CORNELL UNIVERSITY
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Announcement of The College of Engineering for 1931-32 and 1932-33

Comprising

The School of Civil Engineering
The Sibley School of Mechanical Engineering
The School of Electrical Engineering

Ithaca, New York
Published by the University
August 15, 1931

THE UNIVERSITY CALENDAR FOR 1932–33

1932 — FIRST TERM

Sept. 16, *Friday*,	Entrance examinations begin.	
Sept. 26, *Monday*,	Registration and assignment of new students.	
Sept. 27, *Tuesday*,		
Sept. 27, *Tuesday*,	Registration and assignment of old students.	
Sept. 28, *Wednesday*,		
Sept. 29, *Thursday*,	Instruction begins at 8 A. M.	
Oct. 21, *Friday*,	Last day for payment of tuition for the first term.	
Nov. 23, *Wednesday*,	Instruction ends at 6 P. M.	Thanksgiving Recess
Nov. 28, *Monday*,	Instruction resumed at 8 A. M.	
Dec. 17, *Saturday*,	Instruction ends at 1 P. M.	Christmas Recess
1933		
Jan. 2, *Monday*,	Instruction resumed, 8 A. M.	
Jan. 11, *Wednesday*,	Founder's Day.	
Jan. 28, *Saturday*,	Instruction ends.	
Jan. 30, *Monday*,	Term examinations begin.	
Feb. 8, *Wednesday*,	Term ends.	
Feb. 9, *Thursday*,	A holiday.	

SECOND TERM

Feb. 10, *Friday*,	Registration of all students.	
Feb. 13, *Monday*,	Instruction begins at 8 A. M.	
Mar. 6, *Monday*,	Last day for payment of tuition for the second term.	
April 1, *Saturday*,	Instruction ends at 1 P. M.	Spring Recess
April 10, *Monday*,	Instruction resumed, 8 A. M.	
May 27, *Saturday*,	Spring Day: a holiday.	
June 5, *Monday*,	Term examinations begin.	
June 13, *Tuesday*,	End of term examinations.	
June 19, *Monday*,	COMMENCEMENT.	

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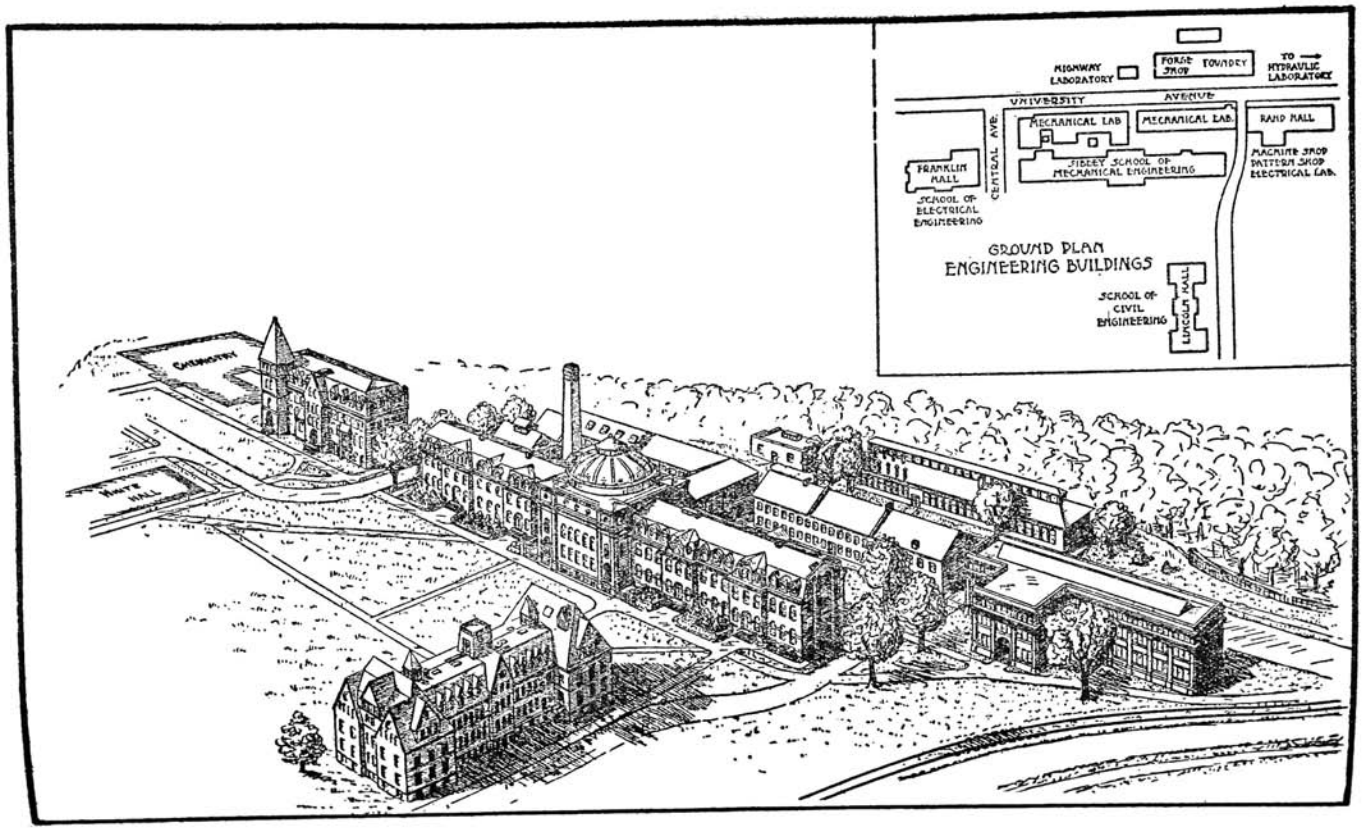
HIGHWAY LABORATORY
FORGE SHOP
FOUNDRY
TO HYDRAULIC LABORATORIES
UNIVERSITY AVENUE
CENTRAL AVE.
MECHANICAL LAB.
MECHANICAL LAB.
RAND HALL
FRANKLIN HALL
SCHOOL OF ELECTRICAL ENGINEERING
SIBLEY SCHOOL OF MECHANICAL ENGINEERING
MACHINE SHOP
PATTERN SHOP
ELECTRICAL LAB.
GROUND PLAN
ENGINEERING BUILDINGS
SCHOOL OF CIVIL ENGINEERING
LINCOLN HALL
CHURCH
WHITE HALL

A HISTORY OF THE COLLEGE OF ENGINEERING

CORNELL UNIVERSITY had its beginning in the Federal Government's grant, for the endowment of education in the several States, of a large portion of the public lands, under the authority of the Morrill Act, an Act of Congress approved by President Lincoln in 1862. The purpose of the Morrill Act was to endow in each State at least one college; by an express provision of the Act, a leading object of each of those colleges was to be the teaching of "such branches of learning as are related to . . . the mechanic arts." The State of New York devoted all the proceeds of its share of the land grant to Cornell University, which was established by charter in 1865 and was opened at Ithaca in 1868. In the very first plan of this University, therefore, was the foundation of a College of Engineering.

EZRA CORNELL, who had brought an eminent talent for practical affairs to the organizing and upbuilding of the telegraph business before and after the creation of the Western Union Telegraph Company, and who had retired in 1858, gave generously of his wealth and lavishly of his powers to the University's establishment. His wise management of New York's share of the land grant multiplied the endowment.

