 2 hours |
| M. E. 5, Thermodynamics | 3 hours |
| M. E. 7, Mechanical Laboratory | 2 hours |
| E. E. 3*a*, Alternating Current Machinery | 2 hours |
| Pol. Ec. 32, Business Organization and Management | 3 hours |
| Ch. E. 7, Non-ferrous Metallurgy | 2 hours |
| Ch. E. 8, Metallography | 2 hours |
| Ch. E. 13, Evaporation, Filtration, Transportation of Liquids | 2 hours |
| Ch. E. 14, Machinery and Processes for Conveying, Grinding and Mixing | 2 hours |
| Ch. E. 18, Non-ferrous Metallography | 2 hours |
| Ch. E. 21, Special Laboratory Work in Metallurgy | 3 to 5 hours |
| Ch. E. 24, Pyrometry and Furnace Design | 2 hours |
| Ch. E. 26, Advanced Ferrous Metallurgy | 3 hours |
| Ch. E. 30, Seminar in Metallurgy | 2 hours |

## B. GAS ENGINEERING GROUP.

| | |
|---|---|
| E. M. 4, Hydromechanics | 3 hours |
| C. E. 26, Specifications and Contracts | 1 hour |
| C. E. 27, Valuation and Estimating | 1 hour |
| M. E. 5, Thermodynamics | 3 hours |
| M. E. 7, Mechanical Laboratory | 2 hours |
| M. E. 9, Power Plants | 2 hours |
| M. E. 15, Gas Engines and Gas Producers | 3 hours |
| E. E. 3, Alternating Current Machinery | 2 hours |
| E. E. 7, Illumination and Photometry | 2 hours |
| Ch. E. 13, Chemical Engineering Machinery | 2 hours |
| Ch. E. 14, Chemical Engineering Machinery | 2 hours |
| Ch. E. 16, Gas Manufacture | 2 hours |
| Ch. E. 23, Chemical Plant Design | 2 hours |
| Ch. E. 24, Pyrometry and Furnace Design | 2 hours |
| Ch. E. 27, Design of Chemical Machinery | 2 hours |
| Ch. E. 28, Extraction, Drying and Distillation | 2 hours |

| | |
|---|---|
| Ch. E. 29, Chemical Engineering Laboratory | 2 hours |
| Pol. Econ. 32, Business Organization | 3 hours |
| Pol. Econ. 38E, Accounting | 3 hours |
| Free Electives | 4 hours |

C. ORGANIC INDUSTRIAL GROUP.

| | |
|---|---|
| Chemistry 43, Organic Laboratory | 5 hours |
| Chemistry 45, Advanced Organic Chemistry | 2 hours |
| Mineralogy 1, Elements of Mineralogy | 2 hours |
| C. E. 31, Water Purification | 2 hours |
| C. E. 33, Sewage Disposal | 2 hours |
| C. E. 34, Sanitary Science | 1 hour |
| Ch. E. 13, Chemical Engineering Machinery | 2 hours |
| Ch. E. 14, Chemical Engineering Machinery | 2 hours |
| Ch. E. 15, Seminar | |
| Ch. E. 16, Gas and Motor Fuels | 2 hours |
| Ch. E. 23, Chemical Plant Design | 2 hours |
| Ch. E. 27, Design of Chemical Machinery | 2 hours |
| Ch. E. 29, Chemical Engineering Laboratory | 2 hours |
| Ch. E. 31, Dyes, Textile and Dyeing | 2 hours |
| Ch. E. 32, Explosives | 2 hours |
| E. M. 4, Hydromechanics | 3 hours |
| Political Econ. 38E, Principles of Accounting | 3 hours |
| Bacteriology | 5 hours |
| Free Electives | 8 hours |

D. GENERAL MANUFACTURING GROUP.

| | |
|---|---|
| E. M. 4, Hydromechanics | 3 hours |
| M. E. 5, Thermodynamics | 3 hours |
| M. E. 6, Machine Design | 4 hours |
| M. E. 7, Mechanical Laboratory | 2 hours |
| M. E. 9, Power Plants | 2 hours |
| M. E. 20, Handling Materials | 2 hours |
| E. E. 3, Alternating Current Machinery | 4 hours |
| C. E. 26, Specifications and Contracts | 2 hours |
| Ch. E. 13, Chemical Engineering Machinery | 2 hours |
| Ch. E. 14, Chemical Engineering Machinery | 2 hours |
| Ch. E. 23, Chemical Plant Design | 2 hours |
| Ch. E. 24, Pyrometry and Furnace Design | 2 hours |
| Ch. E. 27, Design of Chemical Machinery | 2 hours |
| Ch. E. 28, Extraction, Drying and Distillation | 2 hours |
| Ch. E. 29, Chemical Engineering Laboratory | 2 hours |
| Pol. Econ. 32, Business Organization and Management | 3 hours |
| Pol. Econ. 38E, Principles of Accounting | 3 hours |
| Free Electives | 8 hours |

E. PULP AND PAPER MANUFACTURING GROUP.

This group contains options from the courses in pulp and paper manufacture and the courses in chemical engineering machinery in the department of Chemical Engineering; from courses in identification of woods in Forestry and in the microscopic study of woody plants in Botany; from courses in Electrical or Mechanical Engineering; in hydraulics in Civil Engineering; and in Economics.

---

## 152. NAVAL ARCHITECTURE, MARINE ENGINEERING, AND AERONAUTICS

1. *Outline of Required Courses.*

a. Preparatory Courses.

| | |
|---|---|
| English 1, and choice of English 5, 6, 9, 10, or 14 | 6 hours |
| Modern Language and Cultural Electives | 16 hours |
| Mathematics 1, 2, 3, 4 | 18 hours |
| Physics 1E, 2E | 10 hours |
| Chemistry 2E | 5 hours |
| Drawing 1, 2, 3 | 8 hours |
| Shop 2, Forge Shop | 2 hours |
| Total | 65 hours |

b. Secondary and Technical Courses (Naval Architecture and Marine Engineering).

| | |
|---|---|
| Surveying 4, Use of Instruments | 2 hours |
| E. M. 1, Statics | 4 hours |
| E. M. 2, Strength and Elasticity | 3 hours |
| E. M. 3, Dynamics | 2 hours |
| E. M. 4, Hydromechanics | 3 hours |
| M. E. 2, Elements of Machine Design | 3 hours |
| M. E. 3, Heat Engines | 4 hours |
| M. E. 4, Hydraulic Machinery | 3 hours |
| M. E. 6, Machine Design | 4 hours |
| M. E. 7, Mechanical Laboratory | 2 hours |
| M. E. 8, Mechanical Laboratory | 2 hours |
| Elec. Eng. 2*a*, Elec. App. and Circ | 4 hours |
| Chem. Eng. 1, Engineering Materials | 3 hours |
| N. A. 1, Structural Design | 1 hour |
| N. A. 2, Ship Calculations | 3 hours |
| N. A. 4, Resistance and Propulsion of Ships | 3 hours |
| N. A. 5, Structural Drawing | 2 hours |
| Mar. Eng. 8, Marine Boilers | 1 hour |

Mar. Eng. 9, Marine Engines..... 2 hours
Mar. Eng. 10, Marine Boiler Design..... 3 hours
C. E. 2, Theory of Structures..... 3 hours

Total ..... 57 hours

c. Secondary and Technical Courses (Aeronautics).

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

Total ..... 50 hours

Summary:

Preparatory Courses..... 65 hours
Secondary and Technical Courses.....57 or 50 hours
Group Options .....18 or 25 hours

Total ..... 140 hours

2. *Outline of 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 contains not only aeronautical courses but also certain courses given in other departments which are of particular interest for students specializing in Aeronautical Engineering.

A. NAVAL ARCHITECTURE.

N. A. 3, Stability, etc. ..... 3 hours
N. A. 6, Ship Drawing and Design..... 3 hours

| | |
|---|---|
| N. A. 7, Ship Drawing and Design | 3 hours |
| N. A. 12, Experimental Tank Work | 2 hours |
| N. A. 13, Ship and Engine Specifications | 1 hour |
| Electives | 6 hours |
| Total | 18 hours |

B. MARINE ENGINEERING.

| | |
|---|---|
| M. E. 5, Thermodynamics | 3 hours |
| M. E. 13, Steam Turbines | 3 hours |
| M. E. 15, Gas Engines | 3 hours |
| Mar. Eng. 11, Marine Engine Design | 3 hours |
| Electives | 6 hours |
| Total | 18 hours |

C. AERONAUTICS.

| | |
|---|---|
| Aero. 1, General Aeronautics | 2 hours |
| Aero. 2, Theory of Aviation | 2 hours |
| Aero. 3, Theory of Design and Propellers | 3 hours |
| Aero. 4, 4*a*, Aeroplane Design | 4 hours |
| Aero. 5, Aeronautical Laboratory | 1 hour |
| Aero. 6, Design of Aeronautical Motors | 2 hours |
| Electives | 11 hours |
| Total | 25 hours |

## 153. GEODESY AND SURVEYING

1. *Outline of Required Courses.*

a. Preparatory Courses.

| | |
|---|---|
| English 1, and choice of English 5, 6, 9, 10, or 14 | 6 hours |
| Modern Language and Cultural Electives | 16 hours |
| Mathematics 1, 2, 3, 4 | 18 hours |
| Physics 1E, 2E | 10 hours |
| Chemistry 2E | 5 hours |
| Drawing 1, 2, 3, 4 | 11 hours |
| Shop 2, Forge Shop | 2 hours |
| Total | 68 hours |

b. Secondary and Technical Courses.

| | |
|---|---|
| Engineering Mechanics 1, Statics | 4 hours |
| Engineering Mechanics 2, Strength and Elasticity | 3 hours |
| Engineering Mechanics 3, Dynamics | 2 hours |
| Engineering Mechanics 4, Hydromechanics | 3 hours |
| Chemical Engineering 1 | 3 hours |
| Astronomy 1, 3E | 5 hours |
| Geology 3 | 3 hours |
| Electrical Engineering 2*a* | 4 hours |
| Mechanical Engineering 3 | 4 hours |
| Civil Engineering 2, 2*a*, 10 | 8 hours |
| Forestry 24A | 2 hours |
| Surveying 1, 2, 3, 5, 21 | 19 hours |
| Geodesy 1 | 3 hours |
| Total | 63 hours |

Summary:

| | |
|---|---|
| Preparatory Courses | 68 hours |
| Secondary and Technical Courses | 63 hours |
| Electives | 9 hours |
| Total | 140 hours |

The Specialized Department of Geodesy and Surveying was created by the Board of Regents, at the request of the Faculty of the College of Engineering, to provide such training in pure and applied science as may be necessary to interest students in geodetic work, higher surveying, astronomy, and mathematics. The department is convinced that only by the mastery of fundamentals may students develop that proficiency which ultimately stimulates love of work. This new department, representing probably the oldest field of applied science, accepts this fundamental idea as its guiding rule. 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.

## COMBINED COURSE WITH ALBION COLLEGE

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

In general, it is proposed that a student shall spend at least three years at Albion College and two succeeding years at the University. At the end of his first year's work at the University, provided the reports are satisfactory, he will receive the degree of Bach-

elor of Arts from Albion College; the latter institution being willing to accept the work done at the University as the equivalent for the fourth year.

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

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

### First Year

| FIRST SEMESTER | HOURS | SECOND SEMESTER | HOURS |
|---|---|---|---|
| French or German | 4 | German or French | 4 |
| English I | 3 | English I | 3 |
| College Algebra | 4 | Trigonometry | 4 |
| Mechanical Drawing | 2 | Descriptive Geometry | 2 |
| General Physics | 3 | General Physics | 3 |

### Second Year

| | HOURS | | HOURS |
|---|---|---|---|
| French or German | 4 | German or French | 4 |
| English II | 2 | English II | 2 |
| General Chemistry | 4 | Qualitative Analysis | 4 |
| Analytic Geometry | 4 | Calculus | 4 |
| Laboratory Electricity | 1 | Laboratory Electricity | 1 |

### Third Year

| | HOURS | | HOURS |
|---|---|---|---|
| Mechanics | 2 | Mechanics | 2 |
| Advanced Physics | 3 | Advanced Physics | 3 |
| Advanced Analytics and Calculus | 4 | Advanced Calculus | 4 |
| | | Statics | 2 |
| Electives | 6 or 7 | Electives | 4 or 5 |

### Electives

In Civil Engineering:
Geology (3 hours each semester).
Cultural (5 or 6 hours).

In Mechanical and Marine Engineering:
Surveying (2 hours); Machine Drawing (2 hours); Metallurgy (2 hours); Cultural Electives (3 hours each semester).

In Electrical Engineering:
Surveying (2 hours); Machine Drawing (2 hours); Metallurgy (2 hours); Electrical Measurements (3 hours each semester).

## COMBINED COURSE WITH OLIVET COLLEGE

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

### First Year

| FIRST SEMESTER | HOURS | SECOND SEMESTER | HOURS |
|---|---|---|---|
| College Algebra | 3 | Analytic Geometry | 5 |
| Plane Trigonometry | 2 | English | 3 |
| English | 3 | Religion | 1 |
| Applied Psychology | 1 | French or German | 5 |
| French or German | 5 | Gymnasium | ½ |
| Gymnasium | ½ | Elective | 2 |
| Elective | 2 | | |

### Second Year

| | HOURS | | HOURS |
|---|---|---|---|
| Calculus | 3 | Calculus | 3 |
| Physics | 5 | Physics | 5 |
| Chemistry | 5 | Chemistry | 5 |
| French or German | 3 | French or German | 3 |
| Gymnasium | ½ | Gymnasium | ½ |

### Third Year

| | HOURS | | HOURS |
|---|---|---|---|
| Calculus | 2 | Calculus | 2 |
| Surveying | 2 | Descriptive Geometry | 2 |
| Descriptive Geometry | 2 | Mechanics | 4 |
| Mechanics | 3 | Elective | 7 |
| Elective | 6 | Gymnasium | ½ |
| Gymnasium | ½ | | |

### Electives

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

# COLLEGE OF ARCHITECTURE*

## GENERAL STATEMENT

156. 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

157. Architecture, the oldest of the constructive sciences, and since ancient times also ranked as a fine art, deals principally with the design of buildings, their accessories and surroundings, their construction, decoration, and equipment.

Architecture is born of the necessity for buildings and the desire to have them appropriate and pleasing in plan and design, as well as sound in construction. By its very nature, therefore, architecture is much more circumscribed as a medium of expression by utilitarian and technical conditions than is any other of the fine arts; unlike its sister arts of painting and sculpture, it must function at once practically and artistically, and misses its aim in failing in either.

* For admission requirements, etc., see Sec. 6. For courses other than those on Architecture, see Secs. 194-220.

## SERVICES RENDERED BY THE ARCHITECT

158. The duties of the architect consist for the most part in conferences with clients and builders, in the preparation of drawings and documents required for the erection of buildings, and in the supervision of building operations. The drawings consist of several kinds: "Preliminary studies," in which the general arrangement and design of the building are fixed upon, many schemes often being made in order to reach the one most advantageous in point of arrangement, appearance, and economy.

"Working or scale drawings" are prepared after a scheme has been approved by the owner. These are larger drawings which accurately define the proportions of the design, the disposition and dimensions of all the parts, such as the walls, openings, and heights of stories, and show the distribution of the structural, enclosing, and decorative materials. In connection with these drawings all calculations are made to determine the required strength of constructive parts, such as the foundations, 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

159. 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 proportion of the building undertakings of this country, and then primarily for important public projects. Most architects gain their opportunities through demonstrated fitness and integrity. Architects also help determine and often design the decorative features of interiors, for larger work coöperating with decorators, painters, and sculptors; they often design the grounds and approaches of buildings, and have taken an active part in the plan-

ning of cities, independently and in association with landscape designers and engineers, for, after all, buildings must form the most permanent and salient decorative features of the city.

The architect, then, is expected to meet alone or with the aid of his assistants and experts the varied artistic and practical problems related to all classes of buildings. In doing the above he must deal with public and private interests, with an exceptionally wide range of activities and human endeavor, extending from those of the laborer and artisan to those of artists and technical specialists as well as with the products of numberless industries.

---

## TRAINING OF THE ARCHITECT

160. 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 tranied architect having "made good," it is now expected, most fortunately, that in addition to professional training he, like other educated men, have an insight into the larger questions underlying the affairs of the world.

Success in the architectural field depends largely on the same general conditions and personal qualities as are demanded in other professions. Those who expect to follow architecture as a profession should be imbued with an interest in building, in beautiful things, and in drawing. To a certain extent skill in design, construction, and drawing may be attained by all those who persist and have a real interest in the work. Artistic and constructive talent is valuable only if developed by serious work and supported by knowledge, while the mere assimilation of knowledge and acquirement of skilled draftsmanship are insufficient. Unremitting self-discipline and enthusiastic effort are required to attain the creative power and the ability to use knowledge effectively which mark the productive worker.

Until recently it was considered that graduation from a good high school, followed by four years in an architectural school and several years' experience in architects' offices should be the minimum preparation for independent practice, while a longer period of collegiate training, along with travel in this country and study and travel abroad, now actually forms the more extended preparation of many.

The American Institute of Architects and the Association of

Collegiate Schools of Architecture now recommend that students devote at least five years to collegiate study as preparation for the baccalaureate degree in Architecture, dividing the additional year between technical and non-technical subjects with a view to attaining greater breadth and thoroughness.

In the three four-year programs in Architecture now offered at this University fully one-third of the time, approximately three semesters, is given to non-technical subjects, such as English, foreign language, economics, physics, mathematics, geology or mineralogy, fine arts and electives. By apportioning a fifth year between cultural and technical courses the student will spend approximately two full years on fundamental and general subjects and three full years on semi-professional and professional subjects. Since it is desirable to begin drawing and creative work immediately upon entering the Architectural School, the general and cultural courses should be distributed over the entire time the student is in residence rather than completing the cultural before the technical subjects.

The training requisite for the architect may be stated under three principal heads:

a. General education.

b. Technical or professional education.

c. Experience in actual architectural work and business affairs.

## a. GENERAL EDUCATION

The purpose of the first of these is to provide the essentials of a liberal education, that which tends to make the educated man and citizen, and helps give an understanding of the larger questions of life and thought and of the interests of others. Undoubtedly, university life and associations stimulate interest in the above.

The student should therefore while in the university receive those fundamentals of a general education which cannot be studied systematically later when he is absorbed in the exacting routine of the practical field. These studies will help 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 pamphlet.

### 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

161. 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

162. 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, architects who specialize in the design and construction of single classes of buildings, such as hospitals, theatres, schools, churches, office buildings, residential work, or city planning, and who in doing this work employ a corps of trained assistants.

Parallel with the increased demands made on the profession, education in architecture has developed to such an extent that four or more years may be devoted solely to technical subjects. If, however, students were permitted to pursue such an over-professionalized course without preliminary or parallel cultural training they would find, when too late, that they had lost one of the primary opportunities of their college course.

If specialization is desired within the field of architectural education it must be either in the direction of architectural design or construction. Hence, at the University of Michigan there exist three four-year programs, 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.

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

163. 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 hense for the architectural school.

## FOUR-YEAR PROGRAMS OF STUDY

164. Three four-year programs are offered, Programs I and II in Architecture, and Program III, Architectural Engineering, each

requiring four years of study. These should be supplemented by office work during the vacation periods. In each program provision is made for the study of theory, history, and practice of architecture, for training in language, mathematics, science, construction, design, building equipment, drawing, and electives.

The first year being practically identical in these three programs, students can, if advisable, at the end of that period change from one program to another without loss of credit. The courses in drawing, most of those in architectural design, practical building construction, and working drawings, sanitation and architectural history are common to all three programs. General Physics is required in Architecture 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 buildings, 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 engineering course and wish to take up architectural engineering may yet graduate at the end of four years.

During the senior year architectural design forms the chief study in Programs I and II, while in Program III framed structures, structural design and other engineering subjects take up most of the year.

The above programs may be completed in four years by well-prepared and conscientious students; those who have difficulty with a subject can either extend their period of study or make up deficiencies in the Summer Session.

## DEGREE CONFERRED IN THE COLLEGE OF ARCHITECTURE

165. 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.

## GRADUATE STUDY AND DEGREE

166. Students who are able to attend an additional year for graduate work will find the time well spent. Graduate work may be done in design, construction, the history of architecture, and in general studies. Such work shall be of an advanced character, a thesis on the design and construction of a building being required in the second semester.

For graduate courses leading to the degree of Master of Science in Architecture, the student must register in the Graduate School, but will pursue his work under the supervision of the Faculty of the College of Architecture. For particulars, see the Annual Announcement of the Graduate School.

## OTHER CLASSES OF STUDENTS

167. Candidates for both the Bachelor of Arts and Bachelor of Architecture degrees, in order to graduate in Architecture in two years after obtaining the Arts degree, should complete at least the first two years in the architectural courses, while candidates for the first degree. Students wishing to carry on some general college work parallel with or before beginning the work in Architecture, should consult as soon as possible with the Professor of Architecture in order to plan their work in the most advantageous manner. In general, work in drawing and design should be begun early and extend over a long period rather than be concentrated into one or two years.

Graduates of colleges with the Arts degree are able to earn the professional degree in from two to three years, according to the program pursued and the kind of preparation brought by them.

Those who expect to enter from other colleges or to transfer from other departments of this University should aim to bring as much credit as possible in free-hand drawing, as well as credits in descriptive geometry (the equivalent of Drawing 4*a* and 5*a*) 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 Design, and other courses for which they are qualified.

## TWO-YEAR PROGRAM FOR SPECIAL STUDENTS

168. A two-year course is provided for special students in Architecture upon the completion of which there is awarded a certificate of proficiency.

Owing to the difference in the preparation of such students but part of the work is prescribed, the remainder being elective, to be arranged in consultation with the head of the College.

Special students may specialize in either design or construction. Design, history of architecture, and free-hand drawing are studied throughout the two-year program; one year is devoted to construction, another year to building equipment.

In design such students are placed in the class indicated by their preparation. Very often the preparation of such students is sufficient to enable them to enter as regular students. It is then to their advantage to elect as much as possible of one of the four-year programs, returning later to complete the requirements of a regular program.

Special students who enter with enough preparation in mathematics can go on with Mathematics 1, then Architectural Mechanics 19 and 20, finally structural design, Architecture 22, 23, 26, and 27, thus completing part of the advanced building construction within two years of residence.

---

## THE WORK OF THE COLLEGE

169. **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 perspective as a corrective and supplement of design in elevation, to develop appreciation of the third dimension and as 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.

170. **Architectural Design.**—In the courses in architectural design the students work out in the drafting room, designs for a great variety of buildings, ranging from a small structure to large public buildings and groups of buildings. Lectures are given from time to time bearing on the type of building then being designed.

The problems vary from year to year, with the various classes, in order to cover as many as possible of the types of structures which make up architectural practice. Among these are the school, railroad station, library, hospital, church, theatre and auditorium, and such other public structures as the postoffice, museum, the monument, and the bridge, as well as the various kinds of 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, 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.

171. **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.

172. **Allied Arts of Design.**—The course in Allied Arts of Design consists of a study of the elements of decorative design; designs are made for a piece of furniture, decorative glass, metal, and mosaic, and of other decorative features commonly used in connection with buildings.

173. **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, text-books, conferences, visits to buildings, and the preparation of working drawings. The work is at once practical and scientific, analytical and graphical methods being employed, and most of it is completed before the advanced work in architectural design is begun. The character of building materials, their structural and artistic possibilities, and the methods of building practice are studied and problems assigned which train the student in the fundamentals of sound construction.

The drawing work of the course in construction begins with the making of working drawings of a small building. This includes the framing plans of the floors, walls, and roofs, and full-size details of some of the finished portions. This is followed by working drawings for a larger building of heavy construction, and involves soils, foundations, walls, piers, columns, floors, roofs, and details. Steel and reinforced concrete construction are next studied in the course of which girders, columns, trusses, and other structural work of a fireproof 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 ocurse 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.

174. **History of Architecture.**—Architecture, "the mother art," is an art of great and inspiring traditions, and these can be justly appreciated only through careful study of the monuments of the past, both remote and recent, in relation to the other arts and civilization of their time. Owing to the wealth of material and the possibility of illustration, the history of architecture is one of the richest and most valuable subjects in the architectural curriculum. It is at once cultural and technical in character; it helps inculcate an understanding of the true character of architecture, develops the critical power and taste of the student, and demonstrates how we may best profit by the experience and example of the past.

The development of the art of building is traced from the earliest times to the present day. The causes and influences which moulded the various modes of building or styles are analyzed and, where possible, demonstrated by means of the stereopticon. Many of the important buildings of the world are fully illustrated and critically studied, the student thus gaining a knowledge of the finest achievements of the art. Not only are 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 ir 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.

175. **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 intersection, 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.

176. **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 es-

pecially 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. The pencil, charcoal, and monochrome wash are used.

177. **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 rendering 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.

178. **Pen and Ink.**—Rendering in pen and ink is taught for advanced students.

179. **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.

180. **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.

181. **Summer Session.**—The courses offered for Architectural students and others during the summer of 1924 will include architectural design, outdoor sketching and painting, free-hand drawing, descriptive geometry, shades and shadows, perspective and stereotomy.

*Arts Course for Supervisors, Art Instructors, Grade Teachers, School Principals.*—This course includes nature study, industrial art, object drawing, construction, poster designing, costume designing, in-

terior decoration, and home planning and landscape gardening. The Summer Session will begin June 23.

A Special Announcement of the Summer Session can be had by addressing the Secretary of the University

182. **Facilities and Equipment.**—The College of Architecture is housed in large and commodious quarters on the main floor of the Engineering building, immediately adjoining the library and the two principal floors of the adjoining and connecting building to the west. The five 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 room is situated on the top floor at the north of the Engineering building. It is about sixty feet square, is lighted by means of side and north skylights and is fully equipped for the instruction in free-hand drawing, pen and ink, water color, and drawing from life. There is 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.

In addition to the above, there are in the Alumni Memorial building a number of casts from the antique, among which are the Victory of Samothrace, the Hermes of Praxiteles, and some of the remarkable decorative figure sculpture from the Arch of Trajan at Beneventum. Here are also a number of paintings and other objects of artistic and archæological value.

183. **Exhibitions.**—Each year a number of art exhibitions are held in the main gallery of the Alumni Memorial Hall and also in the glazed case in the Architectural Corridor. In the Alumni Memorial gallery have been shown the Third International Water Color Exhibition, sent out through the American Federation of Arts; a collection of etchings by French artists; a group of paintings by California artists and by Western artists; paintings by Leon Bakst illustrating costume design; paintings by J. Paul Slusser of New York; and the Zubiaurre collection of paintings. Exhibitions brought here by the architectural school and shown in the architectural corridor or in the Alumni Memorial Hall included etchings by Frank Brangwin and William Walcot; Javanese batiks loaned by Professor H. H. Bartlett; the Fearon collection of original drawings by Italian masters; etchings by Louis Rosenberg and by Stanley L. Woodward; the seals of Oxford College presented to the school by Henry S. Booth.

Exhibitions of current student work are held from month to month, a larger one serving as a review of the work of the year being held during Commencement week.

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; those of particular interest to these students are named below:

Mr. Joseph G. Reynolds, Jr., of Boston on "The Art of the Glass Worker"; Mr. Aymar Embury II, architect: "The Relation between the Architect and Client"; Mr. Leon Bakst, Russian designer of costumes: "The Art of Painting"; Mr. Arthur Weigall, Egyptologist: "The Recent Discoveries in Upper Egypt"; Count Byron Khun de Prorok, archæologist: "Excavations at Carthage."

184. **The Library.**—No private and few public collections can be as complete as the library of a well-equipped architectural school. These books record the world's experience and achievements in architectural and allied fields and give an opportunity to study critically the finest work of all periods. The architect must have a fair knowledge of the literature bearing on his art, and since he may never possess many of these valuable works, and perhaps rarely again see them, the library forms a valued privilege during the student period.

The Architectural library is housed with the Engineering library. It comprises about 2,800 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 12,000 lantern slides. With the works available in the Engineering library on engineering, heating, ventilation, and illumination, and those in the General library, it constitutes an exceptional collection for the study of construction, architectural 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 architectural journals are received and bound volumes are kept on file.

Among the notable works available a few items which call for special mention are, in ancient literature, the Newton and Marino edition of Vitruvius, Palladio's Fabbriche Antiche, the works of Stuart and Revett, Desgodetz, 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 mediæval architecture, the works of Dehio and von Bezold, Britton, Pugin, Viollet-le-Duc, the Archives de la Commission des Monuments Historiques; in Renaissance architecture, the works of Geymüller, Raschdorff, Cicognara, Blondel, Gotch, Belcher and McCartney, and a very full collection of special works on the buildings of the Renaissance in France.

Every reasonable facility is accorded the student. A librarian is always in attendance, the library being open until ten o'clock at night.

The General Library also contains an excellent collection of reference material on painting, sculpture, and archæology, a large number of photographs of Greek and Roman sculpture, and a collection of nearly five thousand prints, mostly art subject materials.

185. **Materials.**—The College supplies drawing tables and lockers. The student provides himself with all other materials. Large drawing boards may be secured by making a deposit and the payment of a small fee. A good set of instruments and small drawing boards must be purchased. Water colors should not be purchased until after arrival here, when a list of required colors may be had.

## FELLOWSHIPS

186. *The George G. Booth Travelling Fellowship in Architecture.*—The fellowship will be awarded annually, the stipend for the year being $1200. To be eligible the candidate shall be a graduate of the College of Architecture of the University of Michigan or shall have substantially completed the last two years of the four-year course. The award will be made on the basis of the student's general record and a competition in design.

For further information regarding this fellowship candidates should write the College of Architecture.

*Scholarship of the Michigan Chapter of the American Institute of Architects.*—This organization offers a scholarship of $75.00, open to experienced architectural draftsmen and to those who show decided artistic ability. Application should be made to the Professor of Architecture.

*American Academy in Rome.*—Graduates in Architecture are admitted to the annual competition for the fellowship in Architecture of the American Academy in Rome. This fellowship entitles the successful candidate to three years' study abroad with a stipend of $1,000 per annum.

*American Institute of Architects.*—Graduates in Architecture of the University of Michigan are received as candidates by the American Institute of Architects without examination, after they have had a certain amount of office training. The Institute has also established a Junior membership, open upon graduation from this and other recognized schools of the Institute.

*Medal of the American Institute of Architects.*—The Institute annually awards a medal to that member of the graduating class having the highest standing during the four-year period of study in Architecture.

*State Examinations for Admission to Architectural Practice.*—Students who are planning to enter the architectural profession should

bear in mind that twenty states of the Union now have laws prescribing qualifications for architectural practice and require the passing of examinations given by a state board. In a very few years the remaining states will probably have such laws, a number of laws now being under consideration. These examinations comprise tests in the planning, design, construction, and equipment of buildings. Three or four days are usually required for such examination, distributed about as follows: planning and design, one day; reinforced concrete and steel construction, one day; building equipment and specifications, one-half day; architectural history and truss design, one-half day. Candidates may, by passing a somewhat more difficult examination, given under the National Council of Architectural Registration Boards, qualify for interstate practice.

*Architects' Juries.*—Again, as during the past few years, visiting architects have been invited to assist in grading the design problems.

*Association of Collegiate Schools of Architecture.*—The College is a charter member of this organization.

## 187. CREDIT HOURS REQUIRED IN THE THREE FOUR-YEAR PROGRAMS AND IN THE TWO-YEAR PROGRAM FOR SPECIAL STUDENTS

One hour of credit represents ordinarily about three hours of actual work during each week of one semester.

ARCHITECTURE:

| | | | | |
|---|---|---|---|---|
| Elements of design | 3 | 3 | 3 | .. |
| Architectural design | 31 | 37 | 17 | 23 |
| Allied arts design | 3 | 3 | .. | .. |
| History of architecture | 8 | 8 | 6 | 8 |
| Office work | 4 | 4 | 4 | .. |

CONSTRUCTION:

| | | | | |
|---|---|---|---|---|
| Structural mechanics | 6 | 6 | 7 | .. |
| Roofs and bridges, and framed structures | .. | .. | 5 | .. |
| Construction (elementary) | 2 | 2 | 2 | 2 |
| Structural design (steel) | 5 | 5 | 2 | .. |
| Masonry and reinforced concrete | 4 | 4 | 5 | .. |
| 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 |
| Water-color painting | 2 | 2 | .. | 2 |
| Descriptive geometry and shades and shadows | 3 | 3 | 3 | 1 |
| Perspective and stereotomy | 2 | 2 | 2 | 2 |
| SCIENCE: | | | | |
| Mathematics | 13 | 4 | 18 | .. |
| Physics | 4 | 4 | 10 | .. |
| Acoustics | 2 | 2 | .. | .. |
| Chemistry | .. | .. | 5 | .. |
| Geology or Mineralogy | 3 | 3 | 3 | .. |
| LANGUAGE: | | | | |
| English | 6 | 6 | 6 | .. |
| French or German | 12 | 12 | 12 | .. |
| GENERAL: | | | | |
| Business Administration | 3 | 3 | .. | .. |
| History of art | 3 | 3 | .. | 3 |
| Landscape Design or City Planning | .. | 3 | .. | .. |
| Cultural and free electives | 8 | 8 | 10 | 10 |
| | 140 | 140 | 140 | 66 |

## 188. PROGRAM I. ARCHITECTURE.

### First Year

| FIRST SEMESTER | HOURS | SECOND SEMESTER | HOURS |
|---|---|---|---|
| English 1 | 4 | *Modern Language | 4 |
| Alg.,Anal.Geom. (Math.1E) | 4 | Analytic Geom. (Math. 2E) | 4 |
| Desc. Geom. (A. 2) | 3 | Free-hand Drawing (Dr. 22) | 2 |
| Free-hand Drawing (Dr. 21) | 2 | Arch. Design (A. 4) | 3 |
| Elements of Design (A. 1) | 3 | Bldg. Construction (A. 21) | 2 |
| | | Ancient, Med. Arch. (A. 12) | 3 |
| | 16 | | 18 |

### Second Year

| | | | |
|---|---|---|---|
| Calculus (Math. 3E) | 5 | English | 2 |
| Mechanics, Sound and Heat (Phys. 1) | 4 | Perspective, Stereotomy (A. 3) | 2 |
| Free-hand Drawing (Dr. 23) | 2 | Mechanics (A. 19) | 3 |
| Arch. Design (A. 5) | 4 | Arch. Design (A. 6) | 4 |
| Gothic, Ren., Modern Arch. (A. 13) | 3 | Allied Arts (A. 17) | 3 |
| | | Geol. 1 or Min. 16 | 3 |
| | 18 | | 17 |

### Third Year

| | | | |
|---|---|---|---|
| *Language | 4 | *Language | 4 |
| Mechanics (A. 20) | 3 | Free-hand Drawing (Dr. 25) | 2 |
| Arch. Design (A. 7) | 6 | Steel Construction (A. 22) | 3 |
| Arch. Hist. Research (A. 14) | 3 | Structural Design (A. 23) | 2 |
| Water Color (Dr. 24) | 2 | Arch. Design (A. 8) | 6 |
| Bldg. Sanitation (A. 24) | 1 | | |
| | 18 | | 17 |

### Fourth Year

| | | | |
|---|---|---|---|
| Reinforced Concrete (A. 26) | 2 | Hist. of Painting, Sculpture | 3 |
| Structural Design (A. 27) | 2 | Arch. Design (A. 10) | 8 |
| Heating and Ventilation (M. E. 18) | 2 | Business Admin. (Ec. 32) | 3 |
| Life Drawing (Dr. 27) | 2 | Acoustics (Phys. 17) | 2 |
| Electives | 7 | Elective | 1 |
| | 15 | | 17 |

* See Sec. 138.

## 189. PROGRAM II. ARCHITECTURAL DESIGN

### First Year

| FIRST SEMESTER | HOURS | SECOND SEMESTER | HOURS |
|---|---|---|---|
| *Modern Language | 4 | *Language | 4 |
| English 1 | 4 | Alg.,Anal. Geom. (Math. 1E) | 4 |
| Descriptive Geometry (A. 2) | 3 | Free-hand Drawing (Dr. 22) | 2 |
| Free-hand Drawing (Dr. 21) | 2 | Arch. Design (A. 4) | 3 |
| Elements of Design (A. 1) | 3 | Bldg. Construction (A. 21) | 2 |
| | | Ancient, Med. Arch. (A. 12) | 3 |
| | 16 | | 18 |

### Second Year

| | | | |
|---|---|---|---|
| *Language | 4 | English | 2 |
| Mechanics, Sound and Heat (Phys. 1) | 4 | Perspective, Stereotomy (A. 3) | 2 |
| Free-hand Drawing (Dr. 23) | 2 | Mechanics (A. 19) | 3 |
| Arch. Design (A. 5) | 4 | Arch. Design (A. 6) | 4 |
| Gothic, Ren., Modern Arch. (A. 13) | 3 | Allied Arts (A. 17) | 3 |
| | | Geol. 1 or Min. 16 | 3 |
| | 17 | | 17 |

### Third Year

| | | | |
|---|---|---|---|
| Mechanics (A. 20) | 3 | Hist. of Painting, Sculpture | 3 |
| Water Color (Dr. 24) | 2 | Free-hand Drawing (Dr. 25) | 2 |
| Arch. Design (A. 7) | 6 | Arch. Design (A. 8) | 6 |
| Arch. Hist. Research (A. 14) | 2 | Steel Construction (A. 22) | 3 |
| Bldg. Sanitation (A. 24) | 1 | Structural Design (A. 23) | 2 |
| Elective | 3 | Elective | 2 |
| | 17 | | 18 |

### Fourth Year

| | | | |
|---|---|---|---|
| Heat., Vent. (M.E. 18) | 2 | Life Drawing (Dr. 27) | 2 |
| Arch. Design (A. 9) | 6 | Arch. Design (A. 10) | 8 |
| Reinforced Concrete (A. 26) | 2 | Business Admin. (Ec. 32) | 3 |
| Structural Design (A. 27) | 2 | Acoustics (Phys. 17) | 2 |
| Landscape Design I or City Planning | 3 | Elective | 3 |
| | 15 | | 18 |

## 190. PROGRAM III. ARCHITECTURAL ENGINEERING

### First Year

| FIRST SEMESTER | HOURS | SECOND SEMESTER | HOURS |
|---|---|---|---|
| English 1 | 4 | *Modern Language | 4 |
| Alg.,Anal.Geom.(Math. 1E) | 4 | Analytic Geom. (Math. 2E) | 4 |
| Descriptive Geom. (A. 2) | 3 | Free-Hand Drawing (Dr. 22) | 2 |
| Free-hand Drawing (Dr. 21) | 2 | Arch. Design (A. 4) | 3 |
| Elements of Design (A. 1) | 3 | Bldg. Construction (A. 21) | 2 |
| | | Ancient, Med. Arch. (A. 12) | 3 |
| | 16 | | 18 |

### Second Year

| | | | |
|---|---|---|---|
| Calculus (Math. 3E) | 5 | Perspective, Stereotomy (A. 3) | 2 |
| Physics (1E) | 5 | Calculus (Math. 4a) | 3 |
| Free-hand Drawing (Dr. 23) | 2 | Physics (2E) | 5 |
| Arch. Design (A. 5) | 4 | Eng. Mechanics I | 4 |
| Gothic, Ren., Modern Arch. (A. 13) | 3 | Arch. Design (A. 6) | 4 |
| | 19 | | 18 |

### Third Year

| | | | |
|---|---|---|---|
| *Language | 4 | *Language | 4 |
| Calculus (Math. 4b) | 2 | Steel Construction (A. 22a) | 3 |
| Eng. Mechanics (2) | 3 | Structural Des. (A. 23a) | 2 |
| Chemistry (2E) | 5 | Geol. 1 or Min. 16 | 3 |
| Arch. Design (A. 7a) | 4 | Chem. Eng. 1 | 3 |
| | | English | 2 |
| | 18 | | 17 |

### Fourth Year

| | | | |
|---|---|---|---|
| Masonry (A. 36 or C. E. 3) | 3 | Building Details (A. 25) | 2 |
| Surveying 4 | 2 | Testing Materials (E.M. 5) | 2 |
| Heat Engines (M.E. 3) | 4 | Adv. Struct. Design (A. 35) | 4 |
| Bldg. Sanitation (A. 24) | 1 | Heat. and Vent. (M.E. 18) | 2 |
| Elective | 5 | Elective | 5 |
| | 15 | | 15 |

## 191. TWO-YEAR PROGRAM FOR SPECIAL STUDENTS IN ARCHITECTURE

Special students have such varied preparation that a program of courses must practically be planned to meet the needs of each student.

Experienced draftsmen can, in two years, accomplish much in design; they cannot, however, advance far in construction without Mechanics,—Graphic Statics (A. 19) and Strength of Materials (A. 20). They are, therefore, advised to bring preparation in high school algebra and trigonometry, taking Mathematics 1E at the University, then going on with Mechanics,—Architecture 19 and 20. With this training they can elect steel and reniforced concrete construction. Those who desire to specialize in design can substitute other courses for those in mathematics, mechanics, and structural design.

The following is suggested as an outline for special students desiring a well-balanced training when but two years are available:

### First Year

| FIRST SEMESTER | HOURS | SECOND SEMESTER | HOURS |
|---|---|---|---|
| Shades and Shadows (A. 2) | 2 | Perspective and Stereotomy (A. 3) | 2 |
| Free-hand Draw. (Dr.22 or 23) | 2 | Arch. Design (A. 6) | 4 |
| Arch. Design (A. 4) | 3 | Water Color (Dr. 24) | 2 |
| Arch. Design. (A. 5) | 4 | Ancient, Med. Arch (A. 12) | 3 |
| Alg., Anal. Geom. (Math. 1E) or Elective | 4 | Mechanics (A. 19) or Elective | 3 |
| Elective | 1 | Bldg. Construction (A. 21) | 2 |
| | 15 | | 16 |

### Second Year

| | | | |
|---|---|---|---|
| Arch. Design (A. 7) | 6 | Arch. Design (A. 8) | 6 |
| Gothic, Ren., Modern Arch. (A. 13) | 3 | Arch. Hist. Research (A. 14) | 2 |
| Mechanics (A. 20) or Elective | 3 | Steel Construction (A. 22) or | 3 |
| Bldg. Sanitation (A. 24) | 1 | Structural Design (A. 23) or Elective | 2 |
| Heat. and Vent. (M.E. 18) | 2 | Water Color or Pen and Ink | 2 |
| Free-hand Drawing (Dr. 25) | 2 | Hist. of Painting, Sculpture | 3 |
| | 17 | | 18 |

192. **Decorative Design and Interior Decoration.**—Instruction is given in these subjects. Those who desire a systematic program of study, as special students or parallel with their general course, should consult with the Professor of Architecture. They should,

in general, elect courses in free-hand and instrumental drawing, and in water color, in order to acquire skill in expressing their ideas; Elements of Design (A. 1) and Allied Arts Design (A. 17) or Decorative Composition (A. 17*b*) for specific training in fundamental principles of composition and their application; Architectural History (A. 12 and A. 13) and some architectural design to get some grasp of architectural form and the larger aspects of decorative form, as well as to familiarize themselves with the finest existing examples of decoration.

The College of Architecture has a splendid collection of illustrated works, many in color, on decoration in all its aspects, many lantern slides, and a number of original designs for interiors by professional decorators.

# COLLEGES OF ENGINEERING AND ARCHITECTURE

## COURSES OF INSTRUCTION

193. The courses of instruction are subject to change from time to time; those proposed for the year 1924-1925 and required for graduation, are described below, together with some advanced elective and technical courses, which are designated accordingly. The amount of credit toward graduation assigned to each course is indicated by the expression of one hour, two hours, etc., an hour of credit being given for the satisfactory completion of work equivalent to one exercise a week during one semester. Lectures and recitations are usually one hour in length, but in laboratory work, drawing, surveying, and other practice work a longer attendance is required in order to secure an hour of credit. An hour of credit represents ordinarily about three hours of actual work, including preparation.

Courses given in the College of Literature, Science, and the Arts are (with the exception of the courses in German and in French, for which special permission is required) open as electives to Engineering and Architectural student who can spare the time and are qualified to pursue them with advantage.

No credit is given for work done outside of the University during the student's connection with the College, unless such work is substantially equivalent to some course offered in these Colleges, and has been done under approved supervision.

## 194. AERONAUTICS

Professors SADLER, PAWLOWSKI, Mr. STALKER, Mr. UPSON

1. GENERAL AERONAUTICS. Lectures and recitations. *Two hours.* First semester.

An introductory course giving the essential principles of aeronautics (balloons, dirigibles, ornithopters, helicopters, aeroplanes, helicoplanes, and kites), history of flight and description of modern aircraft.

Open to all students.

2. THEORY OF AVIATION. Lectures and recitations. *Two hours.* Second semester.

The course deals with the following questions: properties of the air, general discussion of aerodynamics, aerodynamical properties of planes and various constructive elements of an aeroplane, analysis of performance, equilibrium, and stability of aeroplanes, air currents. In this course each student makes a complete analysis of performance of a given aeroplane, as well as a determination of its stability.

Must be preceded by Courses 1, E. M. 2 and E. M. 3.

3. THEORY OF DESIGN OF PROPELLERS. Lectures, recitations, and drawing. *Three hours.* First semester.

Theory of propellers and analysis of propeller performance on the Drzewiecki system; Eiffel's method of propeller analysis and graphical method of determining propellers for specified conditions; analytical and graphical methods of investigating the strength of propellers and influence of gyrostatic moments in quick turns. The student will design a propeller and analyze the distribution of stresses in the blades.

Must be preceded or accompanied by Course 2.

4. AEROPLANE DESIGN. Lectures and recitations. *Two hours.* First semester.

This course includes the investigation of the design of the aeroplane from the aeronautical and strength standpoints. The strength and design of all the details are discussed and a completed design prepared.

Must be preceded or accompanied by Course 3, and preceded by M. E. 6 and C. E. 2.

4*a*. AEROPLANE DESIGN. Continuation of preceding course. Drawing only. *Two hours.*

5. AERODYNAMIC LABORATORY. *One hour.* Second semester.

An elementary course covering use of instruments, investigation of aerodynamical properties of the various combinations of bodies and aerofoils used in aeroplanes and airships, test of propellers.

Must be preceded or accompanied by Courses 2 and 3, and preceded by M. E. 7.

6. DESIGN OF AERONAUTICAL MOTORS. Lectures and drawing. *Two hours. Second semester.*
Complementary course to M. E. 15 or M. E. 30, dealing with special features of the aeronautical motors, a more refined method of cam design, analysis of vibrations and balancing of motors, critical study of various types of motors, and complete general plans of a motor of certain type are prepared.
Must be preceded by M. E. 15 or M. E. 30.

7. THEORY OF BALLOONS AND DIRIGIBLES. Lectures and recitations. *Two hours.*
Study of equilibrium and stability of spherical balloons and dirigibles; description of French, German, Italian, British, and American types; resistance and propulsion, stability of dirigibles; operation and maintenance of balloons and dirigibles.
Must be preceded by Courses 1, 2, and 3.

8. DESIGN OF BALLOONS AND DIRIGIBLES. Lectures and drawing. *Four hours.*
Investigation of the design of a balloon and a dirigible from the aeronautical and strength standpoints. Questions of strength and design of all the details of the non-rigid, semi-rigid, and rigid types are discussed and complete general plans of one type are prepared.
Must be preceded by Course 7.

9. THEORY AND DESIGN OF KITES. Lectures, recitations, and drawing. *Two hours.*
Critical study of various types of man-carrying kites and the launching devices. Investigation of the design from the aeronautical and strength standpoints. Completed design of a kite train of one type is prepared.
Must be preceded by Course 7.

10. DESIGN OF AERODROMES AND HANGARS. Lectures, recitations, and drawing. *Two hours.*
Planning and equipment of aerodromes and aero-ports; construction of transportable, stationary, revolving, and floating hangars. Compelte general plan of one type are prepared.
Must be preceded by Courses 2 and 7.

11. ADVANCED STABILITY. Lectures and recitations. Advanced study of more complicated phenomena of stability according to Bryan, with Bairstow's applications of experimentally determined resistance derivatives and rotary coefficients.
Must be preceded by Course 2 and Math. 4*b* (Differntial Equations).

12. SEMINARY. Reading and reports on selected aerodynamical and aeronautical problems. Credit to be arranged. Open only to graduates and seniors who receive special permission. A reading knowledge of French and German is most desirable.

13. ADVANCED DESIGN. Continuation of Course 4*a*, taking up some of the more complex or special problems. Credit to be arranged.
Open primarily to graduates.

14. RESEARCH. Continuation of Course 5, offering an opportunity for students to pursue advanced experimental and analytical investigations of any problems in connection with aeronautics. The work of the course consists of investigations for securing data on the more difficult problems of aeronautics and mathematical interpretation of the results. Credit to be arranged.
Must be preceded by Math. 57 and 58. Open primarily to graduates. A reading knowledge of French and German is desirable.

*Note.*—Course 10 is not offered this year, but special work in this subject may be elected under Course 12.

## 195. ARCHITECTURE

Professors LORCH, SAARINEN, ROUSSEAU, Mr. WILLBY, Associate Professors MCCONKEY, TROUT, Assistant Professors BENNETT, NEWMAN; Mr. MAKIELSKI, Mr. BARNES, Mr. O'DELL, Mr. FOWLER, Mr. MATHEWS, Mr. PELIKAN, and Mr. ANGELL

1. ELEMENTS OF DESIGN. *Three hours.* Both semesters.
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. Architectural elements, their function and form; the influence of material. The pier, lintel, arch, openings; the plan and roof.
Methods of indication, rendering, lettering. Drawing exercises and lectures. This course or its equivalent must precede all architectural design courses. It should be accompanied or preceded by Architecture 2 and 21.

2. ARCHITECTURAL DRAWING. *Three hours.* Both semesters.
Descriptive Geometry; shades and shadows; use of instruments, simple projections and their application to plans, sections and elevations, roof intersections.

3. ARCHITECTURAL DRAWING. *Two hours.* Second semester.
Advanced projections and stereotomy; application to arch and vaulting problems; architectural isometric and perspective drawing.

## Architectural Design

In the following courses in Architectural Design problems are assigned to be worked out in the drafting room. Lectures are given from time to time bearing on the type of building then being designed. Study of the requirements of various classes of buildings and of the artistic possibilities of building materials, training of the student in composition in plan, section, elevation, and perspective, in accurate draftsmanship and rendering in line, black-and-white, and color.

Courses 4 to 10, inclusive, constitute a progressive series of problems in architectural planning and design, advancing from the small building to the more important classes of buildings and to the group problems. The courses must be taken in the order given.

4. ARCHITECTURAL DESIGN. *Three hours.* Both semesters.
A continuation of Course 1; the orders and simple problems in design. Illustrated lectures and drawing exercises.
Course 4 must be preceded by Courses 1, 2, and by Drawing 21.

5. ARCHITECTURAL DESIGN. *Four hours.* Both semesters.
The small ensemble. Course 5 should be preceded by Courses 3, 4, and 21 in Architecture and by Drawing 22.

6. ARCHITECTURAL DESIGN. *Four hours.* Both semesters.
This course, a continuation of Course 5, should be preceded by Architecture 5.

7. ARCHITECTURAL DESIGN. *Six hours.* Both semesters.
Plan problems. This course must be preceded by Architecture 6.

7*a*. ARCHITECTURAL DESIGN. *Four hours.* Both semesters.
For students in Program III.

8. ARCHITECTURAL DESIGN. *Six hours.* Both semesters.
Plan problems. This course must be preceded by Architecture 7.

9. ARCHITECTURAL DESIGN. *Six hours.* Both semesters.
Advanced plan problems. This course must be preceded by Architecture 8.

10. ARCHITECTURAL DESIGN. *Eight hours.* Both semesters.
Advanced plan problems. This course must be preceded by Architecture 8 or 9.

10*b*. ARCHITECTURAL DESIGN. *Credit to be arranged.*
Advanced plan problems and office practice. This course must be preceded by Architecture 7.

11. ARCHITECTURAL DESIGN. *Credit to be arranged.*
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.
Must be preceded by Architecture 6.

## 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 MEDIAEVAL ARCHITECTURE. *Three hours.* Second semester.
Should be preceded by Drawing 21 and accompanied by Architecture 4.
The architecture of Egypt, Assyria, Persia, Greece, and Rome, and a survey of the subsequent architectural development to Gothic architecture.

13. GOTHIC, RENAISSANCE, AND MODERN ARCHITECTURE. *Three hours.* First semester.
Should be preceded by Architecture 12.
The Gothic, Renaissance, and Modern Architecture of European countries, and Architecture in the United States.

14. ARCHITECTURAL HISTORY RESEARCH. *Two hours.* Both semesters.
Must be preceded by Courses 12 and 13 and two years of architectural design.
A study of the architectural development of some type of building and the preparation of an illustrated report or thesis.

15. GENERAL COURSE IN THE HISTORY OF ARCHITECTURE. *Two hours.*
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 archaeology desiring a more intensive study of the technical and historical development of architecture, Courses 12, 13, and 14 are recommended.