HIRAM SIBLEY OF ROCHESTER, the founder and first president of the Western Union Telegraph Company, a trustee of the University from 1865 until his death in 1888, was a liberal benefactor of the University's department of mechanical engineering. In 1871 he erected a building to house what was then called the college of mechanic arts, equipped it, and endowed the Sibley Professorship of Mechanic Arts to the amount of fifty thousand dollars. During the years from 1870 to 1887, Mr. Sibley gave more than $180,000 for the building and equipment of lecture halls, shops, and laboratories. His benefactions have been continued by his son, MR. HIRAM W. SIBLEY, who has given about $170,000 for construction and equipment.

When Cornell University began its work, in 1868, it included a College of Mathematics and Engineering and a College of Mechanic Arts. The former of these consisted of two schools, namely, a school of mathematics and a school of civil engineering. In 1871 mathematics was set apart, and architecture was associated with civil engineering in a single college until 1873, when another separation took place, and civil engineering was organized as a department; it retained that form until 1890, when the College of Civil Engineering was established.

The original College of Mechanic Arts offered instruction in shop work, drawing, and elementary engineering, in conformity with the provisions of the Morrill Act and the Charter, and provided a theoretical and practical course of four years leading to the bachelor's degree in mechanical engineering. In 1885, in recognition of the growth in importance of the profession of mechanical engineering,

the college was renamed The Sibley College of Mechanical Engineering and the Mechanic Arts.

Courses in electrical engineering were first established at Cornell in 1883, under the guidance of the Department of Physics. In 1889 the direction of the professional courses in electrical engineering was transferred to Sibley College and the present course in electrical engineering was developed within that college.

In 1919 the Board of Trustees, recognizing that all practice in engineering has a common groundwork, voted to consolidate all instruction in engineering at Cornell in a single institution to be called The College of Engineering. This single college comprises three schools, namely, the School of Civil Engineering, the Sibley School of Mechanical Engineering, and the School of Electrical Engineering. The last-named school has grown from the former department of electrical engineering in Sibley College. The combination has proved itself to be sound educationally, to be in harmony with the progress of industry, and to have administrative merit.

Besides the College of Engineering, Cornell University comprises the Graduate School, in which the student's work may lead to the degree of Doctor of Philosophy, to the degree of Doctor of the Science of Law, or to the master's degree in arts, science, agriculture, architecture, fine arts, landscape architecture, forestry, chemistry, laws, education, civil engineering, mechanical engineering, or electrical engineering; the College of Arts and Sciences, whose courses lead to the degree of Bachelor of Arts or that of Bachelor of Chemistry; the Law School; the Medical College, which gives most of its instruction in its main building at First Avenue and Twenty-eighth Street, New York City; the New York State Veterinary College; the New York State College of Agriculture; the New York State College of Home Economics; and the College of Architecture, in which a student may earn the degree of Bachelor of Architecture, Bachelor of Landscape Architecture, or Bachelor of Fine Arts. There are about nine hundred persons in the University's teaching staff and its students number about five thousand.

The College of Engineering has intimate relations with the rest of the University. Its students, constituting about one-fourth of the University's whole enrollment, are associated with the faculties and students of the other colleges. This is an association in which the student extends his intellectual horizon and gains a clearer understanding of the relation of engineering to other human interests.

The University is situated at Ithaca, in the central part of the State of New York, about seven hours by rail from the City of New York and about three hours from Buffalo. Ithaca is accessible by way of two trunk lines, the Lackawanna and Lehigh Valley Railroads, and it has connections by rail with several stations on the New York Central system. The University's campus and contiguous lands occupy about fifteen hundred acres. The campus is on a hill, overlooking the city of Ithaca and a good many miles of Cayuga Lake.

THE FACULTY

THE COLLEGE OF ENGINEERING

LIVINGSTON FARRAND, A.B., M.D., L.H.D., LL.D., President of the University.
DEXTER SIMPSON KIMBALL, A.B., M.E., LL.D., Dean of the College and Professor of Industrial Engineering.
MAUDE S. NEWMAN, Secretary of the College.

THE SCHOOL OF CIVIL ENGINEERING

EUGENE ELWIN HASKELL, C.E., Professor of Experimental Hydraulics, Emeritus.
HENRY SYLVESTER JACOBY, C.E., Professor of Bridge Engineering, Emeritus.
HENRY NEELY OGDEN, C.E., Professor of Sanitary Engineering.
FRED ASA BARNES, M.C.E., Professor of Railroad Engineering.
SIDNEY GONZALES GEORGE, C.E., Professor of Mechanics of Engineering.
JOHN THOMAS PARSON, Professor of Drawing.
ERNEST WILLIAM SCHODER, Ph.D., World War Memorial Professor of Experimental Hydraulics.
FRANCIS JOSEPH SEERY, S.B., Professor of Hydraulic Engineering.
SAMUEL LATIMER BOOTHROYD, M.S., Professor of Astronomy.
ERNEST WILLIAM RETTGER, Ph.D., Professor of Mechanics of Engineering.
CHARLES LEOPOLD WALKER, C.E., Professor of Sanitary Engineering and Secretary of the College Faculty.
PAUL HALLADAY UNDERWOOD, C.E., Professor of Surveying, in charge of the School Library.
HERBERT HENRY SCOFIELD, M.E., Professor of Testing Materials.
WALTER L. CONWELL, C.E., Professor of Highway Engineering and Chairman of the Administrative Committee.
LEONARD CHURCH URQUHART, C.E., Professor of Structural Engineering.
MILES ALBION POND, Ph.B., Assistant Professor of Descriptive Geometry.
EARLE NELSON BURROWS, M.C.E., Assistant Professor of Structural Engineering.
LEONARD ALEXANDER LAWRENCE, B.S., Assistant Professor of Surveying.
CARL CRANDALL, C.E., Assistant Professor of Railroad Engineering and Secretary of the Faculty of Civil Engineering.
JOHN EDWIN PERRY, B.S. in C.E., Assistant Professor of Railroad Engineering.
CHARLES EDWARD O'ROURKE, C.E., Assistant Professor of Structural Engineering.
ERIC VAIL HOWELL, M.C.E., Assistant Professor of Mechanics.
ROMEYN Y. THATCHER, C.E., Assistant Professor of Railroad Engineering.
CLAUDE M. PENDLETON, C.E., Marc Eidlitz Instructor in Surveying.
ARTHUR F. BOYLES, C.E., Instructor in Surveying.
FRED J. SPRY, C.E., Instructor in Drawing.
KENNETH L. ROBERTS, B.S., Instructor in Astronomy.
LOWELL J. CHAWNER, A.B., C.E., Instructor in Structural Engineering.
HENRY A. PFISTERER, C.E., Instructor in Structural Engineering.
EDWARD S. FABIAN, A.B., M.A., Instructor in Drawing.
ARTHUR N. VANDERLIP, M.C.E., McMullen Research Scholar and Assistant in Department of Testing Materials.

The Sibley School of Mechanical Engineering

Herman Diederichs, M.E., Director of the School, John E. Sweet Professor in Engineering, and Professor of Experimental Engineering.

Albert William Smith, B.M.E., M.M.E., Professor of Mechanical Engineering, Emeritus.

George Robert McDermott, Professor of Structural Design, Emeritus.

Millard Clayton Ernsberger, A.B., M.E., Professor of Power Engineering, Emeritus.

William Nichols Barnard, M.E., Professor of Power Engineering.

Edgar Harper Wood, M.M.E., Professor of Mechanics of Engineering.

Calvin Dodge Albert, M.E., Professor of Machine Design.

Albert Edward Wells, Sibley Professor of Mechanic Arts.

Frank Oakes Ellenwood, A.B., M.E., Professor of Power Engineering.

Will Miller Sawdon, B.S., M.M.E., Professor of Experimental Engineering, assigned to Engineering Research.

George Burr Upton, M.M.E., Professor of Experimental Engineering.

Seymour Stanton Garrett, C.E., World War Memorial Professor of Industrial Economics.

Victor Raymond Gage, M.M.E., Professor of Experimental Engineering.

Myron A. Lee, M.M.E., Professor of Industrial Engineering.

Frederick George Switzer, M.M.E., Professor of Hydraulic Engineering.

Clarence Ellsworth Townsend, M.E., Professor of Engineering Drawing.

Fred Stillman Rogers, B.S., M.E., Professor of Machine Design.

Adam Clarke Davis, jr., M.E., Professor of Experimental Engineering.

Walter Rodney Cornell, B.S., C.E., Professor of Mechanics of Engineering.

John Robert Bangs, jr., M.E., Professor of Administrative Engineering and Personnel Director of the College of Engineering.

Roy Edwards Clark, M.E., Assistant Professor of Power Engineering.

Enoch Francis Garner, M.E., Assistant Professor of Machine Design.

Warren Howard Hook, M.E., Assistant Professor of Power Engineering.

William Emerson Mordoff, M.E., Assistant Professor of Machine Construction.

Harold Charles Perkins, M.E., Assistant Professor of Mechanics of Engineering.

Simeon John Koshkin, M.E. (E.C.P.), Assistant Professor of Machine Design.

William Cook Andrae, M.M.E., Assistant Professor of Experimental Engineering.

Karl Dawson Wood, M.E., M.S., Assistant Professor of Mechanics of Engineering.

Charles Osborn Mackey, M.E., Assistant Professor of Power Engineering.

Dexter Simpson Kimball, jr., M.M.E., Assistant Professor of Industrial Engineering.

Homer James Hotchkiss, A.M., M.M.E., Instructor in Engineering Drawing.

Stephen Farrell Cleary, M.E., Instructor in Engineering Drawing.

Leslie A. Fenner, M.E., Instructor in Engineering Drawing.

George Raymond Hanselman, M.E., Instructor in Administrative Engineering.

Robert Cunningham Morris, Instructor in Machine Design.

CARROLL BROMLEY CLARK, M.E., Instructor in Experimental Engineering.
JOSEPH OLMSTEAD JEFFREY, M.E., Instructor in Experimental Engineering.
CLYDE IRA MILLARD, E.E., Instructor in Machine Design.
HARRISON LOUIS GOODMAN, M.E., Instructor in Experimental Engineering.
LUDOLPH FRISCH WELANETZ, M.E., Instructor in Experimental Engineering.
JOHN ROBERT MOYNIHAN, M.E., McMullen Research Scholar and Instructor in Experimental Engineering.
FLOYD CLEVELAND KNIGHT, Instructor in Machine Design.
HOWARD NEWTON FAIRCHILD, M.E., E.E., Instructor in Heat-Power Engineering.
CYRIL WALDIE TERRY, M.E., Instructor in Machine Design.
DAVID ALEXANDER FISHER, M.E., Instructor in Experimental Engineering.
CHARLES STANLEY JACKOWSKI, M.E., Instructor in Engineering Drawing.
CLARENCE RICHARD KINGSTON, E.E., Instructor in Machine Design.
RALPH W. HODGES, Instructor in Introductory Engineering Laboratory.

SHOP ASSISTANTS

BURDETTE N. HOWE, Foreman in the Machine Shop.
CHARLES E. PATTERSON, Foreman in the Foundry.
LEROY HOOPER, Foreman in the Pattern Shop.
WALTER LISTON HEAD, Assistant in Introductory Engineering Laboratory.
HOWARD STANLEY BUSH, Assistant in the Pattern Shop.
ERNEST STANLEY YAWGER, Assistant in the Pattern Shop.
GEORGE SANDERSON, Assistant in the Foundry.
RUDOLPH P. SCHALLOWITZ, Assistant in the Machine Shop.

THE SCHOOL OF ELECTRICAL ENGINEERING

PAUL MARTYN LINCOLN, M.E. (in E.E.), Director of the School and Professor of Electrical Engineering.
VLADIMIR KARAPETOFF, C.E., M.M.E., Professor of Electrical Engineering.
WILLIAM CYRUS BALLARD, jr., M.E. (in E.E.), Professor of Electrical Engineering.
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TRUE MCLEAN, E.E., Assistant Professor of Electrical Engineering.
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FRANK JESSUP BRISTOL, E.E., Instructor in Electrical Engineering.
WILLIAM DANIEL MOEDER, E.E., Instructor in Electrical Engineering.
HERBERT WELLS HOEFER, B.S. in E.E. and M.E., Instructor in Electrical Engineering.
ARNE WIKSTROM, E.E., Instructor in Electrical Engineering.
ROLAND LLOYD ROY, B.S. in E.E., Instructor in Electrical Engineering.
JOHN PALEN WOOD, M.E., E.E., Instructor in Electrical Engineering.
ELTON WRIGHT JONES, B.S. in E.E., M.S. in E.E., Instructor in Electrical Engineering.
HARRY SOHAN, M.E.E., McMullen Research Scholar and Instructor in Electrical Engineering.

OTHER OFFICERS

DOROTHY SAVERCOOL, Recorder.
LULU M. MARKELL, Secretary to the Dean.
MARY R. KORHERR, Secretary to the Director of the School of Civil Engineering.
GRACE W. FISH, Librarian of the School of Civil Engineering.
CLINTON D. CASS, Mechanician of the School of Civil Engineering.
LENA GERTRUDE MARSH, Librarian of the Sibley School of Mechanical Engineering.
J. GRACE SIMPSON, Secretary to the Director of the Sibley School of Mechanical Engineering.
MARGARET KOMAROMI, Clerk of Employment Bureau.
GEORGE WASHINGTON RACE, Mechanician in the Sibley School of Mechanical Engineering.
SAMUEL CORNELIUS PATCH, Mechanician in the Sibley School of Mechanical Engineering.
ALFRED WILLIAM NEIGH, Engineer in the Sibley School of Mechanical Engineering.
CHARLES A. RACE, Assistant Mechanician in the Sibley School of Mechanical Engineering.
KATHERINE HANDLEN, Secretary to the Director of the School of Electrical Engineering.
Mrs. I. M. BATCHELLOR, Librarian of the School of Electrical Engineering.
GEORGE ALFRED CULLIGAN, Mechanician in the School of Electrical Engineering.

PURPOSE OF THE INSTRUCTION

Thorough Training in Fundamentals

The curricula of the Schools of the College of Engineering consist primarily, of courses designed to teach the fundamental principles, theoretical and practical that underlie the various branches of engineering. In addition, such work is required in pure and applied economics as is needed by the engineer of the present time. Late in the course some degree of specialization is permitted; but since the time allowed for this is quite limited, specialization cannot be carried very far. In fact, the Faculty of Engineering is strongly of the opinion that the duty of the technical school to its undergraduates is to train them thoroughly in the fundamental subjects and that the four-year course is not too long for this purpose. Hence the demand for the introduction of specialization early in the course has always been resisted.