17. THE ALLIED ARTS OF DESIGN. *Three hours.* Both semesters.
A study of the elements of decorative design and ornament, and a survey of the decorative equipment of buildings, such as

furniture, metal work, glass, ceramics, textiles, mural painting, and decorative sculpture.
Short problems in design, research work, illustrated lectures.
Prerequisites: Drawing 21 and 22; Architecture 5 and 12 or 13.

17*a*. DECORATIVE DESIGN. *Hours to be arranged.* Both semesters.
A continuation of Course 17.

17*b*. DECORATIVE COMPOSITION. *Two hours.* The study of the principles of art as applied to the industries.

17*c*. DECORATIVE COMPOSITION. *Two hours.* Continuation of Arch. 17*b*.

18. ARCHITECTURAL COMPOSITION. *One hour.*
This course supplements the course in architectural design by a series of illustrated lectures.

### Building Construction and Equipment

19. ARCHITECTURAL MECHANICS. Statics, Stresses in Simple Frames. *Three hours.* Both semesters.
The principles of equilibrium. Analysis of stresses in simple frames by graphic and algebraic methods. Must be preceded by Mathematics 1E and Physics 1.

20. ARCHITECTURAL MECHANICS. Advanced Problems in Statics. Strength of Materials. *Three hours.* Both semesters.
Must be preceded by Architecture 19.

21. WOOD CONSTRUCTION. Lectures, conferences, drawing, and visits to buildings. *Two hours.*
Building materials and processes; working drawing; specifications and estimates of cost.
This course must be preceded by Architecture 1 and 2.

22. STEEL AND FIREPROOF CONSTRUCTION. *Three hours.* Second semester. Must be preceded by Architecture 19 and 20.
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.

22*a*. STRUCTURAL THEORY. *Three hours.* Both semesters.
Must be preceded by E. M. 1 and E. M. 2.
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.

23. STRUCTURAL DESIGN: STEEL. *Two hours.* Second semester.
Must be preceded or accompanied by Architecture 22.
Working drawings and details of a steel-frame building.

23*a*. STRUCTURAL DESIGN. *Two hours.* Both semesters.
Must be preceded or accompanied by Architecture 22*a*.
Lectures and drafting accompanying Architecture 22*a*. 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 designs and working drawings. Emphasis is laid on the cultivation of careful, systematic, and practical habits in computation.

24. BUILDING SANITATION. *One hour.* First semester.
Plumbing and drainage. A study of materials, fixtures, methods of assembling, and modes of arrangement. Lectures and drawings.
Prerequisites: Architecture 4 and 21.

25. BUILDING DETAILS. *Two hours.* Second semester.
Must be preceded by Architecture 6 and 21.
The purpose of this course is to give some specific training in detailing portions of buildings. Scale and full-size details.

26. MASONRY AND REINFORCED CONCRETE. *Two hours.* First semester. Must be preceded by Architecture 19 and 20.
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.

27. STRUCTURAL DESIGN: MASONRY. *Two hours.* First semester.
Must be accompanied by Architecture 26.
The design of foundations, columns, slabs, beams, and girders of various types, as used in buildings.

35*a*. STRUCTURAL THEORY (ADVANCED). *Four hours.*
Must be preceded by Architecture 22*a*, and a course in reinforced concrete.
Recitations, problems, text, and lectures. This is an extended course in continuation of Architecture 22*a*. 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, the slope deflection method, and higher framed structures. Study is

devoted to the analysis of wind stresses in buildings and brief study is devoted to the elastic theory of metal, stone, and concrete arches.

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.

35*b*. STRUCTURAL DESIGN (ADVANCED). *Three hours.*

Must be preceded by Architecture 23*a*, and preceded or accompanied by Architecture 35*a*.

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.

36. CONCRETE THEORY. *Three hours.* 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. I and E. M. II and should be preceded by A. 22*a*.

## Drawing and Painting

The following courses are open to others as well as Architectural students. The courses are to be elected as Drawing 21, 22, etc., and in the order given.

All of the courses are offered both semesters and instruction is given in Courses 21 to 26, inclusive, every morning and every afternoon with the exception of Saturday afternoon only.

Drawing in charcoal, pencil, and wash, largely from casts and from the living model. This work may be varied somewhat to permit some sketching out of doors. Pen and ink should not be elected until after the student has mastered the fundamentals of representation.

For the general student Courses 21, 22, and 24 will give an elementary training in drawing and painting. Course 30 provides more advanced work in painting; Courses 25, 26, and 27 more advanced training in drawing. Course 23 is a special course in the drawing of ornament for students of architecture and decoration, while Course 35 is primarily for Architectural students, although open to others. Outdoor sketching and painting can best be studied during the Summer Session.

At present there are no classes in portrait painting, but such instruction can, under certain conditions, be arranged for groups of students who have advanced preparation. Still-life painting in water color or oil cannot be studied profitably without some preliminary

training in free-hand drawing (Drawing 21 and 22). For drawing from the living model some preliminary training is required from the antique (Drawing 25 and 26).

Advancement in all these courses is individual, depending on the progress made by the student and determined largely by work done without criticism. Advanced standing may be had as in other subjects on the basis of satisfactory work done elsewhere. Drawings should be brought to help determine the student's standing, also letters or certificates from the institution attended.

21. FREE-HAND DRAWING. *Two hours.* Introductory Course.
Drawing from simple forms in line, and light and shade. Free-hand Perspective.

22. FREE-HAND DRAWING. *Two hours.*
Drawing from simple decorative forms in charcoal and pencil.

23. FREE-HAND DRAWING. *Two hours.*
Drawing from decorative forms.
Must be preceded by Drawing 22.

24. WATER COLOR PAINTING. *Two hours.*
Painting from still life.
Must be preceded by Drawing 21 and 22.

25. FREE-HAND DRAWING. *Two hours.*
Drawing from parts of the figure.

26. FREE-HAND DRAWING. *Two hours.*
Drawing from the full figure.

27 and 28. FREE-HAND DRAWING. *Two hours each.*
Drawing from life.
Admission to these courses is limited to those who have satisfactorily completed the preceding courses or their equivalent.

30. WATER COLOR PAINTING. *Two hours.*
Painting in water color from still life. This course must be preceded by Drawing 24.

31. PASTEL DRAWING AND PAINTING. *Two hours.*
Drawing and Painting from still life in pastel.
Must be preceded by Drawing 24.

32. DRAWING AND PAINTING IN OIL. *Two hours.*
Drawing and Painting from still life in oil.
Must be preceded by Drawing 24.

33. CLAY MODELING. *Two hours.*

35. PEN AND INK DRAWING. *One or two hours.* Elective.
For regular students of Architecture this course must be pre-

ceded 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.

36. PENCIL SKETCHING. *One or two hours.* Pencil technique, from architecture and landscape.

38. COSTUME SKETCH. *One hour.* Drawing from the costumed model in various media.

38*a*. ADVANCED COSTUME SKETCH. *One hour.*

*PRIMARILY FOR GRADUATES*

30 ARCHITECTURAL DESIGN. Special problems in planning and design. Must be preceded by the equivalent of Architecture 10.

33. ARCHITECTURAL HISTORY. A thesis on the architectural work of a period or on a particular monument. Must be preceded by the equivalent of Architecture 12, 13, and 14.

38. STRUCTURAL DESIGN. Special problems in building construction. Must be preceded by the equivalent of Architecture 35. *Hours to be arranged.*

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:

5*s*. *Elementary Architectural Design. Three hours.* Architectural form, drawing, and rendering; introductory problems in architectural design.

7*s*. *Intermediate Architectural Design. Credit to be arranged.*

9*s*. *Advanced Architectural Design.* Plant problems. *Credit to be arranged.*

FREE-HAND DRAWING.

A. *Free-Hand Drawing in Charcoal and Pencil.* Elementary. The aim of this course is to cultivate the eye and train the hand in order to develop the ability to represent correctly and interest-

ingly simple decorative forms. The work assigned to each student will depend upon the previous preparation of the student and is planned to meet the needs of students of Architecture and Architectural Engineering, teachers, and others. For the students of Architecture and Architectural Engineering the work of the course will conform to that of Courses 21, 22, and 23 as given in the regular session. *Two hours credit.*

A. *Free-Hand Drawing.* Advanced. The work of the course, if elected by students of Architecture or Architectural Engineering will conform to that of Courses 24, 25, 26, 27 and 28, as given in the regular session. For teachers and others the instruction will consist in drawing from casts and still life, and some outdoor sketching and painting. The work will be arranged to meet the needs of the student. *Two hours credit.*

---

## 196. ASTRONOMY

Professors HUSSEY, CURTISS, Assistant Professors RUFUS, ROSSITER.

Courses 1, 2, and 2*a* and 8*a* are recommended to those who wish to obtain a general knowledge of Modern Astronomy without entering far into its mathematical details.

Courses in addition to those mentioned below are listed in the College of Literature, Science, and the Arts. These include advanced work in Theoretical Astronomy, Practical Astronomy, and Astrophysics. The instruments of the Observatory, when not otherwise employed, will be available to advanced studied who have the technical ability to use them to advantage.

1. GENERAL ASTRONOMY. The Solar System. *Three hours.* Both semesters.

   A descriptive course, including the fundamental principles of Astronomy, and a presentation of the leading facts respecting the sun, moon, planets, and comets. Occasional lantern illustrations.

2. GENERAL ASTRONOMY. Stars and Nebulæ. *Three hours.* Both semesters.

   A general descriptive course in stellar and nebular astronomy. Occasional lantern illustrations. May be taken in continuation of Course 1, or independently, as desired.

2*a*. ELEMENTARY OBSERVATIONAL ASTRONOMY. *One hour.* Both semesters.

   Constellation studies and telescopic examinations of the heavenly bodies. Selected problems with the celestial globe and the equatorial telescope. Observational work and lectures at the Observatory.

3. PRACTICAL ASTRONOMY. *Two hours.* Both semesters.
The elements of Spherical Astronomy. Theory of the sextant and transit and their use in the solution of practical problems, including determinations of time, latitude, azimuth, and longitude. The observational work at the Observatory in connection with this course will be varied to suit the needs of students from the different departments. See Course 3E.

3E. GEODETIC ASTRONOMY. *Two hours.* Both semesters.
Covers ground of Course 3, with less Observatory practice and more classroom work, including a short course in Descriptive Astronomy.

6. LEAST SQUARES AND EMPIRICAL CURVES. *Two hours.* Second semester only.
Theory of the error curve and the treatment of observational data according to the Method of Least Squares.

22. NAVIGATION. *Lectures. Three hours.* Second semester only.
The principles of piloting, dead reckoning, and Nautical Astronomy, including practice with sextant.

SUMMER SESSION

Courses 1*s*, 2*s*, and 3 or 3E will be given during the Summer Session of 1924. Provision will also be made for graduate students who are specializing in Astronomy.

## 197. BACTERIOLOGY, AND WATER ANALYSIS

Professor NOYY, Mr. EMERSON.

3E. PRACTICAL BACTERIOLOGY.
This course is open only to students of Sanitary Engineering. Three afternoons each week during the second half of the first semester, beginning December 1.

5E. WATER ANALYSIS.
Two afternoons weekly, from October 1 to December 1.
This course is open only to students of Sanitary Engineering.

## 198. CHEMICAL ENGINEERING

Professors A. H. WHITE, A. E. WHITE, BADGER, LESLIE, Assistant Professors WOOD, UPTHEGROVE, BAKER, CAMPBELL, HAYWARD, Mr. BROWN, Mr. GENIESSE, Mr. CARR.

Students intending to specialize in Chemical Engineering are advised to obtain a reading knowledge of both French and German. If only one language can be studied, it should be German, which, on account of the importance of its scientific literature, will be found to be almost indispensable to the advanced student.

1. ENGINEERING MATERIALS. Lectures and recitations. *Three hours.* Both semesters.

An elementary study of the manufacture and properties of the ferrous and non-ferrous alloys, cements, clay products, and protective coatings.

Prerequisite: Chem. 2E.

2*a*. FUELS AND FURNACES. Lectures, recitations and laboratory. *Three hours.* Both semesters.

A study of the preparation, combustion and utilization of fuels, including measurement of temperatures; analysis of gases, determination of heating values, and computation of heat balances, maximum temperatures, furnaces efficiencies and relative costs.

Prerequisite: Preceded or accompanied by Course 1 in Chemical Engineering and 2E in Physics.

3. STRUCTURE AND PROPERTIES OF METALS. Lectures, recitations and laboratory. *Three hours.* Both semesters.

A study of the structure of metals as affected by composition, and thermal and mechanical treatment; the relation of structure and thermal and mechanical treatment to properties; and the factors that determine or limit the uses of metals and common alloys.

Prerequisites: Course 1 in Chemical Engineering and Course 2E in Physics.

4. CHEMICAL TECHNOLOGY OF THE INORGANIC INDUSTRIES. Lectures and recitations. *Two hours.* Both semesters.

A descriptive study of the processes and manufacturing methods used in the more important industries based on inorganic chemical technology. The subjects included are: Evaporation and fractional crystallization; salt, potash nitrates and borax; sulphur; sulphuric, hydrochloric, and nitric acids; fixation of atmospheric nitrogen; chlorine, bromine and iodine; bleaching powder; soda ash; caustic soda; electric furnace products, including aluminum, graphite, carborundum, and cyanamide.

Prerequisites: Course 2 in Chem. Eng. Course 8 or 8E in Chemistry, and Course 2E in Physics.

5. CHEMICAL TECHNOLOGY OF THE ORGANIC INDUSTRIES. Lectures and recitations. *Four hours.* Both semesters.

A descriptive study of the processes and manufacturing methods used in the more important industries based on organic chemical technology. The subjects included are: Destructive distillation of wood and coal; manufactured and natural gases; petroleum and its products; coal tar; fats, oils, and waxes; soaps, fatty acids, and glycerine; paints and varnishes; rubber; glue, casein, and proteins; leather; starch and dextrins; corn products and glucose; sugar; industrial alcohol; cellu-

lose and nitrocellulose; pyroxylin plastics, artificial leather and silk; explosives; paper; textiles; bleaching and dyeing; dyes and intermediates.

Prerequisites: Course 2 in Ch. Eng.; 7 and 8 or 8E in Chemistry.

7. NON-FERROUS METALLURGY. Lectures and recitations. *Two hours.* First semester only.

A course in the metallurgy of copper, zinc, lead, tin, nickel, and aluminum, covering extractive processes, fabrication and production and properties of alloys.

Prerequisite: Course 2 in Chemical Engineering; or Course 1 in Chemical Engineering and Course 3 in Mechanical Engineering.

8. METALLOGRAPHY OF IRON AND STEEL. Lectures and laboratory work. *Two hours.* Both semesters.

Especial study is made of the microscopic structure of iron, steel, and other alloys, and of the effects upon these structures caused by heat treatment, mechanical work, and composition.

Prerequisite: This course must be preceded by Course 6 in Chemical Engineering, Course 8 or 8E in Chemistry, and Course 2 or 6 in Engineering Mechanics.

10. TECHNICAL EXAMINATION OF GAS AND FUEL. *One hour.* Both semesters.

Laboratory work. The analysis of commercial gases and the determination of the heating value of fuels.

Designed especially for Mechanical Engineering students. Not open to students in Chemical Engineering.

Prerequisite: Must be preceded by Course 1 in Chemical Engineering, Course 2E in Chemistry, and Course 1E in Physics, and accompanied by Course 7 in Mechanical Engineering.

12. SPECIAL PROBLEMS. *Three to eight hours.* Both semesters.

The purpose of this course is to train the student in methods of independent study. 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, as far as possible, urged to select that which interests him most.

Prerequisite: Course 1, 2, and 4 in Chemical Engineering, and Chemistry 5, with Course 5 in Chemical Engineering, and Chemistry 7 and 7*a* in addition if the subject involves organic chemistry; or E. M. 2*a* or 6 if the subject involves metallurgy. A reading knowledge of French or German (preferably German) is also required.

13. EVAPORATION, FILTRATION, AND TRANSPORTATION OF LIQUIDS. *Two hours.* First semester only.

A study of the principles of transportation of liquids, heat transfer, heating and evaporating, and filtration. The construction

of commercial types of equipment for carrying out these operations is studied from trade bulletins and blueprints of plant equipment.

Prerequisite: Courses 1, 2, and 4 in Chemical Engineering.

14. MACHINERY AND PROCESS FOR CONVEYING, GRINDING, AND MIXING. *Two hours.* Second semester only.

A descriptive study of the treatment of materials on the manufacturing scale.

Prerequisite: Courses 1, 2, and 4 in Chemical Engineering.

15. SEMINARY. Reading and reports on selected subjects. *Two hours.* Both semesters.

Open only to graduates and seniors who receive special permission. A reading knowledge of German and French is required.

16. THE MANUFACTURE OF ILLUMINATING AND FUEL GASES AND MOTOR FUELS. Lectures and recitations. *Two hours.* Second semester only.

The course is devoted to a study of the manufacture of coal gas, water gas, producer gas, oil gas, natural gas, gasoline and motor fuels.

Prerequisite: Course 5 in Chemical Engineering.

18. METALLOGRAPHY OF THE NON-FERROUS METALS. *Two hours.* Second semester only.

A 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.

Prerequisite: Course 7 or 8 in Chemical Engineering.

21. SPECIAL LABORATORY WORK. *Three to eight hours.* Both semesters.

Research work along special lines. The courses are open only to graduates and seniors who receive special permission.

*a.* THE CONSTITUTION OF STEEL.

Research work on the constitution of steel as influenced by chemical composition, and heat and mechanical treatment.

*b.* HYDRAULIC CEMENTS.

Research work on the properties of hydraulic cements as influenced by chemical composition, temperature of burning and heat treatment.

*c.* GAS.

Research relating to the manufacture, properties, and uses of coal gas, water gas, oil gas, and producer gas.

*d.* PAINTS AND VARNISHES.

Research on the manufacture and properties of protective coatings.

*e.* PULP AND PAPER.
An advanced course in the manufacture of pulp and some phases of paper manufacture.

*h.* EVAPORATION.
Work on the design of evaporators and on problems connected with handling of liquids on the commercial scale.
Should be preceded or accompanied by Course 13.

*i.* ADVANCED METALLURGY (FERROUS).
Advanced work on the structure and properties of iron and steel.

*j.* ADVANCED METALLURGY (NON-FERROUS).
Advanced work on the structure and properties of non-ferrous metals and alloys.

*k.* PETROLEUM AND MOTOR FUELS.
Studies of problems connected with the distillation, cracking, and refining of petroleum and its products.

*l.* MOTOR FUEL UTILIZATION.
Studies of the problems involved in the utilization of gasoline and other motor fuels.

*m.* DISTILLATION.
Work on the theory, design, and performance of distillation equipment.

*n.* CAST METALS.
Investigations on processes for producing metal castings.

*o.* REFRACTORIES.
A study of the thermal and physical properties of refractory materials.

23. DESIGN OF CHEMICAL PLANTS. *Two hours.* Second semester.
A simple chemical process is selected, and the student proceeds to plan the steps in the process and select the type of apparatus for each.
Must be preceded by Course 13, and preceded or accompanied by Course 14 in Chemical Engineering and Course 2 in Mechanical Engineering.

24. PYROMETRY AND FURNACE CONTROL. *Two hours.* Both semesters.
A study of the theory, construction, calibration and use of commercial pyrometers. The well equipped laboratory furnishes opportunity for first hand acquaintance with all important types of pyrometers, their applications and limitations.
Must be preceded by Course 2E in Physics and Course 6 in Chemical Engineering.

26. ADVANCED FERROUS METALLURGY. Lectures and recitations. *Two hours.* Second semester.
A study of the constitution of irons and steels and the effect on

their properties of composition, heat treatment, and mechanical work

Prerequisites: Courses 6 and 8 in Chemical Engineering.

27. DESIGN OF CHEMICAL MACHINERY. Conferences and drafting. *Two hours.* Both semesters.

The student selects some piece of chemical machinery and makes a complete set of drawings as would be required for its actual construction.

Prerequisites: Course 13 in Chemical Engineering and Course 2 in Mechanical Engineering.

28. EQUIPMENT AND PROCESSES FOR DRYING, DISTILLATION, GAS ABSORPTION, AND EXTRACTION.

A study of the fundamental theory of drying, distillation, gas absorption, and extraction. This is supplemented by a critical description study of apparatus now in common use.

Prerequisites: Must be preceded by Courses 4 and 5 in Chemical Engineering.

29. CHEMICAL ENGINEERING LABORATORY. Two to five hours. Evaporator Laboratory. *Hours to be arranged.* Both semesters.

A series of tests on various types of chemical engineering equipment. This course is designed for students who wish training of this kind without concentrating on one problem.

30. SEMINARY IN METALLURGY. Reading and reports on metallurgical subjects. *Two hours.* Both semesters. Only open to graduates and seniors who receive special permission.

32. EXPLOSIVES AND PYROTECHNICS. *Four hours.*

This course is offered at the request of the Postgraduate School of the U. S. Naval Academy at Annapolis. The course includes a study of the processes used in the manufacture of commercial and military explosives and pyrotechnics as well as a study of their properties and uses.

Prerequisites: Must be preceded or accompanied by Chemical Engineering 5 and Chemistry 7*a*.

33. SEMINARY IN HEAT TRANSFER. *Two hours.*

Conferences and problems. Open only to graduates and seniors who receive special permission.

34. PULPS FOR PAPER MANUFACTURE. *Two hours.*

Open only to graduate students.

36. PAPER MANUFACTURE. *Two hours.*

Open only to graduate students.

## SUMMER SESSION

Summer Session Courses, 1, 2*a*, 3, 8, and 12, as described in the regular sessions, will be given in the Summer Session of 1924.

## 199. CHEMISTRY

Professors CAMPBELL, GOMBERG, BIGELOW, LICHTY, SMEATON, WILLARD, BARTELL, Assistant Professors CARNEY, SCHOEPFLE, MELOCHE, FERGUSON, MCALPINE, Mr. COLE, Dr. HODGES, Dr. SNOW, Mr. SOULE, Dr. WEATHERILL, Dr. BLICKE, Mr. TABERN.

Students admitted with a deficiency in entrance chemistry may remove it by completing Courses 1 or 1*b*, but the credit thus obtained is entered on the admission, not on the graduation, requirements. Students who have thus completed Course 1 or 1*b* will proceed with Course 2 instead of 2E.

Other courses in chemistry are given in the College of Literature, Science, and the Arts, and in the Graduate School, and may be elected by students of the College of Engineering who have had the requisite preparation.

Students intending to specialize in chemistry are advised to obtain a reading knowledge of both French and German.

1. GENERAL AND INORGANIC CHEMISTRY. *Four hours.* Two lectures, two recitations, two laboratory periods. First semester only.
This course embraces a study of non-metallic elements and their compounds, with special emphasis upon the interpretation of chemical phenomena from the viewpoint of recent theory and investigation, accompanied by a systematically arranged course of laboratory experiments designed to illustrate the fundamental principles underlying the science.

1*b*. GENERAL AND INORGANIC CHEMISTRY. *Four hours.* Two lectures, two recitations, two laboratory periods weekly.
This course offers an opportunity for those entering the University at the opening of the second semester to commence the study of chemistry, but no student will be admitted who might have elected Course 1. Special permission must be obtained from the instructor in order to elect this course.

2E. GENERAL AND INORGANIC CHEMISTRY. Two lectures, two recitations, and two laboratory periods weekly. *Five hours.* Both semesters.
The descriptive chemistry of the non-metals and metals is covered, with special reference to engineering problems. The course is based upon modern theoretical principles, including the development of the stoichiometrical laws, the law of mass action, chemical equilibria, the kinetic theory of gases, theory of solution, theory of electrolytic dissociation, atomic and molecular hypothesis, and the periodic classification.
This course is for students who have presented a unit of chemistry for entrance. An examination will be held within the first four weeks and those considered inadequately prepared will be transferred to Course 1, to be elected without credit.

2. GENERAL AND INORGANIC CHEMISTRY. Continuation of Course 1. *Four hours.* Second semester only.

3. QUALITATIVE ANALYSIS. Recitations and laboratory work. *Five hours.* Both semesters.

In this course the distinctive properties of some of the more common chemical compounds are studied, with special reference to their use in analysis. In addition to practice with known materials, the correct analysis of a considerable number of unknowns is required.

Open to those who have completed Course 2 or 2E.

3*a*. QUALITATIVE ANALYSIS. Recitations and laboratory work. *Four hours.* Both semesters.

A study of the distinctive properties of some common substances in water solutions and the reactions used in the identification of such substances. Attention is directed to reactions which bear on problems met in engineering practice.

Open to those who have completed Course 2 or 2E.

3*b*. QUALITATIVE ANALYSIS. Continuation of Course 3*a*. *Four hours.* Both semesters.

This course involves the identification of a wider range of substances and the analysis of more difficult mixtures, including some alloys, slags, and phosphates.

5. QUANTITATIVE ANALYSIS. Recitations and laboratory work. *Five hours.* Both semesters.

General methods of determining the amounts of constituents present in simple and complex mixtures are studied in classroom and laboratory.

Open to those who have completed Course 3 or 3*b*.

7. ORGANIC CHEMISTRY. Lectures, recitations, and laboratory work on the properties and classification of carbon compounds. *Five hours.* Both semesters.

7*a*. ORGANIC CHEMISTRY. Lectures, recitations, and laboratory work. *Five hours.* Continuation of Course 7 Both semesters.

8. ELEMENTARY THEORETICAL AND PHYSICAL CHEMISTRY. Lectures and recitations. *Four hours.* Second semester only.

8E. ELEMENTARY THEORETICAL AND PHYSICAL CHEMISTRY. Lectures and recitations. *Three hours.* First semester only.

Special attention will be paid to the study of chemical equilibrium, velocity of chemical reactions, and applications of physicochemical theory. Open to those who have completed Chemistry 3 or 3*b* and Physics 2. A knowledge of calculus is also required.

13. PHYSICAL-CHEMICAL MEASUREMENTS. Laboratory work. *Three to eight hours.* Both semesters.
Methods for the determination of molecular weight, viscosity, surface tension, reaction velocity, solubility, etc.; optical measurements with refractometer, polarimeter, and spectroscope; electrical measurements,—such as conductivity, transport numbers, and electromotive force. Open to those who have completed or are taking Courses 5 and 8E.

14. ELECTROCHEMISTRY. Lectures. *Two hours.* First semester only.
An elementary treatment of the fundamentals of the subject.

14*a*. ELECTROCHEMISTRY. Laboratory work. *Two hours.* First semester only.
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.
Open to those who have completed or are taking Course 14, or its equivalent.