It is well recognized that theoretical instruction must be supplemented by experience in practice and by contact with life before one can attain his greatest usefulness in the profession; hence an effort is made to bring the student into contact with teachers who are closely in touch with engineering practice, to the end that he may thus become familiar with problems encountered in modern engineering and with practical methods of solving them. It is hoped in this way to shorten somewhat the period of adjustment for the graduate when he begins actual engineering work.

Five and Six-Year Courses Recommended

Since the work in the regular four-year course in this College is largely technical, it is desirable that the student devote more time to his course in order to broaden the training. This may be done by devoting five or six years.

In a five-year course, the student enters the College of Engineering with the regular entrance, and pursues the regular work for two or three years. After having obtained the fundamentals in engineering in this way, he may then spread the rest of the engineering work of the regular four-year course over three or two years more and add, in the way of electives, the equivalent of one year's work in the field of liberal arts.

A SIX-YEAR COURSE leading to the degrees of A.B. and C.E., or A.B. and M.E., or A.B. and E.E. is recommended for students who can afford the additional time and expense. The entrance requirements for this course include less mathematical preparation than is specified for the four-year or five-year course, but the student must meet the entrance requirements specified by the College of Arts and Sciences,

in which he will be enrolled for the first four years. The necessary arrangement of his studies in the course is set forth under the head of Admission to the Six-year Course, on page 36.

Owing to the large amount of liberal work in the curriculum, the two degrees of A.B. and C.E. may be obtained in five years plus two summer sessions.

In conjunction with the Department of Chemistry of the College of Arts and Sciences, the College of Engineering offers a five-year course in Chemical Engineering. Students in this course register, for the first four years, in the College of Arts and Sciences with the entrance requirements specified for the degree of B.Chem. This degree is conferred at the end of four years. For the fifth year, registration is in the College of Engineering, Sibley School of Mechanical Engineering. The degree of Chemical Engineer is conferred at the end of the fifth year. For details of this course see page 78.

The Sibley School of Mechanical Engineering and the School of Electrical Engineering also offer four-year courses in Administrative Engineering, leading to the degree of B.S. in Administrative Engineering. For details of these courses see pages 79 and 95.

In addition to the prescribed courses in the College of Engineering, those students who have the necessary time available may elect, with the permission of their class adviser, any course in any college of the University, provided they have had the required preparation for the work.

The General Plan of Studies

As already stated, the course of preparatory and professional studies has been planned with a view to laying a substantial foundation for the general and technical knowledge needed by practitioners in civil, mechanical, and electrical engineering, so that the graduates, guided by their theoretical education, and as much of engineering practice as can well be taught in schools, may develop into useful investigators and constructors.

The facilities for instruction, both fundamental and advanced, are extensive. The students entering upon the work of the first term in the College take practically the same courses, it being recognized that the fundamental work should be the same for all engineers. From the beginning the work of the civil engineering students is differentiated in drawing, while the work of the mechanical and electrical engineering students is the same for one year. At the beginning of the second year the courses for mechanical and electrical engineering students differentiate, and these students commence to specialize in their particular branches.

For the Courses of Instruction, covering the work of the first year for all engineering students, see pages 46–48 of this Announcement. The work of the last three years is outlined on pages 50–66 for civil engineers, on pages 67–91 for mechanical engineers, and on pages 92–100 for electrical engineers.

In general the work of the freshman students comprises fundamental training in mathematics, physics, chemistry, drawing, surveying, and shop work.

CIVIL ENGINEERING students follow this with as thorough a preparation as possible for the general purpose of the profession in the following subjects: the survey, design, and construction of buildings, roads, railroads, canals, sewers, and water works; the construction of foundations under water and on land, and of super-structures and tunnels; the survey, improvement, and protection of coasts, and the regulation of rivers, harbours, and lakes; the astronomical determination of geographical coordinates for geodetic and other purposes; the application of mechanics, graphical statics, and descriptive geometry to the construction of the various kinds of arches, girders, roofs, trusses, suspension and cantilever bridges; the drainage of districts, sewerage of towns and the irrigation and reclaiming of land; the application, and tests of hydraulic and electric motors and steam engines; the preparation of drawings, plans, specifications, and the proper inspection and tests of the materials used in construction. Instruction is given in engineering economy, finance, and jurisprudence. The latter subject deals in an elementary manner with the questions of easements and servitudes, and the fundamental principles of the law of contracts and riparian rights. Opportunity is also given to seniors from certain approved courses from any department of the University.

MECHANICAL ENGINEERING students in the last three years of the course receive a thorough training in machine design, in shop methods and management, in thermodynamics and heat-power, in the fundamentals of electrical engineering, and in mechanical laboratory practice. They may in their last year specialize in heat-power work, steam or internal combustion engines, industrial engineering, water power, or in automotive engineering.

Electrical Engineering students receive a thorough foundation in general engineering principles as well as in the principles and practice of Electrical Engineering. Students with proper qualifications may during the junior and senior year specialize in Physics. In the senior year students may elect to specialize in one of a number of different branches of Electrical Engineering such as

(a) Electrical Design
(b) Generation and Transmission of Electrical Energy
(c) Electrical Communication.

Students in the Course in *Administrative Engineering*, either in M.E. or in E.E., receive first a fundamental grounding in Mathematics, Physics, Chemistry, Mechanics, and Machine Design, which is, principally in the last two years, supplemented by instruction in Economics, Accounting, Cost Finding, Corporation Finance, Marketing, etc. The aim in this course is to preserve a strong engineering background.

CHEMICAL ENGINEERING students receive, during the first four years, a thorough training in inorganic and organic Chemistry supplemented by the fundamentals of Engineering. The fifth year is devoted largely to Industrial Chemistry and advanced engineering courses.

OPPORTUNITIES FOR EMPLOYMENT AFTER GRADUATION

A training in civil, mechanical, or electrical engineering opens wide opportunities for employment in all branches of industry.

CIVIL ENGINEERING graduates are in demand by both technical and general business enterprises. In the technical field graduates are employed in surveying operations of all kinds including aerial surveys and also the geological and geodetic surveys of the U. S. Government; many are employed in the design and construction of irrigation, reclamation, river and flood control, harbor improvement, and hydroelectric projects; as sanitary engineers designing and constructing water supply systems, sewerage systems, and purification plants; by railroads in their location, maintenance, construction, and operating departments; as highway engineers in all classes of highway work; as structural engineers in the design and construction of steel and reinforced concrete bridges and also steel frame and reinforced concrete buildings; as testing engineers examining and testing the properties of structural materials, etc. There is a growing field of employment for the civil engineer in city and regional planning and as city managers. Many graduates are also engaged in contracting in its many forms. In the field of general business, experience clearly indicates increased opportunity in many business enterprises for the graduate in Civil Engineering because the training in analysis and precision are assets of value in the fields of finance valuations, real estate, and other kindred activities of the business world.

MECHANICAL ENGINEERING underlies nearly all branches of the industries: its province includes the design, construction, operation and testing of steam engines, steam turbines, boilers and power-plant auxiliaries, gas and oil engines, with their auxiliaries, hydraulic machinery, pumping engines, railway equipment, compressed air machinery, ice-making and refrigerating machinery, equipment for heating and ventilation, machine tools, mill equipment and transmission machinery. The work of the mechanical engineer includes the planning of power plants and factories, the selection and installation of their equipment, the development of the systems of operation and of manufacturing processes, and the organization and administration of industries.

ELECTRICAL ENGINEERING includes the design, construction, operation, and testing of electrical equipment used for the generation, transmission, and utilization of electrical energy.

The graduate trained in *Administrative Engineering* is fitted to fill any one of the many positions in the borderland between engineering

and business. From all available information, the demand for men in this field is growing.

Graduates of the course in Chemical Engineering find employment both as chemists and as managers of chemical industries.

From the foregoing very brief outline of some of the fields covered by the branches of engineering for which the students of the College of Engineering are fundamentally prepared, it is seen that the opportunities for graduates to obtain employment are broad. Graduates after gaining requisite experience in practice, usually occupy such positions as designers, supervisors of construction, inspectors, testers, research engineers, superintendents of departments, works managers, efficiency engineers, specialists in welfare work and in labor problems, consulting engineers, insurance investigators, commercial representatives, engineering salesmen, educators, and managers and presidents of commercial organizations.

There has always been a dearth of men fitted to fill the higher positions in the fields of engineering and business; and the salary and position that the graduate will eventually obtain depend not only on his special training but on his inherent ability, industry, initiative, capacity to recognize and seize opportunities as they arise, and on his other personal qualities. The young man who has just graduated from the College of Engineering usually has little difficulty in finding immediate employment with salary sufficient for self-support, and if he shows the proper qualifications he may rise eventually to the highest positions attainable in engineering and business fields.

Each school maintains an EMPLOYMENT BUREAU for its graduates. Correspondence should be addressed to the Director of the school concerned.

PERSONNEL SYSTEM

The College of Engineering operates a personnel system, the purpose of which is to help the student in deciding the nature of the work he desires to follow. It also endeavors to point out his desirable as well as his undesirable characteristics.

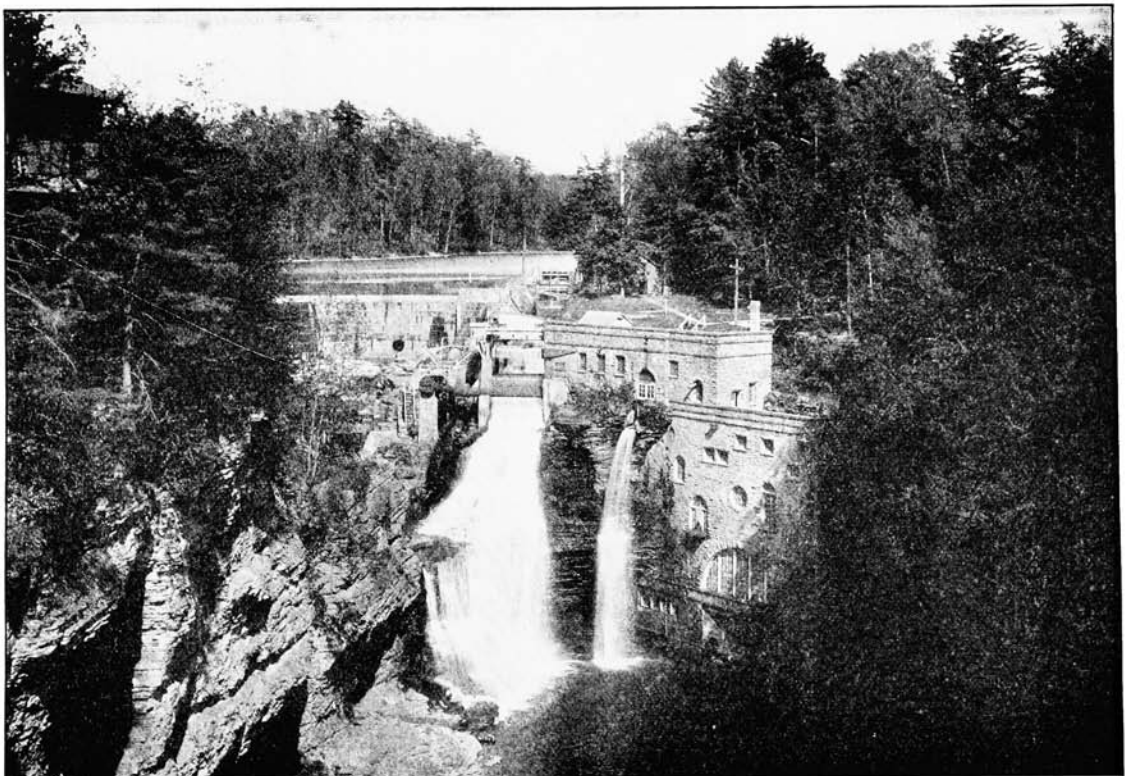
During the first and second years the students are rated by the instructors under whom they do their work. In the third and fourth years, each student selects a committee made up of five members of the faculty and five members of his own class whom he thinks especially capable of giving him an accurate rating. The rating is compiled by the personnel director and returned to the student. A confidential copy is also kept in the files of the personnel director. In this way there will be available to every student, through the personnel director, information that he could not otherwise obtain, and which should prove of great value to him in laying part of the foundation for a successful career. It will be the duty of the personnel director to acquaint himself with the desirable and undesirable traits of each student as shown by the composite rating; to point out to the student the advantages of carefully developing his desirable

traits; to decide which of the undesirable traits may be changed, and to advise him accordingly. With such advice, the student will be in a position, during a highly formative period of his life, to develop the characteristics which will aid him materially in later life.

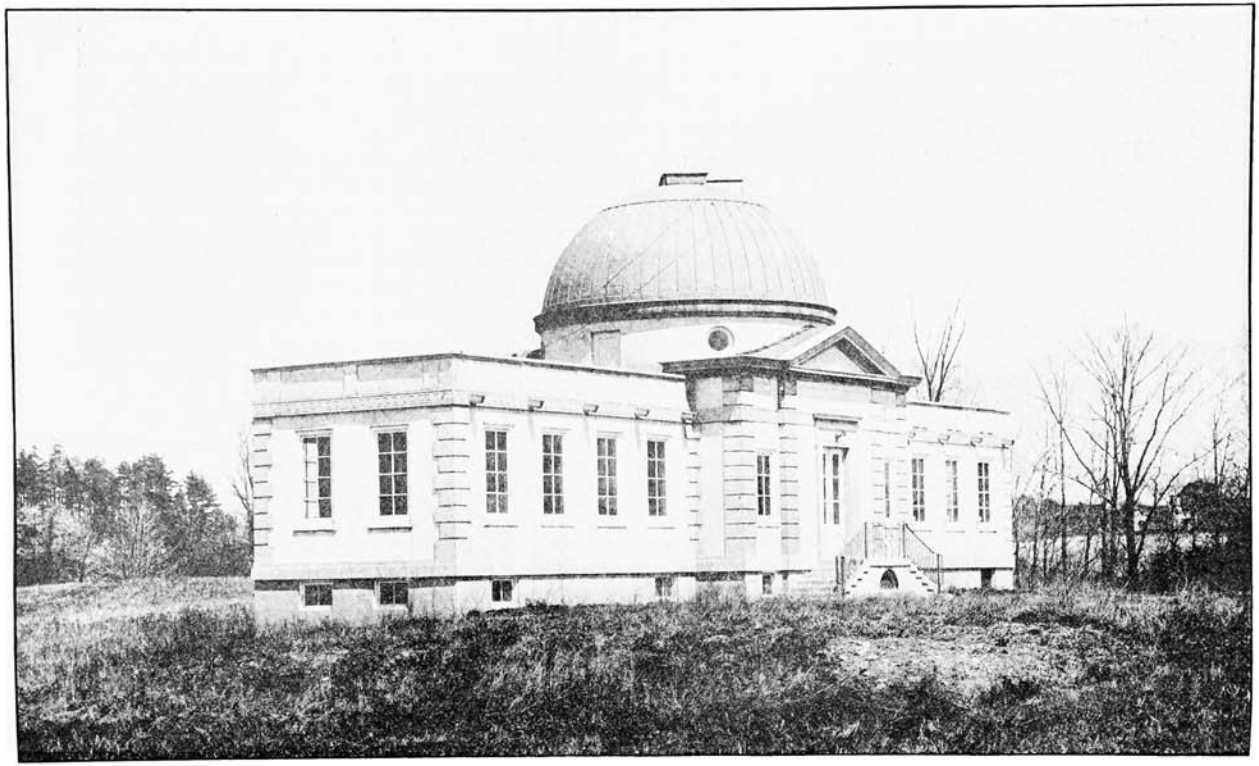
VOCATIONAL COUNSEL. During the senior year each student is interviewed and an analysis of his aptitudes is made. As a result he may intelligently interview representatives of industries, a large number of whom come to the University each spring seeking employees for their firms.