14*b*. APPLIED ELECTROCHEMISTRY. Laboratory work. *Two hours.* Second semester only.
Application of principles of electrochemistry to analytical and industrial processes.

15. HISTORY OF CHEMISTRY AND DEVELOPMENT OF CHEMICAL THEORY. *Two hours.* Both semesters.

23. ADVANCED THEORETICAL AND PHYSICAL CHEMISTRY. Lectures. *Two hours.* Second semester only.
A continuation of Course 8E. Special attention is given to velocity of chemical reactions and chemical equilibria. The work includes a study of the principles of thermo-chemistry, applications of the phase rule, and a brief survey of recent advances in the field of Physical Chemistry.

25. CHEMISTRY OF COLLOIDS. Lectures. *Two hours.* Second semester only.
Open only to those obtaining permission of the instructor.

28. ADVANCED QUANTITATIVE ANALYSIS. Lectures and laboratory work. *Four or five hours.* Both semesters.
Application is made of the principles laid down in Course 5 to the analysis of some technical products, including coal, iron, and other ores, a silicate rock, and ferrous and non-ferrous alloys.
Open to those who have completed Course 5.

31. INDEPENDENT WORK IN MINERAL ANALYSIS. *Five hours.* Both semesters.

A study of some of the more difficult and uncommon problems of quantitative analysis. The student is left largely to his own resources.
Open to those who have completed Course 28.

32. PHYSICO-CHEMICAL METHODS IN ANALYTICAL CHEMISTRY. Lectures and labroatory work. *Two hours.* First semester only.
Open to those who have completed Courses 8E and 28.

36. RESEARCH IN INORGANIC CHEMISTRY. Special attention will be given to the chemical constitution of metals, silicates, or other substances of importance. *Credit to be arranged.*
Course 36 requires special permission.

37. ORIGINAL INVESTIGATION IN ANALYTICAL CHEMISTRY. Laboratory work. *Credit to be arranged.*
Course 37 is open only to those who have special permission.

43. ADVANCED ORGANIC CHEMISTRY AND ULTIMATE ANALYSIS. Laboratory work and reading. *Two to five hours.* Both semesters.

45. ADVANCED ORGANIC CHEMISTRY. Lectures and reading. *Two hours.* First semester only.
Open to those who have completed Courses 7 and 7*a*.

47. ADVANCED ORGANIC CHEMISTRY. Lectures and reading. *Two hours.* Second semester only.
Open to those who have completed Courses 7 and 7*a*.

### SUMMER SESSION

Course 1, 2, 3, 3*a*, 3*b*, 5, 7*a*, 8E, 15, 28, 37, and 43, as described for the regular session, will be given in the Summer Session of 1924.

## 200. CIVIL ENGINEERING

Professors RIGGS, KING, HOAD, GRAM, DECKER, BLANCHARD, WORLEY, CISSEL, WISLER, SWINTON, BATEMAN, SHERLOCK, Mr. ALT, Mr. POPE, Mr. HOUSEL.
Structural Group C. E. 2 to C. E. 9, inclusive.
Hydraulic Group C. E. 10 to C. E. 19, inclusive.
Transportation Group C. E. 20 to C. E. 29, inclusive.
Sanitary and Municipal Group C. E. 30 to C. E. 39, inclusive.
Highway and Highway Transport Group C. E. 40 to C. E. 49, inclusive.
Graduate Group C. E. 60 to C. E. 84, inclusive.
Graduate Short Period Courses in Highway Engineering and Highway Transport C. E. 67 to C. E. 84, inclusive.

2. THEORY OF STRUCTURES. *Three hours.* Both semesters.
Lectures, text and problems covering analysis of stresses in sim-

ple structures under various conditions of loading. Both graphical and analytical methods are discussed and applied to practice problems.

Course 2 must be preceded by Course 2 in Engineering Mechanics. Required of all Civil Engineering students.

2*a*. ELEMENTARY DESIGN OF STRUCTURES. *Three hours.* Both semesters.

Lectures and drawing work, covering theory of beams and plate girders, mill buildings, and elements of design of simple structures.

Course 2*a* must be accompanied or preceded by Course 2 and preceded by Drawing 3.

Required of all Civil Engineering students.

The number of hours in this course is changed to three in 1924-25. Adjustments will be made in the case of students who have been in residence.

3. MASONRY. *Four hours.* Both semesters.

Lectures, text, and problems covering properties of materials, analysis of stresses in masonry structures, particularly plain and reinforced concrete; foundations, footings, piling, pipe rings, culverts, portals and arches.

Course 3 must be preceded by Course 2.

Required of all Civil Engineering students.

The number of hours in this course is changed to four in 1924-25. Adjustments will be made when necessary in the case of students who have been in residence.

4. ADVANCED THEORY OF STRUCTURES. *Two hours.* Second semester only.

Lectures, problems, and assigned reading covering analysis of stresses in special types of structures, cantilevers, draw spans, and arches.

This course is a continuation of Course 2 for students especially interested in structural engineering, and must be preceded by it.

5. DESIGN OF STRUCTURES. *Three hours.* Both semesters.

Lectures, text and drawing covering the general design of reinforced concrete, steel, and timber structures. Two afternoons a week.

Course 5 must be preceded by Course 2*a* and 3.

Course 5 required of all Civil Engineering students electing Group A, Structural Engineering.

6. ADVANCED MASONRY AND FOUNDATIONS. *Two hours.* Both semesters.

Lectures, text, and problems covering theory of ordinary foundations; footings; piling; advanced study of reinforced concrete and its application in practical problems; analysis of

stresses and elements of design of special types of masonry structures, pipe rings, culverts, portals, and arches.
Course 6 must be preceded by Course 3.

7. ADVANCED DESIGN OF STRUCTURES. *One to four hours.*
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.
Course 7 is open to graduate students and to qualified seniors by special permission.

*a. Bridge Design. Four hours.* Second semester only.
Lectures, recitations and drawing covering studies of Waterway Determination; Live Loads for Railway and Highway Bridges, Bridge Floors and Design of Bridge Superstructure and Foundations. Must be preceded by Courses 4 and 5.

*b. Reinforced Concrete. Three hours.* Both semesters.
Lectures and drawing covering the various structural features of reinforced concrete building construction, and drafting room practice in the general design and detailing of reinforced concrete. Must be preceded by Course 5.

*c. Arches. Two hours.* Second semester.
Lectures, recitations and drawing covering the analysis of stresses and design of various types of arches. Particular attention is given to arches of reinforced concrete. Must be preceded by Course 5.

*d. Timber Construction. One hour.* Both semesters.
Lectures and drawing covering the physical characteristics of structural woods, principles involved in the selection of timber for structural purposes, grading rules, commercial practice and design of typical timber constructions. Must be preceded by Course 2*a*.

10. HYDROLOGY. *Three hours.* Both semesters.
Lectures, reference, texts, problems, and field work. Stream gauging; study of drainage basins; relation between precipitation and run-off; effect of seepage, evaporation and temperature on run-off; estimates of discharge from existing data; fluctuations in discharge of streams—daily, monthly, and yearly; the storage of water; study of floods.
Course 10 must be preceded by Course 4 in Engineering Mechanics. Required of all Civil Engineering students.

11. HYDRAULICS. *Two hours.* First semester only.
Lectures, reference texts, and problems. Flow of water in open channels; flow of water in pipes; the use of weirs; determina-

tion of hydraulic coefficients; transportation of sediment in streams and canals.

Course 11 must be preceded by Course 4 in Engineering Mechanics.

12. DEVELOPMENT OF WATER POWER. *Three hours.* Second semester. Hydraulic problems in connection with water power development; hydraulics of turbines; market conditions; estimates of cost of construction and operation; economic considerations; reports; dams and power houses.

Course 12 must be preceded by Course 4 in Engineering Mechanics, and preceded by Course 10.

13. ADMINISTRATION OF WATER RESOURCES. *Two hours.* Second semester only.

The administration of streams of foreign countries: (a) Under the common law. (b) Modern administration under the direction of engineers. The development of the common law doctrine and its introduction into the United States. The expansion of the doctrine by court decision and present day status of stream administration in the United States. The necessity of an engineering administration. Study of stream administration in Western states where the courts are resorted to only upon appeal, and where litigation is not common. Specific problems relating to the organization of an administration for any particular state.

Open to fourth and fifth-year students.

14. IRRIGATION AND DRAINAGE. *Two hours.* Second semester only. Lectures, reference texts, and problems.

History of the development of both sciences; demand for them in the United States and throughout the world; principles underlying the use of water from streams; laws relating to irrigation and drainage; laying out irrigation and drainage systems — structures, designs, construction; maintenance of irrigation and drainage systems; use of water; economic considerations.

Course 14 must be preceded by Course 10.

16. DESIGN OF HYDRAULIC STRUCTURES. *Three hours.* Second semester only. Lectures and design.

Dams; power houses; tunnels; penstocks; pressure pipes; headgates, spillways, other structures.

Open only to fourth and fifth-year students.

Course 16 must be preceded by Courses 3 and 10, and accompanied by Course 12.

Required of students electing Group B, Hydraulic Engineering.

18. RIVERS AND HARBORS. *One hour.* Second semester only. Lectures and assigned reading.

Breakwaters; dredging, wharves, sea-walls, and river regulation.

20. RAILROAD LOCATION. *Two hours.* First semester only.
Field and office methods of railroad location; train resistance; curve resistance; the vertical profile.
Organization and capitalization of railroads; estimation of volume of traffic; the locomotive; locomotive types; engine rating; assistant engines; resistance to traction; the influence of location on earning power.
Open only to students in Engineering.

21. RAILROAD ENGINEERING. *Two hours.* Both semesters.
Grading, track, railway structures, water, fuel, and icing stations; signaling; types of construction; methods and costs of construction, maintenance, and location.
Open to students in Engineering and Railroad Administration Course.

22. TRANSPORTATION. *Two hours.* Second semester only.
History of transportation; the relationship of waterway and railway transportation; the highways and highway transport as auxiliaries of transportation; the relation of transportation to the political and economic development of the nation.
This course is for students of the Economics department who desire a general knowledge of transportation, and for students of Engineering.

23. RAILROAD DESIGN. *Three hours.* Second semester only.
Yard and station ground maps; turnouts and track special work; yard design; railway structures; study of standard plans of railroads; problems in special railway structures.
This course is designed to offer a series of problems such as are regularly met in railway practice. Occasional field work and inspection trips take the place of some of the design periods.
Required design course for students electing Group C, Transportation Group.
Must be accompanied by Courses 20 and 21.
Open only to fourth and fifth-year Engineering students.

26. SPECIFICATIONS AND CONTRACTS. *Two hours.* Both semesters.
Lectures and assigned reading or discussion.
The essential elements of a contract; bids and bidders on public work; the conduct of public lettings; clauses which should be included in properly drawn contracts covering time, liquidated damages, manner of payment, extra work, defective materials or work; custom and usage as affecting engineering contracts; the duties and powers of the engineer; limitation of engineer's powers; breach of contract; specifications; matter to be included; proper methods of preparing the engineer as a professional man; contracts for professional services; the engineer in court; witness as to facts; expert witness.
Open to fourth and fifth-year students in Engineering and Architecture.
Required of all Civil Engineering students.

27. PUBLIC UTILITY PROBLEMS. *Two hours.* Both semesters.
Lectures and outside reading.
The Relations of Public Utility Corporations to the public served by them. Modern problems which have grown out of the failure to understand these relations.
The reason for making valuations; theories of value; original cost; cost of reproduction; depreciation; going value and other intangible values. Estimating methods to be adopted under differing conditions. The analysis of estimates; Reasons for variation of estimates in different localities. Overhead items of expense engineering, legal expense and interest. Part of the work of this course will be in the analysis of unit prices to give the student a clear conception of the items that must be taken into account in estimating for various purposes.
Open to fourth and fifth-year students.

30. WATER WORKS. *Three hours.* Both semesters.

Lectures and recitations, with assigned reading and problems.
A general study of the municipal water supply problem. Includes a consideration of the sources and character of water supplies, and of the quality required for various municipal purposes; development of supply by means of impounding reservoirs, wells, infiltration galleries, and intakes; design and construction of aqueducts and pipe lines; purification by settling basins and filters; distribution; storage reservoirs, standpipes and elevated tanks, cast iron pipe; the use of meters; fire protection.
Course 30 must be preceded by Course 4 in Engineering Mechanics. Required of all Civil Engineering students.

31. WATER PURIFICATION. *Two hours.* Second semester only.
Lectures and recitations, largely supplemented by library reading and the study of plans.
This course relates chiefly to engineering methods and devices for improving the sanitary quality and enhancing the economic value of municipal water supplies. It involves studies of the relation of water supply to public health, the sources of impurities in water supplies, the effect of storage, the control of water sheds. Sedimentation, the action of coagulants, filtration, sterilization, iron removal, water softening, and other processes are studied in detail, both in the class room and by trips to nearby municipal purification plants.
Course 31 must be preceded by Course 30.
Open only to fourth-year and fifth-year students.

32. SEWERAGE. *Two hours.* Both semesters.
Lectures and recitations, with assigned problems.
A general course in municipal sewerage and drainage, comprising a study of the systems of sewerage, the design of storm water, sanitary and combined sewers; trunk and intercepting sewers

and inverted syphons; ground water infiltration and its effects; sewer assessments; and a brief survey of the disposal of sewage.

Course 32 must be preceded by Course 4 in Engineering Mechanics. Required of all Civil Engineering students.

33. SEWAGE DISPOSAL. *Two hours.* Second semester only.
Lectures, recitations, and library reading, supplemented by visits to sewage disposal plants.
This is a comprehensive survey of the sanitary, legal and economic problems involved in the disposal of city sewage and industrial wastes, and a detailed study of the various processes and engineering structures employed in sewage treatment. It includes a study of the subject of stream pollution and of the self-purification of streams and other bodies of water.
Course 33 must be preceded by Course 32.
Open only to fourth-year and fifth-year students.

34. MUNICIPAL AND INDUSTRIAL SANITATION. *Two hours.* First semester only.
Lectures and library reading. A general study of the foundations upon which the practice of public sanitation rests. The prevention of certain diseases, such as typhoid fever, malaria, and yellow fever, through control of the physical environment. Effect upon public health of water purification, sewage treatment, good drainage, and other sanitary improvements. Industrial sanitation and health conservation.
Open to fourth-year and fifth-year students.

35. SANITARY ENGINEERING DESIGN. *Three hours.* Second semester only. Lectures and drawing room work.
A drawing room course in the design of typical structures related to water supply, water purification, sewerage and sewage disposal.
Course 35 must be preceded by Course 3; and accompanied by either Course 32, Course 33, or Course 34.
Open only to fourth-year and fifth-year students.
Required of students electing Group D, Sanitary and Municipal Engineering.

36. MUNICIPAL ENGINEERING. *Two hours.* Second semester only.
Lectures and library reading.
This subject covers the subjects of street cleaning—organization, methods, cost; — the collection and disposal of garbage and other city wastes; and certain other administrative problems with which the city engineering office has to deal.
Open only to fourth-year and fifth-year students.

40. HIGHWAY ENGINEERING. *Three hours.* Both semesters.
Lectures and recitations with assigned reading.
The course will treat of the fundamentals of highway engineer-

ing, including a study of the historical development of highways and highway transport; economics, administration and legislation; preliminary investigations and transportation surveys; surveying and mapping peculiar to highway engineering; essential factors in the economic design of highways, including road and street systems, location, drainage, foundations, widths, curves, grades, and selection of type of surfacing; essential features of the construction and maintenance of the different types of roads and pavements and the materials used therein; street cleaning and snow removal; and highway structures.

Required of all Civil Engineering students.

This course is changed to a three hour course in 1924-25 for students matriculating in that year. During 1924-25 the old two hour course will be given and the change put into effect in 1925-26.

41. HIGHWAY ENGINEERING THEORY AND ECONOMICS, AND HIGHWAY TRANSPORT SURVEYS. *Two hours.* Second semester only.

Lectures and recitations, with assigned library reading and problems, supplemented by inspection trips.

Under theory and economics of highway improvements will be considered the following subjects: road and street systems, the individual highway, drainage systems, foundations, locations, intersections, widths, cross-sections, curves, grades, selection of type of wearing course, and comparison of roads and pavements. Highway transport surveys will cover the subject of traffic classification and census; methods of estimating future highway transport; highway factors affecting economic highway transport; investigations of highway routes, transport legislation and regulations, rural and urban transportation opportunities and competing carriers including railway and waterway transport facilities.

Course 41 must be preceded or accompanied by Course 40, and by Course 1 in Engineering Mechanics except by written approval.

Open to fourth-year, fifth-year, and graduate students in engineering. Fourth-year and graduate students in the College of Literature, Science and the Arts having the written approval of the Committee on Business Administration may elect this course for credit.

42. HIGHWAY ENGINEERING LABORATORY. *Two hours.* Both semesters.

Lectures, assigned reading, and laboratory work.

This course includes the testing of cements and aggregates used in cement-concrete construction, the testing of broken stone and slag for hardness, toughness, abrasion, cementation, absorption and specific gravity; tests of the physical properties of sand and clay mixtures; sand, gravel, brick, wood block and stone blocks; tests of bituminous materials. Special em-

phasis is laid upon proper methods of making, reporting, and interpreting tests of construction materials.
Course 42 must be preceded or accompanied by Course 40.
Open to fourth-year, fifth-year, and graduate students.

43. HIGHWAY ENGINEERING DESIGN. *Three hours.* Second semester only.
Lectures and recitations, with assigned reading and design problems, supplemented by inspection trips.
This course covers the design of highways and highway systems, drainage systems, culverts and small highway bridges, foundations, curves, grades, right-of-way and street intersections, widths of right-of-way and roadways, and cross-sections, and discussion of field methods of reconnoisance and surveying, and office methods used in mapping, estimating, and recording.
Course 43 must be preceded or accompanied by Course 41, or with written approval, by Course 44.
Open to fourth-year, fifth-year, and graduate students.

44. HIGHWAY TRANSPORT ECONOMICS, METHODS, LEGISLATION, AND MANAGEMENT. *Two hours.* Second semester only.
Lectures and recitations, with assigned library reading.
History of American and foreign highway transport methods. Economic comparison of methods of transport of passengers and commodities by highway, railway, and waterway. Municipal haulage; municipal delivery systems; store door delivery; intercity haulage; intercity express; long and short rural haulage; rural motor express; plant and factory haulage; horse transportation methods; terminal clearing houses. Legislation pertaining to weights, dimensions, speeds, and operation of motor trucks, tractors, trailers, and motor buses. Franchises for highway transport routes; rate legislation; traffic regulations. Fundamentals of efficient management and the different highway transport methods; administration and organization of transportation companies. Cost and record systems; elements of cost of operation of motor vehicles.
Open to fourth-year, fifth-year, and graduate students in engineering. Fourth-year and graduate students of the College of Literature, Science, and the Arts having the written approval of the Committee on Business Administration may elect this course for credit.

60. SANITARY ENGINEERING RESEARCH. *Credit to be arranged.*
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. Open to graduate students only. By appointment.

61. IRRIGATION AND DRAINAGE. *Two hours.* Continuation of Course 14. Open only to seniors and fifth-year students as an advanced course.

62. ADVANCED HYDRAULIC DESIGN. *Two hours.*
Continuation of Course 16 for fifth-year students.

64. HYDRAULIC ENGINEERING RESEARCH. *Credit to be arranged.*
Assigned work on some definite problem of Hydraulics. A wide range of matter and method is available, covering field experiments, laboratory experiments, and designing. Open only to graduate students and fifth-year students who have completed courses in the Hydraulic Group.

65. STRUCTURAL ENGINEERING RESEARCH. *Credit to be arranged.*
Assigned work on some approved problem in Structural Engineering, preferably experimental work with discussion of derived data. Open only to graduate students and fifth-year students who have taken prescribed courses in the Structural Group.

66. HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT RESEARCH. *Credit to be arranged.*
Assigned work on approved problems relating to administration, organization, economics, design, materials, construction and maintenance in the field of highway engineering research, or on approved problems relating to highway transport surveys, economics, methods, legislation, and management. Open only to seniors having the written approval of the Professor of Highway Engineering and Highway Transport, and to graduate students who have completed or are taking courses in the Highway Engineering and Highway Transport Group.

GRADUATE SHORT PERIOD COURSES

Graduate courses in highway engineering and highway transport leading to the degree of Master of Science or Master of Science in Engineering have been arranged especially for men engaged in the practice of highway engineering and highway transport. These courses will be given during the months of December to March, inclusive. Each course will consist of thirty lectures and will be given in a period of two weeks. Each course will count as two hours credit towards the total of twenty-four hours required for the Master's degree. This plan will afford highway engineers, chemists, contractors, engineer-salesmen, highway transport engineers, and managers, motor truck salesmen, and others interested in highway engineering and highway transport an opportunity to obtain advanced knowledge during the season of the year when a leave of absence may be easily obtained. These courses are open to graduate students and qualified special students.

67. HIGHWAY TRANSPORT SURVEYS. *Two hours.*
Lectures and library reading.
This course covers the subject of traffic classification and census, weights, speeds, and dimensions of vehicles, highway factors affecting economic highway transport, investigations of highway routes, transport legislation and regulations, rural and urban transportation opportunities and competing carriers including railway and waterway transport facilities.

68. BITUMINOUS SURFACES AND BITUMINOUS PAVEMENTS. *Two hours.*
Lectures and library reading.
This course will cover bituminous surfaces, bituminous macadam pavements, bituminous concrete pavements, asphalt block pavements, and sheet asphalt pavements. Each type of construction will be considered from the following standpoints: Description and historical development; economic value, conditions under which it may be used, and foundations; theory and design, external forces, stresses, and strains; kinds of bituminous and non-bituminous materials used and desirable qualities thereof; methods of construction; types of machinery used, important features and manipulation thereof; inspection methods; nature of wear and deterioration, and causes of premature failure; methods of maintenance; guarantees, essential features, and economics.

69. HIGHWAY LABORATORY RESEARCH. *Two hours.*
Lectures, library reading, and laboratory investigations.
This course will include advanced problems pertaining to the physical properties of earth, sand and clay mixtures, sand, gravel, broken stone, broken slag, paving brick, cement-concrete, wood blocks and stone blocks; highway laboratory administration, organization, and equipment; sampling and inspection methods; reports and records; field surveys and investigations.

70. HIGHWAY STRUCTURES. *Two hours.*
Lectures and library reading.
Advanced course in the study of the economics and maintenance of all types of highway bridges and culverts, including preliminary investigations; determination of waterways; standard types of highway bridges of wood, steel, cement-concrete, and reinforced concrete; highway bridge foundations and floors; various classes of loads; retaining walls; design of foundations and pavements as structures.
Prerequisite: Theory and Design of Structures.

71. HIGHWAY SPECIFICATIONS, CONTRACTS, AND JURISPRUDENCE. *Two hours.*
Lectures and library reading.
The essential elements of a contract; bids and bidders on public

work; the conduct of public lettings; clauses which should be included in properly drawn contracts covering time, liquidated damages, manner of payment, extra work, defective materials or work; custom and usage as affecting engineering contracts; the duties and powers of the engineer; limitation of engineer's powers; breach of contract; specifications; matter to be included; proper methods of preparing; the engineer as a professional man; contracts for professional services; jurisprudence relating to surface waters and boundaries of highways.

72. EARTH, SAND-CLAY, GRAVEL, AND BROKEN STONE ROADS. *Two hours.*

Lectures and library reading.

This course covers the characteristics, economic utilization, and fundamentals of construction and maintenance of earth, sand-clay, gravel, and broken stone roads, and the essential properties and methods of testing of soils, gravels, and rock.

73. BRICK, CEMENT-CONCRETE, STONE BLOCK, AND WOOD BLOCK PAVEMENTS. *Two hours.*

Lectures and library reading.

This course covers the characteristics, economic utilization, and fundamentals of construction and maintenance of brick, cement-concrete, stone block, and wood block pavements and the essential properties and methods of testing brick, cement-concrete, stone block, and wood block.

74. BITUMINOUS MATERIALS. *Two hours.*

Lectures, library reading, and laboratory work.

Hydrocarbons; classification of bituminous materials; refining processes; petroleum; native and oil asphalts; rock asphalts; crude and refined tars; creosoting oils; tests for bituminous materials; interpretation of results of tests; factors governing specifications for bituminous materials; purchase, transportation, storage, and inspection of bituminous materials.

75. HIGHWAY ENGINEERING SEMINAR. *Two hours.*

Library research, and preparation and presentation of reports, papers, and briefs.

Assigned work on approved definite problems relating to administration, organization, economics, design, materials, construction, and maintenance in the field of Highway Engineering.

76. HIGHWAY ENGINEERING THEORY AND DESIGN. *Two hours.*

Lectures and library reading.

Theory and design of drainage systems, foundations, highway systems, and individual highway, location, intersections, widths, cross-sections, curves, and grades; selection of type of wearing

course; comparison of roads and pavements; field methods of reconnoisance; efficient office methods.

This course must be preceded by Courses 40 and 67 and Drawing 1 or their equivalent.

77. HIGHWAY ENGINEERING FINANCING, ADMINISTRATION, AND ORGANIZATION. *Two hours.*

Lectures and library reading.

Long-term, short-term, and serial bonds; annual appropriations; local assessments; expenses to be financed; scope and character of organization; administrative control of construction, maintenance, street cleaning, and snow removal; planning boards and visible records; unit cost records.

78. GRADING MACHINERY AND OPERATION. *Two hours.*

Lectures and library reading.

Consideration affecting the purchase of grading machinery; fundamentals of different types of grading machines; efficient methods of using grading equipment; clearing and grubbing; economic comparison of methods of making excavations and embankments with different types of machines; grading organization.

79. AMERICAN AND ENGLISH HIGHWAY TRAFFIC LEGISLATION AND REGULATIONS. *Two hours.*

Lectures and library reading.

Legislation pertaining to weights, dimensions, and speeds of motor trucks, tractors, trailers, and motor-buses; franchises for highway transport routes; rate legislation; national, state, county, township, and municipal laws, licenses, taxes, and traffic regulations.

80. INTERRELATIONSHIP OF HIGHWAY, RAILWAY, AND WATERWAY TRANSPORT. *Two hours.*

Lectures and library reading.

Development of highway, railway, and waterway transportation; economic comparison of methods of transport of passengers and commodities; characteristics and efficiency of each type of transportation; influencing factors of distances, haulage, rates, kinds of freight, packing, equipment, and port, terminal, and warehouse facilities.

81. AMERICAN AND ENGLISH HIGHWAY TRANSPORT METHODS. *Two hours.*

Lectures and library reading.