A FIVE-YEAR SERVICE PLAN to graduates has recently been inaugurated which consists of circularizing the class at the beginning of each year for five years after graduation to learn of their work, success, and desires as to change in position. Information regarding many excellent opportunities reaches the Dean's office, and graduates frequently are enabled to make very desirable connections through having up-to-date information regarding themselves on file with the Personnel Director.

AN EMPLOYMENT BULLETIN, listing all employment opportunities which are received at the Dean's office, is issued bi-weekly and sent to all the Cornell Clubs throughout the country and also to individual graduates who care for such service.



THE HYDRAULIC LABORATORY



THE FUERTES ASTRONOMICAL OBSERVATORY

BUILDINGS: LABORATORIES, LIBRARIES AND OTHER EQUIPMENT

BUILDINGS

The building occupied by the School of Civil Engineering is LINCOLN HALL, a substantial brownstone structure, 200 feet long and 70 feet wide. In addition to the laboratories and museums, the building contains the working library of the School, aggregating over five thousand volumes, reading rooms, classrooms, and drafting rooms. The astronomical equipment and portions of the geodetic equipment are housed in the Fuertes Observatory, which contains all the instruments required for determining time, latitude, longitude, and a imuth. Several of the instruments are duplicates of those used by the United States Coast and Geodetic Survey. A large hydraulic laboratory is situated at the lower end of Beebe Lake in Fall Creek Gorge, near Lincoln Hall.

The Sibley School of Mechanical Engineering received its name from the late Hiram Sibley of Rochester, who between the years 1870 and 1887, gave $180,000 toward its endowment and equipment. Mr. Hiram W. Sibley has added more than $170,000 for later constructions and equipment. The SIBLEY BUILDINGS are situated at the north end of the Campus, and stand upon ground leased from the University for the purposes of the School, under an agreement with the late Hiram Sibley. There are five large buildings in the group.

The main building is 370 feet long, 50 feet wide, and three stories in height. It contains the reading room and reference library, drawing rooms, lecture rooms, offices, classrooms, and a large and well-lighted auditorium.

The Department of Experimental Engineering occupies two two-story buildings, each about 150 feet long by 40 feet wide, besides a boiler plant 30 by 40 feet, a refrigeration laboratory 30 by 40 feet, and the east basement of the main building.

RAND HALL was added to the Sibley School group (at a cost of $60,000) through the generosity of Mrs. Florence O. R. Lang. This building is a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr., the father, uncle, and brother of the donor. It is a three-story building, the main portion of which is 170 feet long and 50 feet wide; it contains the machine shop and pattern shop, and a portion is used temporarily for the electrical laboratories.

The foundry and forge shops occupy a one-story building, 180 feet long and 40 feet wide.

The School of Electrical Engineering is housed in FRANKLIN HALL, but a portion of the electrical laboratory is temporarily situated on the second floor of Rand Hall.

LABORATORIES AND MUSEUMS

Civil Engineering

The Civil Engineering Laboratories are housed in four distinct buildings and comprise the following:

The Cement Laboratory. This laboratory contains machines for tension tests, compression machines of from two to two hundred tons capacity, and an impact machine. For direct experiment with cement there is also provided a large number of tension and compression briquette molds, a water tank with capacity for the storage of three thousand briquettes, a moist cabinet with a capacity of seven hundred briquettes, and a Freas automatic electric drying oven; scales, slates, and plateglass mixing tables, thermometers, permeability apparatus, several sets of apparatus for measuring linear and volume changes during setting, and apparatus for determining specific gravity, normal consistency, time of set, and constancy of volume by normal and accelerated tests; also standard sieves for determining fineness, a Ro-Tap Testing Sieve Shaker, and apparatus for determining voids in sand and stone.

The Testing Laboratory. The equipment of this laboratory includes a Riehlé 400,000-lb. testing machine with a capacity for beams and girders up to 19 inches in width and 18 feet in length, and for specimens in tension and compression up to 12 feet in length; a Riehlé 50,000-lb. testing machine; an Olsen 100,000-lb. testing machine; an Olsen 50,000-lb. testing machine; an Olsen 10,000-lb. wire testing machine; a Thurston autographic torsion testing machine; a Riehlé torsion testing machine of 60,000 inch-pounds capacity for testing rods and shafts up to one and a half inches in diameter and six feet in length; a Riehlé 5,000-lb. transverse load testing machine for flexural tests of bars of wood and metal up to four feet in length; an Amsler-Laffon compression testing machine; a standard Page impact machine for tests of road material; a Riehlé grinder for stone specimens; a standard Deval machine for abrasion tests of road material; and a standard rattler for paving brick. The equipment also includes a set of torsion clinometers reading to single minutes for use with the Riehlé torsion machine; a Henning extensometer for tension tests of metals, and two self-indicating dial extensometers with fittings which adapt them for use in testing steel or iron tension or compression specimens, and also for testing full-sized concrete beams and columns and for tests of wire. Four Berry strain gages are available for practical measurements of deformation of steel and concrete structures. The Martens mirror extensometer is also available. Knock-down forms are provided for the molding of large concrete beams and columns, and an Austin Cube Mixer is available for making concrete.

The Highway Laboratory. The laboratory is equipped with apparatus for making all the standard tests on non-bituminous and

bituminous materials used in highway construction and maintenance and also for examining the properties of subgrade soils.

The section of the laboratory for testing non-bituminous materials such as gravel, rock, etc., is in the basement of Lincoln Hall. It is equipped with a Deval machine, core drill, rock saw, grinding lap, Page impact machine, ball mill, briquette molding machine, cementation testing machine, Dorry machine, rattler, and other accessories for conducting tests.