History of American and English highway transportation methods; comparison of horse and motor transport; municipal haulage; municipal delivery systems, store door delivery, intercity haulage, long and short haulage outside of cities, rural motor express, return loads bureaus, motor truck parcel post,

plant and factory haulage, army transport methods, horse transportation methods; efficient methods of packing, handling, loading, and unloading raw and manufactured materials.

82. HIGHWAY TRANSPORT MANAGEMENT, COSTS, AND RECORD SYSTEMS. *Two hours.*
Lectures and library reading.
Fundamentals of efficient management of the different highway transport methods; administration and organization of transportation companies; cost and record systems; elements of cost of operation of motor vehicles, including direct, overhead, and lost time charges; relation of highways to operating cost.

83. HIGHWAY TRANSPORT SEMINAR. *Two hours.*
Library research, and preparation and presentation of reports, papers, and briefs.
Assigned work on special problems relating especially to such subjects as highway transport economics; interrelationship of highway transport, good roads, and rural development; consumers' organizations; community schools and the motorbuses; effect of roadways on vehicles.

84. HIGHWAY TRANSPORT MANAGEMENT. *Two hours.*
Lectures and library reading.
Fundamentals of efficient management of the different highway transport methods; administration and organization of transportation companies; planning delivery systems; scheduling and routing; management of office, garage, clearing houses, unloading and loading, and operation of trucks and other vehicles; drivers' bonus and commission systems; supervision by mechanical devices.

## 201. DRAWING

Professors MILLER and GOULDING, Assistant Professors FINCH, PALMER, COOK, HANSEN, MORLEY, and POTTS, Mr. CLARK, Mr. COLE, and Mr. EICHELBERGER.

1. MECHANICAL AND MACHINE DRAWING. *Three hours.* Both semesters.
This is the beginning course in Drawing and is required of all engineers. Students are required to report for three two-hour periods per week and in addition are responsible for three hours of preparation or home work. Instruction in this course covers the principles of orthographic projection, mechanical letters and titles, dimensioning, notes, sectioning, bolts, nuts, fasteners, the making of simple working drawings, the making of details from assemblies, assembly drawing from details, the use of instruments, construction of curves, free-hand lettering,

reading of drawings, checking of drawings, tracing, blue printing, brown printing, photostating, and reproduction of tracings.

Text—Miller's Mechanical Drawing.

1*a*. INSTRUMENTAL AND FREE-HAND DRAWING. This is planned for students of Dentistry. *One hour.* First semester only. The time devoted to the course is taken up witn practice in the use of instruments, lettering, and free-hand sketching, to the end that the student may be able to read and make working drawings of dental and other appliances and such sketches as may be necessary in illustrating his several subjects in Dental Anatomy and kindred courses.

Text—Special Notes.

2. DESCRIPTIVE GEOMETRY. *Three hours.* Both semesters.

This is the second course in Drawing and is required of all engineers. Students are required to report for three two-hour periods per week and are responsible for three hours of preparation or home work. Instruction and exercises are given on combinations of the point, line, and plane, intersections, developments, tangent planes, and warped surfaces. All exercises on the above are printed by the Department on drawing paper and presented to the student for solution.

Text—Miller's Descriptive Geometry. Prerequisite—Course 1.

3. MECHANISM, SKETCHING, AND DRAFTING ROOM PRACTICE. *Two hours.* Both semesters.

This course is required of all engineers and the students are required to report for two two-hour periods per week and are responsible for two hours of preparation or home work. Instruction covers the making free-hand of detailed drawings from assemblies, orthographic sketches from models, isometric and oblique sketches, conventional representation and drawings of equipment or work peculiar to the various professions, and the elements of perspective. The principal object of this course is to teach the student to represent free-hand in orthographic, isometric, and oblique projection objects common in the practice of engineering with facility and accuracy. Further instruction is given in the reading of drawings, mechanical, isometric, and oblique projection, symbols, conventions, lettering, photographic reproduction, dimensioning and sectioning, gears, etc.

Text—Miller's Mechanical Drafting. Prerequisite—Course 2.

4. MECHANISM. *Two or three hours.* Both semesters.

All students who take this course are required to report for two two-hour periods per week. The three-hour course includes, likewise, from four to five hours of preparation, research or

drafting, while the two-hour course requires only two additional hours of preparation or home work. Instruction is given in the principles and elements of mechanism, the geometric analysis of mechanism, the history of the development of the various elementary mechanisms, and the synthesis of mechanisms. It is the purpose of this course to acquaint the student first with the elementary principles over which all the elements of machines are properly designed, the purposes of the various elementary mechanisms, for example, gears, cams, levers, etc., also to teach the student how to analyze existing compound mechanisms or combinations of simple mechanisms in the form of machines, tracing the transmission of power and motion from the driver to the driven, or to the ultimate accomplishment of the machine, and finally, the development of some ingenuity in combining the various elementary mechanisms into a machine for the accomplishment of a certain purpose.

Text—Schwamb & Merrill's Elements of Mechanism. Prerequisite—Course 3.

10. FREE-HAND LETTERING. *Two hours.* Both semesters.

This course is designed to give the student practice in the simple forms of letters used in the drafting room and the laying out of titles.

11. SPHERICAL PROJECTIONS. Recitations and drawing. *One hour.* Second semester only.

A study of the various projections of the sphere, for the purpose of mapping large portions of the earth's surface. Construction, use, and analysis of statistical charts. Conic method.

Course 11 must be preceded by Course 2.

12. STATISTICAL CHARTING. Lecture and drawing room work. *Two hours.*

A study of the statistical method and of charting in particular. The aim of the course is to give the student a thorough training in the construction, use, and analysis of statistical charts. The lectures will furnish the fundamental principles of statistics and of charting. These will be applied in the drawing room to industrial, social, transportation, or other statistical problems.

13. PATENT OFFICE DRAFTING. This course is to be taken without credit.

It is intended primarily for such students as wish to obtain a knowledge of methods employed in illustrating patent devices. The standard practice and demands of the U. S. Patent Office as well as foreign patent offices will be considered.

## 202. ELECTRICAL ENGINEERING

Professors BAILEY, HIGBIE, LOVELL, CANNON, Assistant Professors MOORE, FAIRMAN, Mr. DREESE, Mr. ATTWOOD, Mr. MILLER, Mr. STOUT, Mr. BULL, Mr. GAULT.

1. PRINCIPLES OF ELECTRICITY AND MAGNETISM. Lectures, recitations, and computing periods. *Three hours.* Both semesters.
A mathematical and physical treatment of force actions and energy relations in electrostatic and electromagnetic fields; capacitance and inductance of systems of conductors. This course aims to acquaint the student with the ideas of flux and potential as used in physical science and to give him some facility in solving the simpler problems.
Prerequisite: Physics 2E.

2. DIRECT CURRENT APPARATUS AND CIRCUITS. Recitations and laboratory work. *Four hours.* Both semesters.
Course 2 must be preceded by Courses 1 and 2 in Physics and by Engineering Mechanics 1. For Electrical students only.

2*a*. ELECTRICAL APPARATUS AND CIRCUITS. Recitations and laboratory work. *Four hours.* Both semesters.
This course is intended for non-electrical students.

3. ALTERNATING CURRENT CIRCUITS. Recitations and laboratory work. *Four hours.* Both semesters.
This course must be preceded by Course 2, and preceded or accompanied by Course 1 in Electrical Engineering. It is devoted partly to carrying forward the consideration of circuits and machines operating with continuous currents begun in Course 2. Most of Course 3, however, is spent in developing familiarity and facility in applying usefully and practically the physical and mathematical principles of circuits carrying alternating currents. Incidentally, the characteristics of the transformer are studied thoroughly as exemplifying electric and magnetic circuits, and also to some extent the synchronous generator is similarly studied.

3*a*. ALTERNATING CURRENT APPARATUS. *Four hours.* Both semesters.
This course covers part of the work taken up in Courses 3 and 4. It is designed exclusively for non-electrical students. Recitations and laboratory work.
This course must be preceded by Course 2*a*.

4. ALTERNATING CURRENT MACHINERY. Recitations and laboratory work. *Four hours.* Both semesters.
The work consists in applying the principles studied in previous courses to the synchronous machine, the induction machine,

the rotary converter, and to the various types of single-phase motors. Must be preceded by Course 3.

5. DESIGN OF ELECTRICAL MACHINERY AND APPLIANCES. Lectures, recitations, and computing periods. *Four hours.* Both semesters.

Course 5 must be preceded by Courses 1, 3 and 14, and is the first of two Electrical Design Courses. It may be followed in the second semester by Course 6. In Courses 5 and 6 designs are made of electromagnets, transformers, generators, and motors. Particular attention is given to the calculation of related parts, so as to produce results satisfactory, both theoretically and practically.

6. DESIGN AND ADVANCED THEORY OF THE INDUCTION MOTOR. Lectures, recitations and computations. *Two hours.* Second semester only.

This course is a continuation of Course 4 and 5. It deals largely with the advanced theory and design of the induction motor. Some attention is also given to the various forms of single phase motors.

6*a*. AN EXTENDED FORM OF COURSE 6. *Four hours.* Second semester only.

7. ILLUMINATION AND PHOTOMETRY. Lectures, recitations, and laboratory work. *Two hours.* Both semesters.

Course 7 must be preceded by Electrical Engineering 1. It is devoted to a general study of the theoretical principles underlying measurements and calculations of light in its engineering application to illumination; of the types and inherent characteristics of lamps, and the methods whereby they are adapted to produce suitable illumination; and of the practical features of illumination design.

8. PRINCIPLES OF ELECTRIC TRACTION. Lectures and recitations. *Two hours.* First semester only.

The course covers traffic studies, train schedules, speed-time and power curves, locomotive train haulage, signal systems, cars and locomotives, control systems, traction systems, and the electrification of trunk lines.

Must be preceded by Course 3.

9. SPECIAL LABORATORY PROBLEMS. *Hours and credit to be arranged.* Both semesters.

Special problems are assigned for laboratory investigation with the intent of developing initiative and resourcefulness, but not to the same extent as is expected in research work. To a large degree the students' own desires will control the subjects investigated.

Must be preceded by E. E. 3.

10. ADVANCED THEORY OF ELECTRICAL CIRCUITS. Lectures, home work, and recitations. *Three hours.* Both semesters.
This course must be preceded by Course 3, and it is advisable, if possible, that it be preceded by Course 17. The course deals with the application of mathematical analysis to practical and theoretical problems. It covers such subjects as electrical filters; transmission of electric waves on lines having distributed capacity, inductance, resistance, and leakage; the mechanism of reflection at terminals; electro-magnetic waves in space; Maxwell's equations. Material in this course is fundamental in preparation for work with telephone, telegraph and radio circuits.

11. POWER PLANTS. TRANSMISSION AND DISTRIBUTION. Lectures, recitations, and problems. *Five hours.* Both semesters.
This course gives the student opportunity to apply to the problems of power plant and transmission design the elements of economics as in the selection of apparatus, proportioning of details in an assembled whole, balancing initial and subsequent costs. Some attention is given to the interrelation of mechanical and electrical elements in design.
Must be preceded by E. E. 3.

13. PRINCIPLES OF ELECTRICAL COMMUNICATION. Recitations and laboratory work. *Four hours.* Both semesters.
Course 13 must be preceded by Course 3. This course deals with the main systems of communication in practical use, with reference to their principles and modes of application. The theory of speech transmission by electrical means is taken up, together with illustrative problems involving the use of alternating currents and electromotive forces at high frequencies.

14. MECHANISM OF ELECTRICAL MACHINES. Recitations and drawing. *Three hours.* Both semesters.
Course 14 must be preceded by Engineering Mechanics 2. In this course stress is laid on the technology of production and on the elementary principles of the design of machine parts, with special reference to the mechanical principles underlying the selection of alternative methods of accomplishing given ends.

15. ADVANCED LIGHTING. Seminar in lighting. Investigations and reports. *Two hours.* Second semester only.
Course 15 must be preceded by Course 7 and preceded or accompanied by Course 3. By examining more fully than is possible in Course 7, the theoretical limits to performance of illuminants and systems of illumination, and the trend of development in practice of illumination engineering, it is attempted here to prepare the students for taking a part, possibly, in such development.

17. ELECTROMECHANICS. Lectures, recitations, and problems. *Four hours.* Both semesters.

Analysis of complex alternating current waves, average and effective values, and the meaning of power factor. The method of the complex variable in alternating current problems, the application of differential equations to the solution of simple transients and oscillatory circuits, and the use of hyperbolic functions in solving the general equation of a circuit containing distributed resistance, inductance, capacitance and leakage are aims of the course.

Must be preceded by Course 3.

18. RESEARCH WORK IN ELECTRICAL ENGINEERING. *Hours and credit to be arranged.* Both semesters.

Course 18 is open to students receiving permission of the head of the department before classification, and is intended primarily for graduates. Students electing this course while working under the general supervision of a member of the staff of instruction are expected to plan and carry out the work themselves, and to make a report in the form of a thesis.

19. STUDY OF DESIGN—POWER PLANTS. Lectures and design problems. *Two hours.* Second semester only.

In this course studies are made of modern typical designs of generating stations and sub-stations to give intimate knowledge of the problems met with and the standard installations used. Some of the important electrical features are calculated and drawn up in detail. Hydraulic and steam plants are inspected on field trips.

Must be preceded by E. E. 11.

20. STUDY OF DESIGN—ELECTRIC TRANSMISSION AND DISTRIBUTION SYSTEMS. *Two hours.* Second semester only.

This course deals with the electrical and mechanical features of overhead and underground transmission systems. The efficiency, regulation, control of voltage and power factor, inductive interference, corona and surges are the main electrical items studied. The mechanical problems considered cover the design of the supporting structures, sags and spans, stiff and flexible towers, etc.

Must be preceded by E. E. 11.

22. RADIO ENGINEERING. Lectures, recitations, and laboratory work. *Four hours.* Second semester only.

In this course oscillatory circuits are reviewed and then the study of coupled circuits is undertaken. Later the radiative and absorptive properties of circuits are studied in connection with electromagnetic radiation. The quantitative effects of vacuum tubes, telephone transmitters, and other pieces of ap-

paratus in these circuits is covered. Finally the complete design of a transmitting or receivng set is undertaken.

Course 22 must be preceded by Course 17 and Course 16 in Physics. It must be preceded or accompanied by Course 10.

25. ELECTRICAL ENGINEERING SEMINAR. *Two hours.* Second semester only.

For advanced students only. This course is devoted to the study of some advanced phase of Electrical Engineering. Content of course varies from year to year according to the desires of the department and those electing it.

33. INDUSTRIAL ELECTRICAL ENGINEERING. Lectures and recitations. *Two hours.* First semester only.

Some of the topics studied in this course are individual and group drive by electric motors; selection of motors; power requirements for various kinds of machinery; electric hoists; electric welding; electric furnaces and temperature regulation; electric braking.

This course must be preceded or accompanied by E. E. 4.

36. RATE AND COST ANALYSIS. Lectures and recitations. *One hour.* Second semester only.

Some of the topics studied in this course are: capitalization, fair return on investment, analysis of costs and value of electrical energy; customer charges, demand charges, energy charges; investigations of practical systems used in charging for electrical energy.

This course must be preceded by E. E. 11. Open to seniors only.

## SUMMER SESSION

Courses 2, 2a, 3, 4, 9, 18 will be offered for the Summer Session of 1924. Courses 7, 11, 17 may be given if there is sufficient demand to warrant. 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 Summer School.

## 203. ENGINEERING MECHANICS

Professors PATTERSON, MENEFEE, AIREY, Associate Professor VAN DEN BROEK, Assistant Professors STEVENS, SWINTON, OLMSTED, Mr. LIDDECOAT, Mr. DODGE, Mr. FRANKLIN, Mr. DONNELL.

1. STATICS. *Four hours.* Both semesters.

A study of the fundamental principles of mechanics and their application to the simpler problems of engineering science.

Course 1 must be preceded by Course 3 in Mathematics and Course 1E in Physics, and should be preceded or accompanied by Course 4 in Mathematics.

2. STRENGTH AND ELASTICITY OF MATERIALS. *Three hours.* Both semesters.
A study of the application of mechanical principles to the various problems of stress and strain in engineering materials. The general effects of force on elastic bodies, the bending of beams, twisting of shafts, behavior of struts and ties, etc., are studied in the light of the simpler accepted theories.
Course 2 must be preceded by Course 1.

2*a*. STRENGTH AND ELASTICITY OF MATERIALS. *One hour.* Both semesters.
This course is a laboratory course in which the theoretical work of Course 2 is illustrated by actual laboratory demonstrations done by the student himself.
Course 2*a* must be preceded by Course 1, and accompanied or preceded by Course 2.

3. DYNAMICS. *Two hours.* Both semesters.
Work and energy; the use of velocity, acceleration, and other diagrams in the study of dynamic problems relating to machines.
Course 3 must be preceded by Course 1.

4. HYDROMECHANICS. *Three hours.* Both semesters.
Fluid pressure and fluid motion; Bernoulli's Theorem; flow of water over weirs, through pipes, and in open channels; dynamic action of jets and streams. Use is made of text books and the hydraulic demonstration room.
Must be preceded by Course 1.

5. TESTING MATERIALS. *Two hours.* Both semesters.
The laboratory work is preceded by a critical study for five weeks of published tests of engineering materials; including steel and cast iron in tension, concrete columns in compression, cement in tension and compression, and wood in bending. Written reports are required in which special emphasis is laid on the technic of report writing and the graphical presentation and interpretation of the data.
The remainder of the semester is devoted to laboratory tests on steel, iron, wood, brick, and structural materials, including the standard cement tests, tests for voids in sand and stone, tests of reinforced and unreinforced concrete beams, and granular metric analysis of sand.
Course 5 must be preceded by Courses 1 and 2.

6. STRENGTH OF MATERIALS—TESTING. *Three hours.* Both semesters.
The elementary theory of the strength of ties, struts, beams, and shafts. Laboratory practice in commercial testing and investigative methods.

Course 6 must be preceded by Course 1. It is an abridgment of the work covered in Courses 2 and 5, and may not be elected by anyone who has passed, or intends to elect, either of these courses.

8. ADVANCED DYNAMICS. *Two hours.* Both semesters.
Must be preceded by Course 3.

9. ADVANCED STRENGTH OF MATERIALS. *Two hours.* Both semesters.
A study of monolythic bents and frames by area-moment method; analysis of curved beams (arches) by slope-deflection method; deflection of frames and analysis of frames with one or more redundant members by the method of Least Work.
Must be preceded by Course 2.

10. RESEARCH. *Hours and credit to be arranged.* Both semesters.
Course 10 must be preceded by Course 5 or 2a.

## SUMMER SESSION

Courses 1, 2, 2*a*, 3, and 4, as described above, are given in the Summer Session of 1924.

## 204. ENGLISH*

Professor NELSON, Assistant Professors THORNTON, SCHNEIDER, LANGWORTHY, KLOCKSIEM, Mr. EGLY, Mr. WEGNER, Mr. WALTON, Mr. DAHLSTROM, Mr. BRACKETT.

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

1. THEME-WRITING AND ORAL EXPOSITION. *Four hours.* Both semesters.
This course is a prerequisite for all courses in English, except 21. No foreign student may be classified in English 1 without written permission from Professor NELSON.

1*a*. THEME-WRITING AND ORAL EXPOSITION. *Two hours.* First semester.
This course, which corresponds to the first half of English 1, is for those students in Architecture who cannot take the regular work in English 1.

* All regular students in the Colleges of Engineering and Architecture are required to take six hours of English. In the College of Engineering this consists of English 1 and a two-hour writing course in the junior or senior year, which must be chosen from the following: English 5, 6, 9, 10, or 14. *No other courses can be substituted.* In the College of Architecture the student may take in addition to English 1 any two-hour English course. This course may be taken at any time during the four years, unless the student elects one of the courses open to juniors and seniors only.

2. THEME-WRITING AND ORAL EXPOSITION. *Four hours.* Both semesters.

This course is intended for those students who are interested in various types of writing. Opportunity will be given the student to write essays, short stories, plays, or any other form he may select.

2*a*. THEME-WRITING AND ORAL EXPOSITION. *Four hours.* Second semester.

This course, which corresponds to the second half of English 1, and to English 2, is for those students of Architecture who have in their first semester taken English 1*a*.

3. PUBLIC SPEAKING FOR ENGINEERS. *Two hours.* Both semesters.

A study of the forms of public address of most practical value to engineers. The course will not only deal with the problems of organization, illustration, and effective presentation of technical material, but will also give the student frequent opportunity to present this type of material before an audience for criticism.

In addition to the two recitation periods all students in this course will attend an Assembly Thursday evening at 7 o'clock, which will afford opportunity for the practice work in the course.

4. NOTE-TAKING. *Two hours.* Both semesters.

This course aims to give the student a practical method of note-taking, and to give him sufficient practice in the use of that method to assure him of more coherent results in those technical courses in which note-taking is necessary.

5*. SCIENTIFIC AND TECHNICAL PAPERS. *Two hours.* Both semesters. For juniors and seniors only.

The most efficient methods of collecting scientific and technical material, organizing it, and preparing it either for publication or oral presentation, will be outlined. The practice work will lay particular emphasis upon the effective handling of various types of illustrative material and the interpretation of technical subjects to audiences of non-technical listeners.

6*. REPORT-WRITING. *Two hours. Both semesters.* For seniors only.

The engineering report is studied as a special type of exposition to which are applicable the fundamental principles of all expository writing. The major assignments will be made, as largely as possible, by the department of engineering in which the student is studying, and every effort will be made to correlate the work of the course with the technical work in which the student is engaged.

7. TECHNICAL JOURNALISM. *Two hours.* First semester only.

This course includes an analysis of technical publications of the day; a study of the relation of the technical magazine to the engineering profession, and its use and function as compared with other types of magazines; studies and problems in the work of editing. Incidental attention is given to house organs, descriptive cataloguing, and advertising.

8. TECHNICAL JOURNALISM. *Two hours.* Second semester only. Open only to students who are doing work on the *Technic.*

9*. ADVERTISING AND COMMERCIAL CORRESPONDENCE. *Two hours.* Both semesters. For juniors and seniors only.

A study of fundamental business situations, with especial reference to effective written English. Advertising, general publicity, commercial correspondence. Lectues, reading, and assigned exercises. The lectures will be devoted primarily to the psychology and business usage involved.

[Omitted in 1924-1925.]

10*. SALES. *Two hours.* Both semesters. For juniors and seniors only.

A study of fundamental business situations, with especial reference to effective spoken English. General business interviews, testimony, sales. Lectures, readings, and assigned exercises. The lecture will be devoted primarily to the psychology and business usage involved.

[Omitted in 1924-1925.]

12.* BUSINESS ENGLISH—ADVANCED COURSE. *Two hours.* Both semesters.

A study of fundamental business situations, with special reference to the various relations of advertising to selling campaigns. Lectures, reading, and assigned exercises. Open only to those who have had a previous course in Business English or in the Psychology of Advertising.

[Omitted in 1924-1925.]

14.* THE ENGINEER AND HIS READING. *Two hours.* Both semesters. For juniors and seniors only.

A consideration of the needs of the engineer as a member of society for interests outside his strictly technical field, and of the ideal values to be found in non-technical studies as preparation for professional life. The course will include round-table discussions and the preparation of a definite number of prescribed papers on the topics developed in these discussions.

**Group II. Courses especially designed for foreign students. (See Sec. 43.)**

16. ENGLISH FOR FOREIGN STUDENTS. *Four hours.* First semester. This course purposes: first, to deal simply and practically with the phonetics of English speech in a way which will serve to correct the difficulties of the individual student; second, to give sufficient drill in reading aloud to aid the student to acquire a correct pronunciation and to enlarge his vocabulary; third, to give him practice in conversation of a sort to meet his immediate needs in the classroom and in the life of the community about him. The work consists of phonetic exercises, conversation, dictation, speeches, visits with the instructor to the laboratories, libraries, etc., and at least one personal consultation period each week with the instructor.

17. ENGLISH FOR FOREIGN STUDENTS. *Four hours.* Second semester. A continuation of Course 16 for students who will need special attention.

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

21. READING IN CONTEMPORARY LITERATURE. *Two hours.* Both semesters.
This course may be taken before a student has elected English 1. An introduction to the study of the novel, the drama, and the short story, which form the subject matter of special courses. (See 22, 23, 24, 25, and 26.)

22. STUDIES IN THE NOVEL. *Two hours.* Both semesters.
The purpose of this work is to familiarize the student with the method and form of those English novels which have stood the test of time, and to develop in him a standard of taste which may apply for himself in the reading of the modern novel.

23. THE CONTEMPORARY NOVEL. *Two hours.* Both semesters.
An attempt is made in this course to find underneath the story, which has heretofore been the student's only interest, the deeper meaning and the social significance of certain recent fiction. Lectures, discussion, and written reports.

24. THE SHORT STORY. *Two hours.* Both semesters.
The magazine stories read by the student in a rather aimless and desultory fashion are compared with the best modern examples of this form, with the general purpose of guiding the student's reading to a higher level of taste and enjoyment. Lectures, discussions, oral, and written reports.

25. STUDIES IN THE DRAMA. *Two hours.* First semester only.
Characteristic Greek, French, German, and English plays are read not only with reference to those qualities which make them landmarks in the development of the drama but as an introduction of the drama as a type of literature of especial interest to those who like to finish at one sitting whatever they read. The materials chosen will be such as to prepare the student to judge modern drama intelligently.

26. THE CONTEMPORARY DRAMA. *Two hours.* Both semesters.
The general method employed in this course will be similar to that in Course 24. The material will be chosen from Ibsen, Sudermann, Maeterlinck, Rostand, Pinero, Bennett, etc., and a special effort will be made to have the student develop personal standards which will enable him to judge intelligently the various types of plays which the average theatre-goer will see.

27. SCIENTIFIC READING. *Two hours.* First semester only.
This course aims to open to the student the great and fascinating literature in the field of pure science. Not only will the works of the great historic figures in this field, like Darwin, Huxley, Spencer, Burroughs, and Thoreau, be read, but the more recent works of men like Fabre, Maeterlinck, Beebe, and others who have done so much to make scientific thought accessible to the unscientific reader.

28. SCIENTIFIC READING. *Two hours.* Second semester only.
This course follows the same general plan as the preceding. The authors read are, however, different, so that a student who desires both courses can elect them without duplicating the material studied.

29. STUDIES IN AMERICAN PROSE LITERATURE. *Two hours.* Both semesters.
Appreciation of the contribution of America to the world's literature rather than a mere knowledge of the history of American literature is the purpose of this course. It will include not only readings in our older American writers but in our contemporaries, as well.

## 205. FINE ARTS

Assistant Professor DONALDSON.

1. GENERAL INTRODUCTORY COURSE. *Three hours.* Both semesters.
3. GREEK ART. *Three hours.* First semester.
4. ROMAN AND MEDIEVAL ART. *Three hours.* Second semester.
5. RENAISSANCE IN ITALY. *Three hours.* Second semester.
8. AMERICAN ART. *Three hours.* First semester.

## 206. FORESTRY

Associate Professor YOUNG.

23. GENERAL FORESTRY. *Two hours.* Two lectures. First semester.
The forester's work and problems he has to solve. Economic importance of forestry. History of forestry in the United States and abroad. Our timber resources and their distribution. Factors affecting tree-growth. Influences of forest upon climate, stream-flow, and erosion. How the forest is reproduced and cared for. Tree species desirable for different purposes. Forestry literature.
This course is open to all students. No prerequisites.
Enrollment is limited to fifty. Students wishing to elect this course must enroll with the instructor in advance.

24. GENERAL FORESTRY. *Two hours.* Two lectures. Second semester.
This course is a repetition of Forestry 23 and is subject to the same conditions.

24*a*. IDENTIFICATION OF TREES AND COMMERCIAL WOODS. *Two hours.* Four hours field and laboratory work. Second semester.
This course may be taken as a separate course or as supplementary to Course 24 by students who desire field and laboratory work in the identification of wood and of our common trees.
This course is open to all students. Enrollment is limited to fifteen. Students must enroll with the instructor before electing the course.

## 207. FRENCH*

Professors WAIT, LEE, ADAMS, Mr. JOBIN, Mr. BRITTON, Mr. GAISS, Mr. MCGUIRE, Mr. ANDERSON.

1. ELEMENTARY COURSE. *Four hours.* Both semesters.
Grammar and reading, with practice in writing and speaking French.

2. ELEMENTARY COURSE CONTINUED. *Four hours.* Both semesters.
Grammar and reading, with practice in writing and speaking French.

3. INTERMEDIATE FRENCH. *Four hours.* Both semesters.
Modern prose, conversation and composition, with a thorough review of grammar.

* See Sec. 138 for modern language requirements for graduation.

4. HISTORY OF FRENCH LITERATURE, CONVERSATION, AND COMPOSITION. *Four hours.* Both semesters.

5. ADVANCED COMPOSITION AND CONVERSATION. *Two hours.* Both semesters.

6. FRENCH LITERATURE IN ENGLISH.
An outline of the development of French literature. Lectures, assigned readings, and reports.

9. FRENCH CHEMICAL READING. *Two hours.* Second semester only.
Equivalent to Chemistry 20*a*.

## 208. GEODESY AND SURVEYING

Professor JOHNSTON, Associate Professors MERRICK, CAREY, Assistant Professors BRODIE, BOUCHARD, MITCHELL, Mr. MCFARLAN, Mr. YOUNG, Mr. BLEEKMAN.

1. SURVEYING. Lectures, text assignments, quizzes, field practice. *Three hours.* First semester only.
This course covers the elementary theory and practice of surveying. The following subjects are treated: note-keeping; verniers; linear measurements; angle reading; traverse surveying; computing areas; straight line; circular curves; differential leveling; continuous leveling; profile; grade stakes; vertical curve.

2. SURVEYING. Continuation of Course 1. Lectures, text assignments, quizzes, field practice, drawing. *Four hours.* Second semester only.
This course embraces topographic field work; mapping from notes made in transit and plane table surveys; theory of cross-section work and earthwork calculations; triangulation; adjustment, design, and care of instruments.
Courses 1 and 2 are prerequisites to the work at Camp Davis. They are open to all students who have completed Mathematics 2 or its equivalent.

3. SURVEYING. See Summer Session courses.

4. SURVEYING. Lectures, text assignments, quizzes, field practice. *two hours.* Both semesters and Summer Session. This course must be preceded by Course 2 in Mathematics.
The work consists of linear measurements; reading verniers and angles; running straight line; traverse survey; computing areas; leveling; platting profile and setting grade stakes. Special attention is given to the keeping of complete, neat, and accurate notes.

5. LEAST SQUARES. *Two hours.* Both semesters.
This course embraces the theory of Least Squares with applications relating to the adjustment and comparison of data. Special stress is laid upon the computation of triangulation systems. Some time is given to the determination of empirical formulae.
The course must be preceded by Mathematics 4.

7. MUNICIPAL SURVEYING. *Two hours.* Both semesters.
This course must be preceded by Course 3 in Surveying.
Lectures, text, field and drawing room work; surveys for the location of streets, fixing grades, paving, sewers, property surveys, and the planning and laying out of new subdivisions and additions. A study of the state laws governing surveys of this nature is included.

9. RAILWAY SURVEYING. Text assignments, quizzes, field practice, track problems. *Two hours.* Second semester only.
Course 9 should be preceded by Course 3 in Surveying.

12. SURVEYING. Drawing, lectures, text assignments, quizzes, field practice. *Four hours.* First semester only.
Linear measurements; field notes; reading verniers; reading angles; traverse surveying; computing areas; platting; leveling; making profiles; vertical curves; running straight lines; and setting grade stakes.

13. SURVEYING. *Four hours.* Running parallel with Course 2.
Courses 12 and 13 are designed for students of Forestry, and are, like Courses 1 and 2, prerequisites to Course 3.

21. PHOTOGRAPHY AND CAMERA SURVEYING. *Two hours.* Both semesters.
Lectures; field and laboratory work; history of photography; testing cameras and lenses; exposure of plates; development of negatives; printing, enlarging, and reducing; lantern slides; color work; mapping and field sketching.
This course is open to students who have completed Course 2 or Course 13 in Surveying, Course 1 in Physics, and an elementary course in Chemistry.

22. ADVANCED TOPOGRAPHIC SURVEYING. *Four hours.* First semester only.
This course considers topography as a specialty. It embraces a brief history of the development of topographic methods, the practice of foreign countries, and the status of such surveys in this country. Special attention is given to the purpose of these surveys and the uses to which completed maps are to be put.
This course is for fourth and fifth-year students only.

23. MAP PROJECTIONS AND SKETCHING. *Three hours.* First semester only.
This course covers map projections with special reference to the polyconic system. This is supplemented by exercises in topographic mapping and sketching.
This course is for fourth and fifth-year students only.

31. HISTORY OF ADMINISTRATIVE DEPARTMENTS. *Two hours.* First semester only.
This course deals with the history and organization of national and state departments which conduct extensive surveys.
This course is for fourth and fifth-year students only.

32. LAND LAW. *Three hours.* First semester only.
This course deals with legislation relating to registration of land and estates and the conveyancing of the same; how title to property is acquired; essential elements of deeds; application of common law to waters.

33. LAND LAW. *Three hours.* Second semester only.
A continuation of Course 32, taking up the law of boundaries, adverse possession; prescription and prescriptive rights; easements and rights of way.
Courses 32 and 33 are for fourth and fifth-year students only.

34. REGISTRATION OF LAND TITLES. *Three hours.* Second semester only.
This course deals with legislation relating to the registration of land titles. Special attention is paid to the Torrens Act of Australia and the modifications thereof as it has been adapted to the conditions of other countries.
This course is for fourth and fifth-year students only.

35. BOUNDARY SURVEYS. *Three hours.* Second semester only.
This course deals with the subject of boundary surveys from a legal standpoint. Beginning with boundary surveys in this country and abroad, the course takes up problems relating to the establishment of boundaries which have become uncertain due to obliteration of monuments, errors in surveys, inaccurate description in deeds, or from other causes.
This course is for fourth and fifth-year students only.

36. RIPARIAN BOUNDARIES. *Three hours.* Second semester only.
An effort is made in this course to show the uncertainty of riparian boundaries as now defined by court decision under the Common Law and to point out a method whereby they may be definitely determined.
This course is for fourth and fifth-year students only.

1. GEODESY. *Three hours.* Second semester only.
An introductory course covering the history of the subject, the

elements of modern practice and its applications to several branches of surveying.
This course is for fourth and fifth-year students only.

2. GEODESY. *Two hours.* Second semester only.
The methods employed and field covered by the United States Coast and Geodetic Survey.
This course is for fourth and fifth-year students only.

SUMMER SESSION

3. SURVEYING. Summer Camp. *Eight hours.* Camp fee, $10.00; Summer Session fee, $30.00. See Sec. 19.
This course, given at Camp Davis, includes plane table, stadia, railroad, hydrographic, and land surveys; triangulation, azimuth, and cross-section work.
Particular attention is also given to the care and adjustment of instruments.
Office work includes computations of field data, the making of maps and diagrams, and preparing permanent records of work performed.
Students are given instruction in camp construction and maintenance and in many things which relate to the welfare of those who spend their lives in the open.
This course is open only to those who have completed Courses 1 and 2, or 12 and 13 in Surveying at the University of Michigan, or equivalent courses of other schools. Course 3E in Astronomy is also a prerequisite.

4*s*. SURVEYING. Use of instruments. *Two hours.*
This course is given at Ann Arbor, and covers work embraced in Course 4.

## 209. GEOLOGY

Professors HOBBS and COOK, Dr. VER WIEBE and Mr. GOULD.

3. PHYSICAL GEOLOGY. *Three hours.* Each semester.
Lectures *M, F,* at 11, and 1-hour quiz, *Tu* at 10 or 11, *W* at 10 or 11, and *Th* at 11. Two hours of laboratory per week, *M, Tu,* or *Th* from 3 to 5. Professor HOBBS and assistants.
A general course leading to an understanding of the principles of physical geology; required of students of Geodesy and Surveying, and open to others as an elective.

40. SOIL GEOLOGY. *Three hours.* Second semester. Professor COOK.
A comprehensive survey of the subject, including the origin of soils, their physical and chemical constitution, the influence of climate on soil fertility, irrigation and drainage, tillage, fertilizers, etc., and a consideration of the regolith of the United

States in relation to geologic, physiographic, and climatic factors.

Geology 3 and Mineralogy 1 and 9 are prerequisites.

42*a*. ECONOMIC GEOLOGY (NON-METALS). *Three hours.* First semester. Mr. GOULD.

A general course treating of the nature, occurrence, and distribution of the non-metallic mineral resources, such as coal, oil, and gas, salt, gypsum, building stones, phosphate rock, etc.

42*b*. ECONOMIC GEOLOGY (METALS). *Three hours.* Second semester. Professor COOK.

In this course the metallic mineral resources are treated in the same manner as are the non-metallic resources during the first semester. Although this course may be elected independently of Geology 42*b*, both are essential to a general survey of the subject.

## 210. GERMAN*

Professors WAIT, LEE, Assistant Professor WILD, Mr. GAISS.

1. ELEMENTARY COURSE. *Four hours.* Both semesters.

Grammar and reading, with practice in writing and speaking German.

2. ELEMENTARY COURSE CONTINUED. *Four hours.* Both semesters.

Grammar and reading, with practice in writing and speaking German.

3. INTERMEDIATE GERMAN. *Four hours.* Both semesters.

Modern prose, conversation, and composition, with a thorough review of grammar.

4. READING OF GERMAN SCIENTIFIC AND TECHNICAL LITERATURE.

Among the subjects considered are Chemistry, Physics, Geology, Mineralogy, etc.

5. ADVANCED COURSE IN GERMAN SCIENTIFIC AND TECHNICAL LITERATURE. *Two hours.* Both semesters.

Each student electing this course reads several books selected with reference to his special line of work. He is also directed to the various German journals dealing with topics in which he is interested and required to report on what he has read.

9. GERMAN CHEMICAL READING. *Two hours.* First semester only.

Equivalent to Chemistry 20.

* See Sec. 138.

## 211. LANDSCAPE DESIGN

Professor TEALDI, Assistant Professor WHITTEMORE.

1. INTRODUCTION TO THE STUDY OF LANDSCAPE DESIGN. Lectures, collateral reading, and reports. *Two hours.*

Course 1 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.

Students following the professional curriculum in Landscape Design must elect this course as

1*a*. PROFESSIONAL INTRODUCTORY COURSE. *Three hours credit.*

This course may be elected by others.

Course 1*a* includes a more technical presentation of the subject, time being devoted to the study of plans, elementary design, field trips, reports, etc.

2. CITY PLANNING AND CIVIC IMPROVEMENT. *Two hours.*

There is a growing tendency throughout the state to take up in earnest the different phases of civic improvement. As this subject grows to be recognized in the State of Michigan as it has been in other states, as a matter of vital importance not only to municipalities but to every individual, whether in the country or in the city, there will arise a demand for men and women to lead the way of civic progress in their communities. These leaders will be recruited from teachers and other citizens who have devoted time to a study of this most complex question. Course 2 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.

Students following the professional curriculum in landscape design must elect this course as

2*a*. CITY PLANNING. *Three hours.*

This course may be elected by others.

Course 2*a* includes a more technical presentation of the subject, time being devoted to the study of plans and elementary design, field trips, and reports. It may be considered a practical introduction to City Planning.

## 212. MATHEMATICS

Professors ZIWET, FIELD, RUNNING, LOVE, HILDEBRANDT, Assistant Professors STEVENS, HOPKINS, POOR, NELSON, ROUSE, DENTON, Mr. BLESSING, Mr. KAZARINOFF, Mr. SALLADE, Mr. JONES, Mr. OLSON, Mr. COATES, Mr. CHURCHILL, Mr. DOSTAL.

1. ANALYTIC GEOMETRY AND ALGEBRA. *Four hours.* Both semesters.

1*a*. TRIGONOMETRY. *Two hours.* Both semesters.

2. PLANE AND SOLID ANALYTIC GEOMETRY. *Four hours.* Both semesters.

2*a*. SOLID ANALYTIC GEOMETRY. *Two hours.* First semester.

3. CALCULUS AND SOLID ANALYTIC GEOMETRY. *Five hours.* Both semesters.

3*a*. CALCULUS. *Five hours.* Both semesters.

4. CALCULUS AND DIFFERENTIAL EQUATIONS. *Five hours.* Both semesters.

4*a*. CALCULUS. *Three hours.* Both semesters.

4*b*. DIFFERENTIAL EQUATIONS. *Two hours.* Both semesters.

17. THEORY OF THE POTENTIAL. *Three hours.* First semester. Professor HILDEBRANDT.

25. DIFFERENTIAL GEOMETRY. *Two hours.* Assistant Professor NELSON.

33. MECHANICS. *Three hours.* Throughout the year. Assistant Professor POOR.

35. PROJECTIVE GEOMETRY. *Three hours.* First semester. Professor FIELD.

36. VECTOR ANALYSIS. *Three hours.* Second semester. Professor FIELD.

45. MATHEMATICS OF FINANCE. *Two hours.* Professor RUNNING.

57. GRAPHICAL METHODS. *Two hours.* Professor RUNNING.

73. DIFFERENTIAL EQUATIONS. *Three hours.* Assistant Professor DENTON.

75. ADVANCED CALCULUS. *Three hours.* Professor LOVE.

80. THEORY OF FUNCTIONS OF A COMPLEX VARIABLE. *Three hours.* Assistant Professor HOPKINS.

83. ELASTICITY. *Two hours.* Professor ZIWET.

89. CALCULUS OF VARIATIONS. *Two hours.* Mr. KAZARINOFF.

## 213. MECHANICAL ENGINEERING

Professors COOLEY, ANDERSON, BURSLEY, EMSWILER, FESSENDEN, WILSON, HAWLEY; Associate Professors LAY, SHERZER; Assistant Professors MICKEL, NICKELSEN, KEEFER, WATSON, GORDY, BEGEMAN; Mr. GOOD, Mr. JAGODZINSKI, Mr. KESSLER, Mr. MARIN, Mr. CALHOON.

Courses 2 to 10 inclusive are required for Mechanical Engineers.

2. ELEMENTS OF MACHINE DESIGN. *Three hours.* Both semesters. Two recitations and one three-hour drawing period, per week. This is an elementary course in the practical application of theory to Machine Design. Forces acting in various parts of machines are carefully determined and combined, stresses accurately computed and the Principles of Design applied to the various parts. A brief review of "The Strength of Materials" is first required. Then, in each of the following, theory is carefully applied to practical design: riveted joints, cotters and keys, bolts, nuts and screws, couplings, axles and shafts, journals, bearings, gearing.

Course 2 must be preceded by Course 1 in Engineering Mechanics and Course 1 in Mechanical Engineering or Course 1 in Civil Engineering, and preceded or accompanied by Course 2 in Engineering Mechanics.

3. HEAT ENGINES. *Four hours.* Both semesters.

Four recitations and one lecture per week are given to the study of the general principles involved in the action of the various forms of heat engines. This is an elementary course required for all engineering students. It relates especially to the steam engine and boiler, the steam turbine and the gas engine. Attention is given to the different types of engines, boilers, and gas engines. The general problem of a modern power plant is considered for the benefit of those who do not devote further time to the subject.

Course 3 must be preceded by Courses 1 and 2 in Physics and by Course 3 in Mathematics.

4. HYDRAULIC MACHINERY. *Three hours.* Both semesters.

Lectures and quizzes. In this course is taken up in a general way the theory, construction, and operation of the principal types of hydraulic machinery.

Course 4 must be preceded or accompanied by Course 4 in Engineering Mechanics.

5. THERMODYNAMICS. *Three hours.* Both semesters.
This course embraces the study of the principles governing the action of heat engines, steam, hot air, and gas engines, air compressors, compressed air engines, refrigerating apparatus, and steam turbines.
Course 5 must be preceded by Course 3.

6. THEORY OF MACHINE DESIGN. *Four hours.* Both semesters.
Lectures, recitations, and drawing room work.
This course is a continuation of Course 2. It is, however, more advanced in its character and gives more attention to machine parts subjected to wear and to dynamic forces. A thorough and comprehensive study is made of machine parts transmitting power. The drawing room work consists of computations, assembly and working drawings of (1) a machine based on statistical machine design principles, (2) a machine based on the principles of the theory of elasticity and dynamics.
Course 6 must be preceded by Course 2 and preceded or accompanied by Course E. M. 3.

7. MECHANICAL LABORATORY. First Course. *Two hours.* Both semesters.
This is an elementary course, and precedes all other courses given in the Mechanical Engineering laboratory. The work consists of elementary tests of a steam engine, steam turbine, gas or oil engine, power pump, and steam boiler. The use and calibration of the instruments used in Mechanical Engineering work are exemplified in connection with the calculation of results and tests of the apparatus named above.
Course 7 must be preceded or accompanied by Course 3, preceded by Course 1 in Engineering Mechanics, and accompanied by Course 10 in Chemical Engineering.

8. MECHANICAL LABORATORY. Second Course. *Three hours.* Both semesters.
This course is devoted to the experimental study of a steam turbo-generator, an oil engine, a fan, a steam injector, an air compressor, a refrigerating machine, a steam power plant, and several forms of hydraulic machinery.
Course 8 must be preceded by Course 7.

9. POWER PLANTS. *Three hours.* Both semesters.
This course consists of lectures, recitations, problems, and reports dealing with the design, operation, and economics of power plants. Considerable attention is given to the cost of producing power and the determination of rates.
Course 9 must be preceded by Course 3, and must be preceded or accompanied by Course 4 in Engineering Mechanics.
Open only to seniors and post-graduates.

9*a*. DESIGN OF POWER PLANTS. *Three hours.* Second semester.
The student is given the usual data furnished the engineer and is then expected to select the proper machinery to meet the needs of this power house. After selecting the machinery he then makes the general design of the power house, including setting and piping plans for all the principal machines to be installed.
Open only to seniors and post-graduates.
Course 9*a* must be preceded by Course 9, and preceded by Course 4 in Engineering Mechanics.

10. THEORY OF MACHINE MOVEMENTS. *Two hours.* Both semesters.
Theory of machine movements, gears, linkages, cams, parallel motions, intermittent motions, study of instantaneous centers, periodic centers of motions and effect of acceleration, with assigned drawing problems.
Course 10 must be preceded by Course 3 in Engineering Mechanics.

11. STEAM BOILERS. *Three hours.* First semester.
In this course the commercial types of boilers, stokers and superheaters, the principles of boiler economy and operation, the combustion of fuels, the theory of heat transference, the purchase of coal by specifications, and the storage of coal are considered. Special attention is given to feed water treatment. A study is made of the problems of design.
Course 11 must be preceded by Course 3.

11*a*. DESIGN OF STEAM BOILERS. *Three hours.* Second semester.
In this course is taken up the complete design of steam boilers of different types. It includes the calculation and design of all important details.
Course 11*a* must be preceded by Course 6.

12. STEAM RECIPROCATING ENGINES. *Two hours.* Second semester.
This course embraces the theory of reciprocating steam engines with particular attention to the thermodynamic action. Consideration is given to the various commercial types and the problems of design.
Course 12 must be preceded by Course 5.

12*a*. DESIGN OF STEAM RECIPROCATING ENGINES. *Three hours.* Second semester.
In this course is taken up the complete design of a steam engine. It includes the calculation and design of the important details.
Course 12*a* must be preceded by Course 6.

13. STEAM TURBINES. *Three hours.* Both semesters.
A course in the advanced study of the principles of the flow of fluids, kinetic effects, and thermodynamics, with the steam turbine used as a concrete example. The fundamental differ-

ences in principle of the different types of turbines; the field of application of the steam turbine; and the influence of high vacuum together with the condensing equipment developed for turbine work, are all given extensive attention.

Course 13 must be preceded by Course 5.

15. INTERNAL COMBUSTION ENGINES AND GAS PRODUCERS. *Three hours.* Both semesters.

A course of lectures and recitations is given covering the complete theory of the internal combustion engine and gas producer. Computations are made for different types of internal combustion engines. Details of construction and modern regulating devices are studied.

Course 15 must be preceded by Course 5, and preceded or accompanied by Course 6.

15*a*. DESIGN OF INTERNAL COMBUSTION ENGINES. *Three hours.* Second semester only.

In this course is taken up the complete design of standard types of internal combustion engines. Particular attention is given to the regulating mechanisms.

Course 15*a* must be preceded or accompanied by Course 15, and must be preceded by Course 6.

16. WATER TURBINES. *Three hours.* First semester only.

In this course is taken up the complete theory, construction, and operation of the different types of water turbines. Opportunity is given for advanced work to graduate students and those who wish to make a specialty of turbine design.

Course 16 must be preceded or accompanied by Course 4.

16*a*. DESIGN OF WATER TURBINES. *Three hours* Second semester only.

In this course is taken up the complete design of water turbines of different types. Particular attention is given to the design of turbine runners, layout of runner buckets, guide vanes and regulating mechanism and also to the design of other turbine elements such as draft tubes, turbine casings, and thrust bearings. Opportunity is given for advanced work to graduate students and those who wish to make a specialty of turbine design.

Course 16*a* must be preceded by Course 6.

17. PUMPING MACHINERY. *Three hours.* Second semester only.

In this course is taken up the complete design of water turbines and operation of reciprocating and centrifugal pumps. Opportunity is given for advanced work to graduate students and those who wish to make a specialty of the design of pumps.

Course 17 must be preceded by Course 4.

17*a*. DESIGN OF PUMPING MACHINERY. *Three hours.* Second semester only.

In this course a complete design is made of a centrifugal or reciprocating pump. In the design of centrifugal pumps, special attention is given to the layout of impellers, diffusors and casings. Opportunity for advanced work is offered to graduate students and those who wish to make a specialty of the design of pumping machinery.

Course 17*a* must be preceded by Courses 4 and 6.

18. HEATING AND VENTILATION. *Two hours.* First semester only.

An elementary course of lectures and recitations covering the theory of heat as applied in heating. The design and construction of hot air, direct and indirect steam, hot water, and fan systems of heating are considered.

Course 18 for Architects only.

19. REFRIGERATION AND COMPRESSED AIR. *Three hours.* Second semester only.

A course for advanced students covering the application of the theories of thermodynamics to refrigeration, and compressed air. This course also includes the study of constructive details of refrigerating plants and compressed air systems, and their operation.

Course 19 must be preceded by Course 5.

20. MECHANICAL HANDLING OF MATERIALS. *Two hours.* Both semesters.

Lectures, recitations, problems, reports, and inspection of systems in use. The work covers first the features of design and installation and later the application to various classes of plants, processes, and materials. The following subjects are considered: cranes and derricks, hand and electric travelers, inclined and vertical hoisting, haulage systems, aerial and surface cableways, conveyors of all classes.

Course 20 must be preceded by Course 2 and by Course 2 in Engineering Mechanics.

20*a*. DESIGN OF HOISTING AND CONVEYING MACHINERY. *Three hours.* Both semesters.

This course consists of calculations, reports, drawing and layout work on hoists, cranes and conveyors.

Course 20*a* must be preceded by Course 6.

21*a*. DESIGN OF MACHINE TOOLS. *Three hours.* Second semester only.

The student will design a complete modern machine tool. The magnitude and direction of forces acting on the cutting tools are calculated and all parts of the machine are proportioned to resist these forces. Investigations of special metal-working processes and machines may be undertaken.

Course 21*a* must be preceded by Course 6.

22. RESEARCH WORK IN THE MECHANICAL LABORATORY. *Two or three hours.* Both semesters.
The course offers an opportunity for students to pursue advanced experimental study along any line of work in which they may be specializing, in accordance with the idea embodied in the group system of studies. The work of the course consists of investigations for securing data on the more difficult problems of mechanical engineering. Students electing this course are left largely to their own resources in planning and carrying out the work.
Course 22 must be preceded by Course 8.

23. HYDRAULIC MACHINERY. Advanced laboratory work. *Two or three hours as arranged.* Both semesters.
Tests and investigations of more difficult nature are made especially on water turbines, centrifugal pumps, hydraulic rams, and hydro-electric plants.
Course 23 must be preceded by Course 4.

25. HEATING AND VENTILATION. *Two hours.* Second semester.
A course of lectures and recitations covering the theory of heating and ventilation as applied to the types of heating and ventilating systems.
Must be preceded by Course 3.

25*a*. DESIGN OF HEATING AND VENTILATION SYSTEM. *Three hours.* Second semester.
The student is given the usual data furnished the heating and ventilating engineer, and is then expected to select a system to meet the requirements. After selecting a system he then makes the general layout of the piping, ducts, and auxiliary apparatus, together with all computations as to size of principal parts.
Course 25*a* must be preceded by Course 3.

29. AUTOMOBILES AND MOTOR TRUCKS. *Three hours.* Both semesters.
A general course covering the fundamental principles of operation and design of automobiles and motor trucks and their application in current practice and consisting of lectures, recitations and demonstrations on
Engine general, operating cycles, valves and valve timing, carburetion, ignition systems, oiling systems, cooling, rating and characteristic curves, clutch, transmission, differential, axles, steering mechanism, brakes and springs, engine and car testing, performance curves, operation and control.
Illustrated lectures, text recitations, laboratory demonstrations.
Not open to freshmen.