The laboratory for testing bituminous materials, bituminous mixtures, and subgrade soils is housed in a separate building. This laboratory is equipped with facilities for making the standard tests of specific gravity, consistency, ductility, softening point, total bitumen, etc., on bituminous materials and also with apparatus for the examination of bituminous mixtures determining the liquid limit, plastic limit, shrinkage determinations, wet and dry mechanical analysis, centrifuge moisture equivalent, etc., of subgrade soils.

THE HYDRAULIC LABORATORY. In addition to the usual equipment for the ordinary laboratory experiments, the unique location and construction of this laboratory render practicable investigations requiring a steady gravity water supply for long periods using relatively large flows of water. The water supply is obtained from Fall Creek with a water shed of 126 square miles. Beebe Lake, a pond of about 20 acres, has been formed by the construction of a concrete dam 26 feet high with a spillway crest length of 130.5 feet. At one end of the dam there is an additional flood spillway 141.5 feet long. A rectangular canal 420 feet long and 16 feet wide is supplied from Beebe Lake through six headgates for controlling the amount of flow. The upper portion of the canal is 17.7 feet deep and the lower portion is 10 feet deep. In this canal are two sharp crested weirs 16 feet long over which discharges as large as 400 cubic feet a second may be passed. The lower portion of the large 16-foot canal, 350 feet long between weirs, is used for measurements with floats and current meters. Models of dams may be built in the canal and the flow over them investigated with precision. An electrically operated car spans this canal and is used for rating current meters and Pitot tubes and for experiments that require the towing of floating or submerged objects through still or running water at various speeds. By means of a gear system the speed of the cable which moves the car, may be varied through a range from ¼ to 12 feet a second. There are also two parallel concrete flumes with water supplied from Beebe Lake independently of the large canal. These are 2 feet wide, 2½ feet deep, and 90 feet long extending downstream from a short canal 7 feet wide, 3 feet deep, and 40 feet long near the dam, to a 2,000 cubic foot concrete measuring tank. Outdoor work is usually suspended from December 1 to April 1 because of the freezing weather.

The laboratory building is built against the south cliff of Fall Creek Gorge and extends vertically about 70 feet, from the pool below Triphammer Falls to the top of the gorge. A short branch canal six

feet wide is housed by the upper portion of the laboratory building and may be supplied directly from Beebe Lake by means of a 48-inch cast-iron pipe line with a short 30-inch branch at its lower end. A 30-inch valve controls the flow from the 48-inch pipe into the 6-foot canal. The 6-foot canal discharges either to waste into the pool below Triphammer Falls (a sheer drop of 60 feet) or into the upper end of a steel stand-pipe 6 feet in diameter and 60 feet high. A suitable mechanism causes an instantaneous diversion of discharges as large as 60 cubic feet a second from the waste flume into the standpipe or vice versa. The 6-foot standpipe is provided at the bottom with a 36-inch discharge valve operated by hydraulic pressure. There is a float gage indicating accurately the height of the water surface in the standpipe, when used as a measuring tank. An independent 10-inch pipe line from the 30-inch pipe to the bottom of the laboratory supplies most of the pieces of apparatus used for class work and research. The 6-foot standpipe may also be used as a supply tank, water being supplied to it from either the 6-foot canal or the 10-inch pipe line. In the laboratory building there is also a concrete flume, 2 feet wide, 4 feet deep, and 25 feet long. Flows up to 11 cubic feet a second can be passed through this and measured volumetrically. This flume is arranged conveniently for experiments on small weirs, low-head orifices, etc. There are numerous flanged connections from 4 to 12 inches in diameter for the attachment of apparatus. The hydraulic machinery equipment at present includes only types of the turbine, Pelton-Doble wheel, Fitz Overshot wheel, multi-stage centrifugal pump and hydraulic ram, all arranged for testing.

Although the laboratory needs extensive additions to its equipment, the utility of this plant has been demonstrated by calls from all parts of the country for the performance of experiments of great importance. Among these may be mentioned the valuable results obtained for the United States Deep Waterways Commission, the Michigan Lake Superior Power Company, the City of New York in connection with its water supply, and the United States Geological Survey.

HAROLD I. BELL RESEARCH FUND. In memory of her husband, Harold Ingersoll Bell, C.E., 1905, Mrs. Ellen Foster Bell in 1922 gave the University five thousand dollars to establish the Harold I. Bell Research Fund. The income of the fund is used to purchase equipment and supplies for research in the field of hydraulic engineering and related fields, under the direction of the School of Civil Engineering.

THE SANITARY LABORATORY. This laboratory provides facilities for the physical, chemical, bacteriological, and biological analyses of water and sewage, and for the performance of such other tests as will acquaint the student with current practice as affecting the control and operation of the various types of water purification and sewage disposal plants. The equipment includes microscopes and the necessary accessories for complete bacteriological and biological examinations of water; an autoclave, a hot-air sterilizer, one 37½° and two

20°C. incubators, a chemical balance, a United States Geological Survey turbidity rod and color standards; four experimental sand filters, fitted with loss of head gages, and providing for a total depth of sand and water of nine feet, for determining the rate and efficiency of operation of sand filters, as well as various types of sewage nozzles. The laboratory is well equipped with such glassware, reagents, accessories, and apparatus as are needed for making the chemical analyses of water and sewage affluents.

THE FUERTES ASTRONOMICAL OBSERVATORY is situated north of Beebe Lake. It contains a transit room with four piers, a clock vault, a photographic darkroom, an office, a computing room, a classroom, and a dome for the 12-inch equatorial telescope, in addition to a comparator room and two constant temperature rooms for geodetic laboratory work. Besides the Irving Porter Church Telescope, a very superior 12-inch equatorial, the equipment includes a Howard mean time astronomical clock, chronometers by Negus and Nardin, four chronographs, a Troughton and Simms transit, two Fauth prismatic transits with latitude levels, a Fauth zenith telescope, an altazimuth by Troughton and Simms, a 4-inch portable equatorial telescope, as well as globes, sextants, surveyor's transits, clocks, collimators, micrometers, a spectra measuring apparatus, spherometer, planetarium, level-trier, and various meteorological instruments.

THE GEODETIC LABORATORY is housed in the new observatory building. Facilities are provided for work along the various lines relating to geodesy and advanced surveying, including geodetic astronomy. The standards of length include: Invar tapes standardized at the U. S. Bureau of Standards; a steel meter bar of the International type which has been compared with the International Prototype Meter of the U. S. Bureau of Standards; a Rogers speculum metal decimeter and 4-inch scale, combined, accurately divided and compared; and a 4-meter bar for subsidiary measures. The laboratory equipment also includes a Mendenhall half-second pendulum apparatus for the determination of the acceleration of gravity—the standard type used by the U. S. Coast and Geodetic Survey; a Kew magnetometer, a dip circle, and a declinometer, for observation of terrestrial magnetism; a dividing engine by the Société Genévoise; precision thermometers by Tonnelot and Boudin standardized at the International Bureau in Paris; a small comparator for calibrating thermometers; and the usual auxiliary apparatus. A 100-foot tape comparator is located on the fourth floor of Lincoln Hall.

MECHANICIAN'S ROOM. This room is used in connection with the laboratories for the construction of special apparatus and instruments and for the maintenance of the equipment. It is well supplied with tools and special machines for the purpose, and is in charge of a mechanician.