30. AUTOMOBILE AND MOTOR TRUCK ENGINES. *Three hours.* First semester.
In this course is begun the theory and design of automobile and motor truck engines. It includes the crank case, cylinder

block, pistons, connecting rods, crank shaft, flywheel, cam shaft, cams, timing gears, valves and valve mechanism, oiling system, cooling system. Lectures, text recitations, computations and drawing sections.

Course 30 must be preceded by Courses 6 and 29.

30*a*. DESIGN OF AUTOMOBILE AND MOTOR TRUCK ENGINES. *Three hours.* Second semester.

This course is a continuation of Course 30 and must be preceded by it.

31. DESIGN OF AUTOMOBILE AND MOTOR TRUCK CHASSIS. *Three hours.*

In this course is begun the theory and design of automobile and motor truck chassis. It includes frame and brackets, clutch, transmission, drive shaft, rear axle, front axle, steering mechanism, and springs. Lectures, text recitations, computations, and drawing sections.

Course 31 must be preceded by Courses 6 and 29.

31*a*. DESIGN OF AUTOMOBILE AND MOTOR TRUCK CHASSIS. *Three hours.* Second semester.

Course 31*a* is a continuation of Course 31, and must be preceded by it.

32. AUTOMOBILE TESTING. *Two hours.* Both semesters.

Experimental laboratory and road study of automobiles and motor trucks, and their component parts. Engine tests covering general operation and construction, maximum horse-power, fuel consumption, thermal efficiency, mechanical efficiency, heat balance; study of timing, cooling, oiling systems, ignition systems, carburetion, indicator cards, and characteristic curves; tests on power transmission efficiencies; road tests covering car performance, including speed range, acceleration and fuel consumption.

Course 32 must be preceded by Course 7, and preceded or accompanied by Course 29.

33. ADVANCED AUTOMOBILE TESTING AND RESEARCH. *Two or three hours.* Both semesters.

This course affords an opportunity for advanced experimental work and research upon special problems involved in some automobile unit or in the complete automobile or motor truck. Where the problems are comprehensive, several students may be grouped into one squad, where they are left larely to their own resources in the planning of apparatus and the carrying out of the work.

Must be preceded by Course 32.

34. ADVANCED AUTOMOBILE DESIGN AND RESEARCH. *Credit and hours to be arranged.* Both semesters.

This course affords an opportunity for advanced design and

research upon special problems critical in the design of some automobile unit or of the complete automobile or motor truck. Must be preceded by Courses 32*a* and 31*a*, or their equivalent.

35. SHOP MANAGEMENT. *Three hours.* Both semesters. Lectures, recitations, and laboratory.
This course includes the study of the application of the principles of the Taylor System of Scientific Management to shop and other industries. It includes lectures, assigned reading, reports, and discussions on routing, time and motion study, proper sequence and methods of operations, use of instruction cards, mnemonic classification, stores systems, tool rooms, costs, etc. A certain amount of laboratory and field work will also be required in order to familiarize the student with the application of the principles obtained in the classroom.
This course is open to juniors, seniors, and graduates in the College of Engineering, and in the course in Business Administration in the College of Literature, Science, and the Arts.

36. FIELD WORK IN SHOP MANAGEMENT. *Two hours.* Both semesters.
This course consists of inspection trips to plants in this vicinity and lectures and problems presented by men prominent in the industrial field. The trips and lectures will be concerned with the various topics covered in E. M. 35, such as store room and tool room operation, factory buildings, costs, planning and routing. In this course, the student will be given the opportunity of observing how these various ideas are worked out in the factory.
Must be preceded by Course 35.

37. SPECIAL TOPICS ON THE INTERNAL COMBUSTION ENGINE. *Two hours.* Both semesters.
In this course it is intended to bring the student in touch with the latest developments in the theory, design, and construction in the internal combustion engine field.
This course must be preceded by Course 15.

38. INTERNAL COMBUSTION ENGINEERING. Laboratory Research Work on Internal Combustion Engines. *Credit and hours to be arranged.*
Must be preceded by Courses 8 and 15.

39. INTERNAL COMBUSTION ENGINEERING. Research Design in Internal Combustion Engines. *Credit and hours to be arranged.*
Must be preceded by 15*a*, or accompanied by Course 15*a* and 37.

41. AUTOMOBILE ENGINEERING SEMINAR. *One hour.* Both semesters.
In this course the student prepares a paper on current topics of the automobile industry and one covering an investigation of

some special subject. A discussion of these papers is made by the class.

Must be preceded or accompanied by Course 29.

42. RESEARCH IN SHOP MANAGEMENT. *Two or three hours.* Both semesters.

This course includes the assignment of particular problems to students for their individual study and solution.

Must be preceded by Course 35.

43. FACTORY INTERNAL TRANSPORTATION. *Three hours.* Both semesters. Lectures, recitations, problems and reports.

This course offers an opportunity for students to familiarize themselves with the various systems of factory internal transportation. The course takes up such points as initial cost, cost of operation, upkeep, etc., of the different types of handling equipment and includes problems pertaining to them. Typical installations in several industries will be studied in detail.

Open to seniors and graduates in the College of Engineering, and in the course in Business Administration in the College of Literature, Science, and the Arts.

44. AUTOMOTIVE ELECTRICAL EQUIPMENT. *Three hours.* Both semesters. Lectures, quizzes and laboratory work.

This course is devoted to the study of storage batteries, ignition, starting and lighting equipment as applied to gasoline automobiles and to storage battery equipment, charging apparatus, motors and control equipment, as applied to electrically propelled vehicles.

Must be preceded by Physics 2E and M. E. 29.

50. GYROSCOPIC ACTION AND CRITICAL SPEEDS. *Two hours.* Both semesters.

Fundamental principles. Quantitative discussion for simple case, *i. e.*, constant precessional velocity. Principles of applications to stabilizing of ships—active and passive types. Brennan's and Schelowsky's Monorail Systems. Principles, construction, and sourses of error in the Sperry and Anschutz Gyro-Compasses.

Synchronous action in general. Mathematical study of simple ideal cases of critical speeds. Empirical treatment of complex cases.

Laboratory work with models of active and passive types of gyroscopic stabilizers; also on determination of critical speeds.

Course 50 must be preceded by Course 3 in Engineering Mechanics.

## 214. MILITARY SCIENCE AND TACTICS

Professor CARPENTER, Assistant Professors BROOKS, COLLINS, HOORN, LOUISELL, and DUNN.

The courses in Military Science and Tactics are designed to give a thorough ground work in Military subjects considered necessary as a part of the education of a commissioned officer in the Reserve Corps of the United States Army. A student enrolls for Military Science at the Headquarters, Reserve Officers' Training Corps, on the campus. He also elects his Military Science courses at the same time and place as he elects his other University courses and receives academic credit therefor which counts toward graduation.

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

Successful completion of a Basic and an Advanced Group will lead to a recommendation for a commission as an officer of the Reserve Corps. During the Advanced Group a student receives pay from the Government totaling about $200. A deposit of ten dollars to cover proper responsibility is required of each student. The deposit is refunded upon return of all property and equipment. For further information see special announcement, Military Science and Tactics.

### Coast Artillery Corps

BASIC GROUP

1. ELEMENTARY INFANTRY. Infantry Drill Regulations and Marksmanship. *One hour.* First semester.
   Infantry Drill and practical instruction in firing the rifle.

2. ELEMENTARY INFANTRY (Continued). Fundamental subjects in Military Training. Recitations, lectures, and drill. *One hour.* Second semester.
   Organization, care of small arms, interior guard duty, military courtesy and discipline, military hygiene.

3. HEAVY ARTILLERY MATERIEL. *One hour.* First semester.
   Guns, carriages, ammunition, explosives.

4. ARTILLERY MATERIEL, MAP READING AND SKETCHING. *One hour.* Second semester.
   Special types of artillery, practical and theoretical work in making and reading military sketches.

ADVANCED GROUP

5. ORIENTATION. Topographical operations in locating and laying artillery. Field Engineering, emplacements, obstacles, and camouflage. *Two hours.* First semester.

6. GUNNERY; FIRE CONTROL. Recitations, lectures and laboratory work. *Two hours.* Second semester.
Computation of firing data, meteorological and other corrections, observation and adjustment of fire, firing problems, fire control materiel.

7. MOTOR TRANSPORTATION. Course 29 in Mechanical Engineering Automobiles and Motor Trucks, satisfies the requirements for this course. First semester.

8. MILITARY LAW, MILITARY HISTORY AND POLICY, COMPANY ADMINISTRATION. Recitations, lectures, and laboratory work. *Two hours.* Second semester.
Elements of common law, military law, moot court-martial, rules of land warfare, military policy, company organization and administration, tactical employment of heavy artillery.

## Signal Corps

BASIC GROUP

11. ELEMENTARY INFANTRY. Military telephony. *One hour.* First semester.
Infantry drill and practical instruction in firing the rifle and pistol and military telephony.

2. ELEMENTARY INFANTRY. Fundamental subjects in Military Training. *One hour.* Second semester.
Organization, individual equipment, military hygiene.

13. MILITARY TELEGRAPHY; MILITARY MAP READING AND SKETCHING. *One hour.* First semester.
Recitations, lectures, and laboratory work.

14. FIELD RADIO SETS. Recitations, lectures, and laboratory work. *One hour.* Second semester.
Installation, operation, and care of radio sets, sending and receiving.

ADVANCED GROUP

15. SIGNAL CORPS ORGANIZATION AND TACTICS; FIELD ENGINEERING. Recitations, lectures, and practical work. *Two hours.* First semester.
Organization and tactics, wire net operation and control, minor tactics of Signal Corps, applied signal communications, field orders, trenches, dug-outs, camouflage, obstacles.

16. MILITARY LAW; MILITARY HISTORY AND POLICY; COMPANY ADMINISTRATION; MESSAGE CENTERS. *Two hours.* Second semester.
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, codes and ciphers, message centers.

17. COMMUNICATION ENGINEERING. See Physics 16. First semester.
Course 16 in Physics, Vacuum Tubes in Radio Communication, satisfies the requirements of this course.

18. COMMUNICATION ENGINEERING. Second semester.
Course 10 in Electrical Engineering, Advanced Theory of Electrical Circuits, satisfies the requirements of this course.

## Infantry

### BASIC GROUP

1. ELEMENTARY INFANTRY. Infantry Drill Regulations, and Marksmanship. *One hour.* First semester.
Infantry drill and practical instruction in firing the rifle.

2. ELEMENTARY INFANTRY (Continued). Fundamental subjects in military training. *One hour.* Second semester.
Organization, individual equipment, guard duty, military hygiene, military courtesy and discipline.

23. MUSKETRY; SCOUTING AND PATROLING; AUTOMATIC RIFLE. *One hour.* First semester.
Team work in the use of the rifle, automatic rifle, grenades, and other infantry weapons. Training in the methods of gaining information of the enemy prior to and during the combat. Construction, operation, and firing of the Browning Automatic Rifle.

24. MILITARY MAP READING AND SKETCHING; INFANTRY WEAPONS. *One hour.* Second semester.
Map reading, road and positon sketches, hand and rifle grenades, bayonet fighting.

### ADVANCED GROUP

25. COMMAND AND LEADERSHIP; MINOR TACTICS; MACHINE GUNS. *Two hours.* First semester.
Theoretical and practical instruction in handling men, infantry organization, disposition of infantry weapons and units for defensive combat. Theoretical and practical instruction in machine gunnery.

26. COMMAND AND LEADERSHIP (Continued); ACCOMPANYING WEAPONS, FIELD FORTIFICATION. *Two hours.* Second semester.
Mechanics and tactical use of the one pounder and light mortar. Theoretical and practical instruction in laying out and constructing field fortifications.

27. MINOR TACTICS. Recitations, lectures, and laboratory work. *Two hours.* First semester.
Organization and equipment of various units, offensive and defensive conduct of small units, tactical employment of infantry weapons, combined action, sand-table exercises, map and terrain problems.

28. MILITARY LAW, MILITARY HISTORY AND POLICY, COMPANY ADMINISTRATION, COMMAND AND LEADERSHIP. Recitations, lectures, and laboratory work. *Two hours.* Second semester.
Elements of common law, military law, moot court-martial, rules of land warfare, military policy, company organization and administration, and handling of troops.

## Ordnance

### BASIC GROUP

1. ELEMENTARY INFANTRY. Infantry Drill Regulations and Marksmanship. *One hour.* First semester.
Infantry Drill and practical instruction in firing the rifle.

2. ELEMENTARY INFANTRY (Continued). Fundamental subjects in Military Training. Recitations, lectures, and drill. *One hour.* Second semester.
Organization, care of small arms, interior guard duty, military courtesy and discipline, military hygiene.

3. HEAVY ARTILLERY MATERIEL. *One hour.* First semester.
Guns, carriages, ammunition, and explosives.

4. ARTILLERY MATERIEL, MAP READING AND SKETCHING. *One hour.* Second semester.
Special types of Artillery, practical and theoretical work in making and reading military sketches.

### ADVANCED GROUP

36. ORDNANCE ORGANIZATION AND ADMINISTRATION; COMMAND AND LEADERSHIP. *Two hours.* Second semester.
Organization and administration of the Ordnance Department and of Ordnance Establishments. Duties of an Ordnance officer. This course should be taken during the second semester of the Junior year. Credit in this course is given for drill and instruction in leadership during the entire advanced course.

The Ordnance Department feels that additional technical or administrative work is of more value to a future Ordnance Officer than ordinary military work. For this reason, an ordnance student, instead of taking 8 hours military work during his advanced course, is required to elect six semester hours from the following list of subjects and take course 36. The subjects selected must be in addition to those required by the college in which enrolled. In other words, they must be listed as electives rather than required subjects. They may be taken at any time during the college course.

Chemical Engineering 1, 4, 5, 6, 7, 8, 12, 13, 18, 21, a, i, j, 24, 26, 30, 31, 32. Chemistry 2E, 3, 5, 7, 7a, 8E, 13, 14, 14a, 14b, 25, 28, 26; Civil Engineering 26; Drawing 4; Electrical Engineering 2, 2a, 3, 3a, 4, 5, 11, 14, 17, 19, 20, 33; Engineering Mechanics 1, 2, 2a, 3, 4, 5, 6; English 6; Mathematics 4, 4a, 4b; Mechanical Engineering 2, 3, 4, 5, 6, 7, 8, 10, 20, 20a, 21a, 29, 30, 30a, 31, 31a, 32, 33, 34, 35, 36, 37, 38, 39, 42; Physics 1E, 2E, 5E, 6, 11, 18, 24; Political Economy 1E, 1, 2, 3, 15, 32, 34, 38, 38E, 20; Shop 1, 2, 3, 4, 5, 6, 7, 8, 9.

## Air Service

Arrangements have recently been made with the War Department by which those students of Aeronautics who are enrolled in the Advanced Group of any one of the above mentioned units of the R. O. T. C., and who desire a commission as second lieutenant in the Air Service, Reserve Corps, may attend one Advanced Group Camp of the Air Service at which both theoretical and practical instruction in flying is given, provided, that they have passed the physical examination for the Air Service.

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

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

## General

DRILL. All students of the R. O. T. C. will drill from 3-4 Wednesday afternoon during the first 10 weeks of the first semester

and the last 6 weeks of the second semester. This hour should be left open by all students including those who are taking a course in the Engineering College rather than in the Military Department.

BAND. Students in all units who desire to play in the R. O. T. C. Band will be excused from regular classes from 3 to 4 Wednesday afternoon, and will spend this time in band practice.

Membership in the band is also open to those students of the University who are not enrolled in the R. O. T. C., provided they attend the regular practice on Tuesday at 7:15 P. M., the drill or practice on Wednesday afternoon at 3 to 4 and those special formations of the R. O. T. C. as may be required or authorized by the authorities of the University.

RIFLE PRACTICE. All R. O. T. C. students may practice on the indoor or outdoor range whenever they desire during a scheduled period. Attendance need not be regular.

## Summer Camps

### BASIC

Students in the basic group who desire to attend a basic camp should notify their instructor as early as possible. Attendance is voluntary. Camps will last about 6 weeks, beginning about June 19. All expenses paid by the government.

COAST ARTILLERY CORPS—Will attend Infantry camp at Camp Custer.

SIGNAL CORPS—Camp Custer, Mich. Practical and laboratory work pertaining to the Signal Corps.

INFANTRY—Camp Custer, Mich. Practical work in Infantry Drill, Interior Guard Duty, Ceremonies, Marksmanship, Minor Tactics, Infantry Weapons, and Physical Training.

ORDNANCE—Will attend Infantry camp at Camp Custer.

### 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 of the seventh grade (70c per day in 1923). Ample time and facilities are allowed for recreation.

COAST ARTILLERY CORPS—Fort Monroe, Va. *Six weeks.* June 19 to July 30.

SIGNAL CORPS—Camp Custer, Mich. *Six weeks.* June 19 to July 30.

INFANTRY—Camp Custer, Mich. *Six weeks.* June 19 to July 30.

ORDNANCE—Aberdeen Proving Ground, Md. *Six weeks.* June 19 to July 30. Practical Ordnance work including firing and otherwise testing all types of ammunition, guns, carriages, self-propelled artillery, tractors, tanks, and other ordnance equipment.

AIR SERVICE—Chanute Field, Illinois. *Six weeks.* About June 19th to July 30th. Theoretical and practical work in flying. For Aeronautical Engineers only.

## 215. MINERALOGY AND PETROGRAPHY

Professors KRAUS, HUNT, Assistant Professor PECK, Mr. RAMSDELL, and Mr. HOLDEN.

1. ELEMENTS OF MINERALOGY. *Two hours.* Both semesters.
   Includes the elements of crystallography, and the physical and chemical properties, occurrence, uses, and determination of the more common minerals. Lectures and laboratory work.
   For Course 1, a knowledge of elementary inorganic chemistry is necessary.

2. GENERAL MINERALOGY. Lectures and laboratory work. *Five hours.* First semester only.
   Principles of crystallography, physical and chemical properties, origin, formation, decomposition, distribution, uses, and determination of the more important minerals.
   Students who have successfully completed Course 1 may elect this course as Course 2a and receive *three hours credit.*
   Course 2 must be preceded by Courses 2 and 3 in Chemistry.

4. DETERMINATIVE MINERALOGY. Laboratory work. *Two hours.* Both semesters.
   This course is intended for students who have finished Course 1 and wish to become more proficient in the determination of minerals.

5. QUALITATIVE BLOWPIPE METHODS. *Two hours.* First semester only.
   The use of blowpipe reactions upon charcoal and plaster tablets, as well as other chemical methods useful in the determination of minerals. Lectures and laboratory work.
   Course 5 should be preceded by Course 2, or Courses 1 and 4.

9. LITHOLOGY. *Two hours.* Both semesters.
   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 labora-

tory the student is required to determine by means of the macro-physical properties a large number of rock specimens. Field excursions will also be made in order to acquire facility in the rapid determination of rocks in the field. Lectures and laboratory work.

Course 9 must be preceded by Mineralogy 1 and Geology 1.

12. QUANTITATIVE BLOWPIPE METHODS. *Two hours.* First semester.

Reading and laboratory work. Practice in assaying by blowpipe methods various kinds of ores, especially those of gold, silver, copper, and lead.

Course 12 must be preceded by Course 5.

16. USEFUL MINERALS AND BUILDING AND DECORATIVE STONES. Designed especially for students of Architecture. Laboratory work, two hours a week, to be arranged. *Three hours.* Second semester only.

This course is designed primarily for students of Architectural Engineering. 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 and materials 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. Lectures are also given on the methods of quarrying, finishing, and testing of building stones.

For this course a knowledge of elementary inorganic chemistry is necessary.

17. GEMS AND PRECIOUS STONES. *Two hours.* Lectures and demonstrations. Second semester only.

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

## SUMMER SESSION

Courses 1, 4, 5, 8, and 9 will be offered in 1924. For other courses, see announcement of the Summer Session.

## 216. NAVAL ARCHITECTURE AND MARINE ENGINEERING

Professors SADLER, BRAGG, Assistant Professor LINDBLAD.

1. NAVAL ARCHITECTURE. Structural Design. Lectures and recitations. *One hour.* First semester.

   This course comprises a discussion of the principal features of construction of all types of ships; classification societies' rules; preparation of working plans.

2. NAVAL ARCHITECTURE. Ship Calculations. Lectures and recitations. *Three hours.* Second semester.

   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; freeboard and tonnage; launching; calculation of bending moments and stresses in vessels under various conditions.

3. NAVAL ARCHITECTURE. Stability of Ships and Preliminary Design. *Three hours.* First semester.

   Course 3 must be preceded by Course 2, and includes investigations of the stability of vessels and means of determining the same; discussions 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.

4. NAVAL ARCHITECTURE. Resistance and Propulsion. *Three hours.* Second semester.

   In this course all items affecting the resistance and propulsion of various ships' forms; investigations of the theory and practice involved in the design of propellers; methods of conducting trial trips, etc., are discussed.

5. NAVAL ARCHITECTURE. Structural Drawing. *Two hours.* First and second semesters.

   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.

6. NAVAL ARCHITECTURE. Ship Drawing and Design. *Three hours.* First and second semesters.

   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.

7. NAVAL ARCHITECTURE. Ship Drawing and Design. *Three hours.* First and second semesters.

   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.

8. MARINE BOILERS. Lectures and recitations. *One hour.* First semester.
The design and construction of marine boilers and their accessories are discussed.

9. MARINE ENGINES. Lectures and recitations. *Two hours.* First semester.
Course 9, which must be preceded by Course 3 in Mechanical Engineering and Course 1 in Engineering Mechanics, includes the questions relating to the design, construction, and balancing of triple and quadruple expansion engines. Condensers, air pumps, turning and reversing engines are also discussed. Each student makes all of the preliminary calculations for the design of a marine engine.

10. MARINE BOILER DRAWING AND DESIGN. *Three hours.* Both semesters.
In this course a Scotch marine boiler of general type is designed.

11. MARINE ENGINE DRAWING AND DESIGN. *Three hours.* Both semesters.
The complete general plans of a triple or quadruple expansion engine are prepared, together with all calculations for the same.

12. NAVAL ARCHITECTURE. Experimental Tank.

13. NAVAL ARCHITECTURE. Specifications and Contracts.

14. NAVAL ARCHITECTURE. Shipyard Plants.

15. NAVAL ARCHITECTURE. Advanced Reading and Seminary.

16. NAVAL ARCHITECTURE. Advanced Drawing and Design.

17. MARINE ENGINEERING. Advanced Reading and Seminary.

18. MARINE ENGINEERING. Advanced Drawing and Design.

---

## 217. PHILOSOPHY

Professors WENLEY, VIBBERT, SELLARS and PARKER.

(Owing to the redistribution of courses and hours in the Department of Philosophy and Psychology, students are asked to refer to the Announcement of the College of Literature, Science, and the Arts for final information relative to 1924-1925.)

The courses in Philosophy of most direct value and interest to Engineering students appeal to two classes of students, as follows:

(1) To student of Science, who desire to understand the theory, postulates, and general mental conceptions employed by the Natural Sciences, particularly Physics and Chemistry. The courses bearing on these problems are 1 and 15. Philosophy 1 deals with the general relations between Science and Philosophy as two complementary standpoints in human experience. For those who have time it should be taken along with Course 15.

(2) To students of Architecture, who desire to understand the general theory of beauty, and to know something of the history of Æsthetic doctrine and of the points of view developed in the several great stages of artistic creation. Course 6*a* in the first semester and Course 6*b* in the second semester are devoted exclusively to these subjects. Students of Architecture should elect both courses, beginning, if possible, with Course 6*b* (second semester), and continuing with Course 6*a* in the first semester of the following year.

For full description of courses, see Announcement of the College of Literature, Science, and the Arts.

1. PHILOSOPHICAL INTRODUCTION. *Three hours.* First or second semester. Lectures and discussion sections.

Engineering students are advised to elect the course as given in the first semester.

The object of this course is to explain to beginners, in the most elementary manner possible, the meaning, interest, and scope of Philosophy; to compare its outlook with other standpoints, such as those to the average man (common sense), and especially of science (including Philosophy).

6*a*. ÆSTHETICS. *Two hours.* First semester.

The definition, forms, and standards of Beauty. The relation between Æsthetic values and Ethical and Religious values. This course is of primary interest to students of Architecture and Art.

Should be preceded by Course 6.

6*b*. THE HISTORY OF ÆSTHETICS. *Three hours.* Second semester.

The development of Æsthetic theory in relation to the contemporaneous social, philosophical, and artistic movements. This course is of primary interest to students of Architecture and Art.

15. THE PHILOSOPHICAL IMPLICATIONS OF THE FUNDAMENTAL CONCEPTIONS OF NATURAL SCIENCE. *Three hours.* Second semester.

This course is designed for students of Physics and Chemistry. It is open to all who desire to grasp the presuppositions of the scientific standpoint, and who are interested in the progress of modern thought. It presupposes some knowledge of science, but not of philosophy. The Postulates of Science. The place

of general concepts in Science. The main conceptions employed in the synthesis of Physics, Chemistry, and Biology—what they imply, how they subserve knowledge of Nature, their necessary conditions and limits.

## 218. PHYSICS

Professors RANDALL, WILLIAMS, COLBY, SMITH, Assistant Professors RICH, SLEATOR, LINDSAY, MEYER, BARKER, SAWYER, Dr. DUFFENDACK, Dr. CORK, Dr. KIMBALL, Mr. ST. PETER, Dr. COOLEY, Mr. BRONK, Dr. KLEIN.

For all courses beyond Courses 3 and 4 Physics 1E and 2E (or 1 and 2) and calculus are prerequisites. The individual courses may have particular prerequisites besides.

Z. PHYSICS FOR ADMISSION. This course is intended for students who have not presented the required unit of entrance Physics. It is required for admission to Courses 1 and 1E. *No credit will be allowed for this course.* Four times a week, first semester. *M, W, Th,* and *F,* at 5.

1. GENERAL PHYSICS—MECHANICS, SOUND, AND HEAT. Lectures and recitations four times a week, and laboratory work. Both semesters.

1*a*. PHYSICS PROBLEMS. Once a week. Both semesters.
Students in Architecture 1 and 2 elect 1 and 1*a* for *four hours* credit.

1E. MECHANICS, SOUND, AND HEAT. Lectures, recitations, and laboratory work. *Five hours.* Both semesters.
For Courses 1 and 1E a knowledge of plane trigonometry is indispensable. No student is admitted to the class who has not had a preparatory course in Physics.
In Course 1E at least half of the semester is devoted to Elementary Mechanics; the remainder of the time to Sound and Heat; all with experimental illustrations. All members of the class have one period a week in the laboratory.

2. GENERAL PHYSICS—MAGNETISM, ELECTRICITY, AND LIGHT. Lectures and recitations, four times a week, and laboratory work. Both semesters.

2*a*. PHYSICS PROBLEMS. Once a week. Both semesters.

2E. MAGNETISM, ELECTRICITY, AND LIGHT. Lectures, recitations, and laboratory work. *Five hours.* Both semesters.
Course 2E must be preceded by Course 1E and by Course 2E in Chemistry, or an equivalent. It is a continuation of Course

1E and takes up the fundamental phenomena and laws of these subjects, with ample class illustrations. Laboratory work as in Course 1E.

Courses 1E and 2E are required from all Engineering students. Students transferring their credits from the College of Literature, Science, and the Arts will be required to offer Courses 1, 1*a*, 2, and 2*a*, as equivalents of Course 1E and 2E.

3 and 4. MODERN PHYSICS. *Two hours.* Throughout the year.

Informal lectures and discussions, with demonstrations treating radioactivity, X-rays, the vacuum tube, and other electron and allied phenomena which lead to the theory of matter. The courses will be non-mathematical, requiring as prerequisite Courses 1 and 2 or 1E and 2E.

Courses 3 and 4 undertake 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 them a suitable introduction to advanced courses.

5. ELECTRICAL MEASUREMENTS. Lectures, recitations, and laboratory work. *Four hours.* First semester.

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.

5E. ELECTRICAL MEASUREMENTS. Lectures and laboratory work. *Four hours.* Both semesters.

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.

6. ELECTRICAL MEASUREMENTS. Lectures and laboratory work. *Four hours.* Second semester.

This is a continuation of Course 5, and includes measurements of capacity, 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.

A working knowledge of the calculus is required.

7. MECHANICS. *Three hours.* First semester.
The mechanics of solids, liquids and gases, involving such topics as the various types of motion, moments of inertia, elasticity, friction, viscosity, capillarity, etc.

8. ARCHITECTURAL ACOUSTICS. *Two hours.*
Lectures, with illustrative problems on sound transmission, distribution, and absorption, and an experimental study of the acoustical properties of certain rooms.

9. SOUND. *Four hours.* First semester.
The class work is based on Barton's *Text Book on Sound,* with lectures and reference reading.

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

12. LIGHT. *Four hours.* Lectures, recitations, and laboratory work. This is an intermediate theoretical and experimental course.

14. ELECTRON THEORY AND RADIOACTIVITY. *Two hours.* Lectures and laboratory work. Second semester.
The laboratory work deals 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.

16. VACUUM TUBES IN RADIO COMMUNICATION. *Two hours.* Lectures and laboratory work. Second semester.
The theory of the transmission of electricity through gases will be treated in this course, together with a study of the different types of tubes used in radio work. The characteristics of such tubes will be determined experimentally and the electric circuits employed in their use will receive considerable attention.
Prerequisites: Course 5E in Physics, and a course in alternating currents.

18. MEASUREMENTS OF HIGH TEMPERATURES. *Two hours.* Seconds semester.
An experimental course accompanied by lectures covering the

present methods of high temperature measurement. It includes the calibration and use of the resistance thermometer, the resisance thermometer bridge, the thermocouple, the thermocouple potentiometer, the various technical types of indicators and recorders, the total radiation and optical pyrometers, and laboratory methods of producing high temperatures. The subject matter is taken up from both a practical and a theoretical standpoint.

31. THERMODYNAMICS. *Three hours.* First semester.
This course will treat the two laws from the points of view of Physics (31) or Chemistry (24). The former will be mathematically more rigorous and will in its application prepare for such physical problems as gas theory, radiation, etc. The second course will emphasize in application such problems as the phase rule and chemical equilibrium. Both courses may be elected by the same student, but the total credit will then be reduced to *five hours.*

24. THERMODYNAMICS. *Three hours.* Second semester.
This course, as described under 31, for the first semester, will treat the subject from the standpoint of chemistry.

25. THEORY OF HEAT. *Two hours.* First semester only.
In this course certain selected topics in the Theory of Heat are discussed in lectures.

27, 28. ELECTRICITY AND MAGNETISM. *Two hours.* Throughout the year.
These courses are devoted to a mathematical as distinguished from an experimental study of electrical phenomena.

32. THE KINETIC THEORY OF GASES. *Three hours.* Second semester.
Discussion of the laws of probability, Maxwell-Boltzman law, molecular magnitudes, Brownian movements and Einstein's equation, absorption of gases, and other selected topics. Experimental methods will be considered.

36. X-RAYS. *Three hours.* Second semester.
The fundamental facts and theories connected with the production and measurement of X-rays, together with a study of the development of the subject and its bearing on modern ideas of the structure of matter.

37. GERMAN READING. *Two hours.* First semester.
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.
Course 37 is continued in the second semester as Course 28, *two hours.*

## SUMMER SESSION

Course Z, intended for students preparing for entrance to the College of Engineering, and Courses 1, 1E, 2, 2E, 1*a*, 2*a*, 5, 5E, 6, 6E, 9, 12, 14, 17, 30, and 31, as described for the regular session, will be offered in the Summer Session of 1924.

---

## 219. POLITICAL ECONOMY AND BUSINESS ADMINISTRATION

Professors DAY, TAYLOR, SHARFMAN, PATON, GRIFFIN, and others.

The first two courses of Political Economy listed below—1C and 2C—are designed especially for students in the College of Engineering. In addition, there is enumerated a number of courses in Political Economy and Business Administration which will prove of interest and value to such students of Engineering as are able to devote a larger amount of time to outside fields of study. For a more detailed announcement of these courses and for additional courses in the field of economics, consult the Annual Announcement of the College of Literature, Science, and the Arts, and of the School of Business Administration.

1*c*. Elements of Economics. *Three hours*. First semester only.
This course is especially designed to meet the needs of students whose work lies in professional departments, particularly engineering. It will be devoted to a consideration of the fundamental economic principles and of the important practical current problems of the economic world, particularly insofar as they illustrate these principles.
No student can receive credit for this course and Course 1 or Course 1*a* or Course 1*G*.
Students who plan to take an extended course in economics should take Course 1.

2*c*. Elements of Economics. *Three hours*. Second semester only.
A continuation of 1*c*. Special attention will be given to problems of valuation and the prinicples of government regulation of industry.
Prerequisite: 1*c*.

1*a*. General Economics. Lectures and quizzes. *Three hours*. Both semesters.
This course is designed for seniors, graduates, and students in their last semester of residence, whose chief interest is in some other department and who have time for but one course in economics. It will not be accepted in lieu of Courses 1 and 2 as prerequisite to other economic courses, and is not

open to students who have had or are taking Course 1 or 1*c*, or 1*G*.

This course, beginning with a brief description of modern industrial society, undertakes a study of the leading principles of economics and their application to current problems of industrial organizations, exchange, distribution, and public control of industry.

This course will be repeated the second semester.

1. PRINCIPLES OF ECONOMICS, I. *Three hours.* Both semesters.

This course and Courses 2 constitute a general course in the principles of economics which must precede all other courses in economics except 1*a*, 1*c*, 1*G*, and 38.

2. Principles of Economics, II. *Three hours.* Both semesters.

This course is a continuation of Course 1, by which it must be preceded. (It is not open to students who took Course 1 prior to 1921-1922.)

38. Principles of Accounting, I. *Three hours.* Both semesters.

This introductory course consists primarily in a study of the principles of the double-entry system, the more important technical devices of accounting being briefly considered in this connection. The classification of accounts for managerial and other purposes, the significance and determination of business income, and the treatment of partners' accounts, are among the special topics discussed. Particular attention is given to periodic ledger analysis, to the construction and use of working sheets, and to the preparation of statements of income and financial condition.

Course 1 must precede or accompany this course.

This course is repeated in the second semester.

39. Principles of Accounting, II. *Three hours.* Second semester only.

This is a continuation of Course 38. It is also open (with permission) to students who have completed Course 38E. The work of this course includes a study of the corporate proprietary accounts (capital stock, surplus, dividends, and reserves) and corporate liabilities, the treatment of bond discounts and premiums receiving especial consideration. Among the topics in valuation discussed are the problems of the organization period, the bases for revaluation, depreciation policies and procedures, and the treatment of the intangible assets. A considerable time is devoted to the construction and analysis of detail and summary financial statements.

Prerequisites: Courses 1 and 38.

3. Labor Problems and Trade Unionism. *Three hours.* First semester only.

A survey of the present labor situation, especially in the United

States, with constant recourse to historical background and economic principles for explanation of existing phenomena. Organized movements of workers and employers are studied as to origins, philosophies, methods and results. The student is made acquainted with the issues involved in strikes, boycotts, trade agreements, closed shop policy, etc., but these matters are subordinated throughout to the wider problems of industrial relations. Statistical and descriptive materials on wages, hours, unemployment, cost of living, as well as on the peculiarities and interrelations of unions and employers' associations, are introduced. Reactions between labor problems and the general business cycle are shown; and coöperative and socialistic movements such as syndicalism, are briefly touched upon, where they serve to illuminate the general labor situation. Students are expected to provide themselves, in addition to other texts, with all current numbers of the Monthly Labor Review of the U. S. Bureau of Labor Statistics; hence subscriptions should be entered early. Written and oral solutions of assigned problems will be frequently required.

Prerequisites: Courses 1 and 2.

4. Principles of Public Finance. *Three hours.* First semester only.

This course is devoted to a consideration of the fundamental principles of government finance, together with an analysis of the fiscal system of the United States. It deals with public expenditures, treasury organization and the budget, revenue systems, and public debts. Particular stress will be placed, however, on the study of the nature, principles, and effects of taxation and on the description of Federal, state and local tax systems. The course will be concluded by a brief treatment of war finance, especially the financial problems and methods of the United States during the World War.

Prerequisites: Courses 1 and 2.

6. Railway Problems. Lectures, reading, and discussion. *Three hours.* First semester only.

This course considers the social and industrial significance of modern transportation, traces the development of railway transportation, analyses the chief railway problems in the United States, with special reference to the nature of railway competition and the theory and practice of rate-making, and devotes particular attention to the regulation of railways, especially by the federal government. The course will be concluded by a discussion of the war administration of the railroads and of the adjustments in railway regulation which accompanied the return of the roads to private operation.

Prerequisites: Courses 1 and 2.

9. Money and Banking. *Three hours.* First semester only.
This course undertakes an analysis of theories of money and credit. Attention is given also to monetary history and banking as an agency for capital supply and of the relationship between bank credit and money and prices. Particular attention will be given to the federal system.
This course should be followed by 9*a* by all students expecting to specialize in economics or business administration.
Prerequisites: Courses 1 and 2.

10. Economic Cycles. *Three hours.* Second semester only.
This course deals with the character, the statistical measurement, and the explanation of the economic cycle. Attention is also given to methods of business forecasting.
Prerequisites: Courses 1, 2, and 9.

14. Economic Statistics. *Three hours.* Second semester only.
This course is designed to acquaint the student with the sources and analysis of the more important statistical data of economic science.
Prerequisites: Courses 1, 2, and 9.
This course is open only to seniors and graduate students.

15. Corporations. Lectures, reading, and discussion. *Three hours.* Second semester only.
This course undertakes a study of corporations as an element in industrial society, laying special emphasis upon the so-called trust problem and questions of government regulation of industry.
It deals with the forms of business organization, with particular stress on the nature and history of corporations and their significance in modern life. While it offers an account of the promotion, capitalization, and reorganization of corporations, questions of finance are for the most part subordinated to a consideration of the economic aspects of industrial combination, such as its effects upon efficiency, wages, profits, and prices. The course is concluded by a study of the Sherman Anti-Trust Act and a discussion of the recent trust legislation.
Prerequisites: Courses 1 and 2.

16. Public Service Industries. Lectures, reading, and discussion. *Two hours.* Second semester only.
This course considers the nature of public service industries, such as railroads, street railways, gas and electric companies, telephone and telegraph companies, and their relation to the state and to the municipality. The problem of public ownership and public control is given careful study on the basis of American and European experience, with special consideration of commission regulation in the United States.
Prerequisites: Courses 1, 2, 6, 15, 38, and 39.
This course is open only to seniors and graduate students.

The following courses will be announced in the School of Business Administration:

32. INDUSTRIAL ORGANIZATION AND MANAGEMENT. *Three hours.* Both semesters.

This is a fundamental course in the principles of internal organization and management of industrial enterprises. It will include a discussion of the nature of modern industry and of present industrial tendencies; types of internal organization, the location and arrangement of industrial plants; planning, supervision, and control, purchasing policies, scientific management and the employment of labor.

Prerequisites: Courses 1 and 2.

34. PERSONNEL ADMINISTRATION. *Two hours.* Second semester only.

This is a course in the employment, training, control, and compensation of labor. In the latter part of the course consideration is given to the problem of industrial relations as viewed from the standpoint of the management. The course is designed to give students a knowledge of the fundamental problems involved in the employment and supervision of employees' relations.

Prerequisites: Courses 1, 2, and 32.

36. RAILWAY ORGANIZATION AND OPERATION. *Three hours.* First semester only.

This course undertakes a study of problems incident to the operation of steam railroads from the standpoint of both the railway administrative officer and of public regulatory bodies. It deals with problems of railway organization, and of administrative methods of controlling expenses, and of auditing revenues. It considers the use of statistics as an aid to the attainment of economics in operation.

Prerequisites: Courses 1, 2, 6, and 38.

36*a*. RAILWAY ACCOUNTS. *Three hours.* Second semester only.

This course undertakes a study of the standardized system of accounts prescribed for railroads by the Interstate Commerce Commission. It deals with construction, revenue, expense, income, profit and loss, and balance sheet accounts. This course gives special emphasis to the use of accounting statements by operating officers, by public service commissions, and by investors in railway securities.

Prerequisites: Courses 1, 2, 6, 38, and 39.

37. CORPORATION FINANCE. *Three hours.* First semester only.

This course aims to study the organization and intercorporate relations of modern railway and industrial enterprises, with special reference to problems of finance. It deals with such subjects as the nature and varieties of stocks and bonds, the

distribution and price movements of corporation securities, corporate promotion, capitalization, and reorganization.
Prerequisites: Courses 1, 2, and 15.

40 COST ACCOUNTING. *Three hours.* First semester only.
This course undertakes an analysis of accounts and accounting statements for manufacturing concerns, with special reference to the problems of management. Various methods of allocating indirect expenses to production factors and to specific products are studied. The principles of costing are illustrated in a complete cost set which is worked out by the student as a laboratory course.
Prerequisites: Courses 1, 2, 38, and 39.

## 220. SHOP COURSES

Professor AIREY, Assistant Professors BOSTON, CAMPBELL, Mr. YEATMAN. Mr. PERKINS, Mr. TELFER, Mr. GRENNAN, Mr. REA, Mr. SPIERS, Mr. KNEEBONE.

Shop Courses 1, 2, 3, and 4 may be continued by advanced students as 1*a*, 2*a*, 3*a*, and 4*a*. Special arrangements are made for students who wish to take more advanced work or who desire to prepare themselves for teaching these subjects.
For outline of courses see Section 51.
For Engineering Shops see Section 112.

1. WOODWORK. *Two hours.* Both semesters.
Bench, lathe, and simple pattern work. One-half day per week in shop, one hour being reserved for class room work.

2. METALWORK. *Two hours.* Both semesters.
Consists of a study of the principles and practice applied to the working and treating of wrought iron and steel. One-half day per week in the shop, of which one hour is spent in the class room.

3. FOUNDRY. *Four hours.* Both semesters.
Consists of a study of the principles and practice applied to cast metals including gray iron castings, malleable iron castings, steel castings and various types of non-ferrous castings. Two half-days per week are given to this subject. One hour of each of these periods is spent in the class room.
Must be preceded by Course 2.

4. MACHINE SHOP. *Four hours.* Both semesters.
Two half-days per week in the laboratory with two classroom periods. By lectures and assignments the following subjects are covered: industrial organization, accounting, stock records, standardization and time study, the cutting of metals,—lathe work, milling, drilling, reaming, tapping, broaching, grinding,

and buffing,—also gear cutting, jigs, special tools, standards, gauges, manufacturing layouts, automatic machines, die-casting, punch and die work and spinning.
Must be preceded by Course 2.

6. PATTERN MAKING. *Two hours.* Both semesters.
Pattern making (advanced) consists of designing and constructing wood patterns from working drawings. Hours to be arranged.
Must be preceded by Course 1.

7. JIG AND FIXTURE DESIGN. *Two hours.*
This course consists of drawing periods supplemented by assignments which treat on the principles underlying the design, construction and application of such accessories to manufacture.

8. FOUNDRY COSTS AND ORGANIZATION. *Two hours.* Both semesters.
This course is a study of foundry cost methods, foundry records and standard instructions for foundry operations.
Must be preceded by Course 3.

9. STANDARDIZATION OF LABOR. *Two hours.*
This course treats on the employment of labor, wage payment in relation to standardized conditions and the position of labor in manufacture.

SUMMER SESSION

Courses 1 to 6 inclusive are offered in the Summer Session as 1*s*, 2*s*, etc.

221. **SPANISH***

Professors LEE, ADAMS, KENYON, Assistant Professors ALBALADEJO, Mr. BRITTON, Mr. LUZUNARIS, Mr. ANDERSON.

1. ELEMENTARY COURSE. *Four hours.* Both semesters.
Grammar and reading, with practice in writing and speaking Spanish.

2. ELEMENTARY COURSE CONTINUED. *Four hours.* Both semesters.
Grammar and reading, with practice in writing and speaking Spanish.

3. INTERMEDIATE SPANISH. *Four hours.* Both semesters.
Modern prose, conversation and composition, with a thorough review of grammar.

4. READING OF STANDARD SPANISH WORKS. *Four hours.* Both semesters.
Conversation, composition, business forms and correspondence.

5. ADVANCED COMPOSITION AND CONVERSATION. *Two hours.* Both semesters.

6. SPANISH LITERATURE IN ENGLISH. *Two hours.* Both semesters.
An outline of the development of Spanish literature. Lectures, assigned readings, and reports.

* See Sec. 138.

## FIVE YEAR COURSES

222. In cooperation with the School of Business Administration a five year course leading to the degree of B.S. in Engineering, (Mechanical and Industrial Engineering) has been approved by the Board of Regents and will be in effect at once.

Similar five year courses are being planned in the other technical departments, and it is expected that they will be in effect in 1924-5.

The course in Mechanical and Industrial Engineering includes the following:

| SUBJECTS | HOURS |
|---|---|
| English | 6 |
| Modern languages (or cultural electives) | 16 |
| Mathematics | 18 |
| Physics | 10 |
| Chemistry | 5 |
| Drawing and descriptive geometry | 8 |
| Shop work | 10 |
| Engineering Mechanics | 12 |
| Mechanical Engineering | 24 |
| Chemical Engineering | 4 |
| Electrical Engineering | 4 |
| Civil Engineering | 3 |
| Economics | 36 |
| Shop management and shop transportation | 8 |
| Electives | 12 |
| Total hours | 176 |

The schedule of work is as follows:

### First Year

| FIRST SEMESTER | | SECOND SEMESTER | |
|---|---|---|---|
| *Modern Language | 4 | *Modern Language | 4 |
| Gen. Chem. (2E) | 5 | Gen. Chem. (2E) | 5 |
| or Shop 2 and Eng. 1 | 6 | or Shop 2 and Eng. 1 | 6 |
| Alg. and Anal. Geom. (Math. 1) | 4 | Anal. Geom. (Math. 2) | 4 |
| Drawing 1 | 3 | Drawing 2 | 3 |
| Total hours | 17 or 16 | Total hours | 16 or 17 |

### Second Year

| | | | |
|---|---|---|---|
| *Language | 4 | *Language | 4 |
| Calculus 1 Math. 3) | 5 | Calculus II (Math. 4) | 5 |
| Eng. Materials (Ch. E. 1) | 3 | Physics 1E | 5 |
| Drawing 3 | 2 | Economics 2 | 3 |
| Economics 1 | 3 | | |
| Total hours | 17 | Total hours | 17 |

* See Sec. 138.

### Summer Session

| | |
|---|---|
| Foundry practice (shop 3) | 4 |
| Machine shop practice (shop 4) | 4 |
| Total hours | 8 |

### Third Year

| | | | |
|---|---|---|---|
| Statics (E. M. 1) | 4 | Strength, Elasticity (E. M. 2) | 3 |
| Physics 2E | 5 | Heat Engines (M. E. 3) | 4 |
| Econ. Statistics | 3 | Labor | 3 |
| Accounting | 3 | Accounting | 3 |
| Elective | 3 | Elective | 3 |
| Total hours | 18 | Total hours | 16 |

### Fourth Year

| | | | |
|---|---|---|---|
| Dynamics (E. M. 3) | 2 | Hydro Mechanics (E. M. 4) | 3 |
| Elements Mach. Des. (M. E. 2) | 3 | Mach. Design (M. E. 6) | 4 |
| Mech. Lab. (M. E. 7) | 2 | Thermodynamics (M. E. 5) | 3 |
| Gas & Fuel Anal. (Ch. E. 10) | 1 | Managerial Accounting | 3 |
| Managerial Statistics | 3 | Shop Management (M. E. 35) | 3 |
| Production, Management | 3 | Elective | 2 |
| Elective | 4 | | |
| Total hours | 18 | Total hours | 18 |

### Fifth Year

| | | | |
|---|---|---|---|
| Theory Mach. Movements (M. E. 10) | 2 | Theory of Structures (C. E. 2) | 3 |
| Power Plants (M. E. 9) | 3 | English | 2 |
| Mech. Laboratory (M. E. 8) | 3 | Financial Management | 3 |
| Elect. App. and Circ. (E. E. 2a) | 4 | Personal Management | 3 |
| Financial Management | 3 | Factory Inter. Transp. (M. E. 43) | 3 |
| Shop Management (M. E. 36) | 2 | | |
| Total hours | 17 | Total hours | 14 |

223. Students who have completed the first three years of prescribed work in the College of Engineering with the grade of at least 2.3 (see section 36 for grading system), and who have taken Economics, courses 1 and 2, may transfer to the School of Business Administration; and upon the satisfactory completion of two years of work in the latter school, may be granted the degree of Master of Business Administration.

## ENGLISH FOR FOREIGN STUDENTS

224. As it has been found that many students, whose native language is other than English, have failed in their work because of inability to understand and express themselves in English, the faculties of the Colleges of Engineering and Architecture have adopted rules for the guidance of such students.

All students whose native language is other than English shall, upon matriculation and enrollment in these colleges, be required to report at once to the chairman of the Committee on English. Such students shall satisfy the committee that they possess a sufficient knowledge of English to carry on work in these colleges before they may be classified. The rules further provide for the guidance of these foreign students until their knowledge of English is enough advanced for them to go on without further assistance.

## SUMMARY OF STUDENTS

1923-1924

### COLLEGE OF ENGINEERING

| | 1st Year | 2nd Year | 3rd Year | 4th Year | Specials | Part Time | Totals |
|---|---|---|---|---|---|---|---|
| Civil Engineering..... | | 83 | 120 | 127 | 16 | | 346 |
| Mechanical Engineering.. | | 86 | 116 | 125 | 6 | | 333 |
| Electrical Engineering.... | | 76 | 118 | 81 | 2 | | 277 |
| Chemical Engineering.... | | 57 | 69 | 50 | | | 176 |
| Marine Engineering..... | | 10 | 10 | 10 | 1 | | 31 |
| Aero. Engineering..... | | 13 | 18 | 13 | | | 44 |
| Geodesy and Surveying... | | | 2 | 2 | | | 4 |
| Unclassified, first year.... | 378 | | | | | 3 | 381 |
| Totals | 378 | 325 | 453 | 408 | 25 | 3 | 1592 |

### COLLEGE OF ARCHITECTURE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Architecture I..... | 16 | 13 | 9 | 10 | | | 48 |
| Architecture II..... | 32 | 29 | 23 | 21 | | | 105 |
| Architecture III..... | 33 | 14 | 21 | 15 | | | 83 |
| Special Students..... | | | | | 6 | 4 | 10 |
| Totals | 81 | 56 | 53 | 46 | 6 | 4 | 246 |

| | |
|---|---|
| Undergraduates, College of Engineering..... | 1592 |
| Undergraduates, College of Architecture..... | 246 |
| Students in Colleges of Eng. and Arch. enrolled in Summer Session 1923..... | 525 |
| Students in Engineering registered in the Graduate School.... | 86 |
| Students in Architecture registered in the Graduate School..... | 4 |
| Number of Students (not counted twice) in Engineering and Architecture ..... | 2076 |

# GENERAL INDEX

# UNIVERSITY OF MICHIGAN

(*Continued from inside page of front cover.*)

**College of Dental Surgery,** MARCUS L. WARD, *Dean.*
(Admission Officer: The Dean.)

One year collegiate preparation required. Four-year professional curriculum. Fully equipped, modern laboratories and clinic. Abundant clinical material. One-year curriculum in Dental Hygiene.

**School of Education,** ALLEN S. WHITNEY, *Dean.*
(Admission Officer: The Dean.)
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 and in physical education, athletics, and school health.

**School of Business Administration,** EDMUND E. DAY, *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 curricula with letters and engineering.

**Graduate School,** ALFRED H. LLOYD, *Dean.*
(Admission Officer: The Dean.)

Graduate courses in all departments of study. Special curricula leading to higher degrees in professional subjects.

**Summer Session,** EDWARD H. KRAUS, *Dean.*

More than four hundred regular and special courses in the various Schools and Colleges, including library methods, athletic coaching and administration, botany and zoölogy at the Biological Station in northern Michigan, geology and geography at the camp in Kentucky.

---

Students' rooms supervised and employment bureaus maintained by Professors JOSEPH A. BURSLEY, Dean of Students, and JEAN HAMILTON, Dean of Women, respectively. Students' health and physical welfare conserved by Health Service and Department of Physical Welfare.

---

For catalogues and other particulars, address

SHIRLEY W. SMITH,
Secretary of the University.

THE UNIVERSITY BULLETIN IS REGULARLY ISSUED BY THE UNIVERSITY OF MICHIGAN ONCE EVERY WEEK.

---

ENTERED AS SECOND-CLASS MATTER AT THE POSTOFFICE AT ANN ARBOR, MICHIGAN.

---

THE BULLETIN INCLUDES THE FOLLOWING PUBLICATIONS:—

The Annual Report of the President.

The Catalogue of the University.

The Annual Announcements of the College of Literature, Science, and the Arts, the Colleges of Engineering and Architecture, the Medical School, the Law School, the College of Pharmacy, the College of Dental Surgery, the School of Education, the School of Business Administration, the Graduate School, and the Summer Session.

Other Announcements of the several departments of instruction, Reports and Communications of University officers, etc.