THE MUSEUMS AND DRAWING ROOMS of the School of Civil Engineering contain the following collections: (1) The Muret collection of models in descriptive geometry and stone cutting. (2) The

DeLagrave general and special models in topography and geology. (3) The Schroeder models in descriptive geometry and stereotomy with over 50 brass and silk transformable models made in the college after the Olivier models. (4) The M. Grund collection of bridge and roof details, trusses, and masonry structures, such as right, oblique, and annular arches and domes, and several intricate models in stone cutting, supplemented by similar models by Schroeder and other makers. (5) A model railroad bridge of 25-foot span, one-fourth natural size, and a numerous collection of models of track details. (6) The Digeon collection of movable dams, artificial harbors, and working models in hydraulic engineering. (7) Working models of water wheels, turbines, and other water engines. (8) Several large collections of European and American progress photographs of engineering work showing the progress of construction, and many other photographs, blue-prints, models, and diagrams. (9) A collection of typical geodetic and surveying instruments of historical interest, including a secondary base-line apparatus made under the direction of the United States Coast and Geodetic Survey, a pair of base-bars constructed in this college, solar and magnetic compasses, levels, transits, theodolites, omnimeters, tacheometers, sextants, telemeters, altmeters, hypsometers, odometers, meteorological instruments, etc., with a large number of auxiliary and special instruments such as planimeters, pantographs, elliptographs, calculating devices, and computing machines.

The Laboratories of Mechanical Engineering

The Mechanical Engineering Laboratories and Work Shops comprise the following:

The Materials Testing Laboratory. This laboratory is equipped for tension and compression tests with an Olsen 300,000-lb. machine, a Riehlé 100,000-lb. machine, a 200,000-lb. Emery hydraulic machine, an Olsen 150,000-lb. three-screw machine, an Amsler 100,000-lb. hydraulic machine, together with several other machines varying in capacity from 10,000 to 100,000 pounds. For transverse test there is a Riehlé machine of 200,000 pounds capacity and a Fairbanks machine of 10,000 pounds capacity. There are one Thurston autographic torsion machine, one Olsen torsion machine of 200,000 inch-pounds capacity, two Upton-Lewis fatigue testing machines, and an Amsler-Charpy-Izod impact testing machine. The equipment includes hardness testing machines, extensometers, a cathetometer, gas furnaces, tempering baths, and all other apparatus required for the determination of the physical qualities of engineering materials under tensile, compressive, transverse, and torsional stress, and under different kinds of heat treatment. There is also a Leitz microphotographic equipment, together with the necessary grinding and polishing equipment to exhibit the micro-structure of steel and other materials.

THE STEAM LABORATORY. In this laboratory there is a 150-HP triple expansion Allis-Corliss engine so fitted up that it may be operated as a simple, compound, or triple expansion engine, condensing or non-condensing. There are also several smaller engines, including a Russell, a Harris-Corliss, a Payne, a Fitchburg uniflow, and a Troy steam engine. There are three surface condensers and one jet condenser which may be connected with these engines as desired. There are two 35-kw. horizontal Curtis turbines, and a 15-kw. DeLaval turbine which drives electric generators and may be run condensing or non-condensing, and a Lee turbine driving a Goulds centrifugal pump. A two-stage Worthington air compressor driven by a Uniflow engine and one airbrake pump, together with meters, nozzles, and other instruments, may be used for routine tests. This part of the laboratory also has several fans that can be arranged and equipped for testing. The apparatus and instruments used for engine testing comprise about eighty indicators of different types, about seventy-five steam gauges, a number of calorimeters for determination of the quality of steam, speed counters, tachometers, planimeters, etc. besides a number of dynamometers of various kinds. The boiler section of this laboratory has one 150-HP Babcock and Wilcox water-tube boiler of the marine type, one 100-HP Babcock and Wilcox water-tube boiler of the standard type, both of which are fitted with internal superheaters, and an 80-HP Heine water-tube boiler. The auxiliary apparatus consists of a Cochrane open heater, a Wainwright closed heater, steam pumps, traps, injectors, etc. A full set of scales, measuring tanks, gauges, flue gas apparatus, separating and throttling calorimeters, pyrometers, etc., complete the boiler equipment.

THE GAS ENGINE LABORATORY. The equipment in this laboratory is chosen with a view to providing a great variety of types as to fuel used, governing, etc. It includes an 8-HP Fairbanks gasoline engine, an 8-HP Olds gasoline engine, a 6-HP Ingeco oil engine, a 6-HP and a 15-HP Hornsby-Akroyd oil engine, a 30-HP Westinghouse gas engine with gas producer, a 25-kw General Electric Co. gas motor set, and a 45-HP Diesel engine. High speed engines are represented by a variety of auto and airplane engines. The testing equipment includes a full set of indicators and a Midgley indicator. Dynamometers are represented by a 150-HP Sprague Electric, a 60-HP Diehl Electric, a 150-HP General Electric and two Wheeler hydraulic, good for 100-HP at 4000 r.p.m.

THE HYDRAULIC LABORATORY. This laboratory contains the following machines and apparatus: a 6-inch single-stage DeLaval centrifugal pump; a 2½-inch two-stage Worthington centrifugal pump, a 16-inch Goulds centrifugal pump direct connected to a variable speed motor; a 12-inch Doble water wheel; a 15-inch S. Morgan Smith turbine with Lombard governor; sets of weir boxes with various types of weirs and nozzles for the determination of coefficients of discharge; various types of water meters and other

apparatus for measuring the flow of water, such as Pitot tubes, Venturi meters, current meters, etc.

THE OIL TESTING LABORATORY. This laboratory contains a Cornell oil-testing machine, a Thurston standard railway-testing machine, and several smaller Thurston machines. The rest of the equipment consists of several viscosimeters of different types, flash and burning test apparatus, together with the necessary hydrometers and thermometers.

THE REFRIGERATION LABORATORY. For the study of refrigeration the mechanical laboratory possesses a 2-ton York absorption machine and a very complete York refrigerating compression plant having a capacity of 15 tons of ice.

THE CEMENT LABORATORY. This laboratory not only contains the ordinary apparatus for the testing of cement and concrete, but in addition is equipped with crushing and grinding machinery and a small vertical kiln for making investigations on the manufacture of cement from raw material.

THE FUEL TESTING LABORATORY. This laboratory contains a complete equipment of fuel calorimeters and other apparatus needed for the determination of the composition and calorific value of fuel, whether gaseous, liquid, or solid.

THE BELT TESTING LABORATORY. This laboratory contains a belt testing machine which consists of two 75 HP electric dynamometers capable of operating at any speed up to 1000 r.p.m. and of carrying pulleys up to 36 inches in diameter. The belt tension power transmitted by the belt, and the slip of the belt may be observed. Belts can be tested in widths up to 10 inches and the pulley center distance may be varied from 4½ feet to 20 feet.

The Work Shops of the Sibley School of Mechanical Engineering comprise the following units:

THE FOUNDRY occupies floor space of about 4,800 square feet, and has an equipment for the production of iron and composition castings. The methods of producing duplicate work are demonstrated by molding machines of different types selected to illustrate the production of castings of various kinds at lowest labor cost.

THE PATTERN SHOP occupies the top floor of Rand Hall with floor space of 8,440 square feet. The work given the students in this department includes the use of hand and power operated tools under instructors who are skilled in the trade of pattern making.

THE MACHINE SHOP is located on the ground floor of Rand Hall with the same floor area as the pattern shop. It is equipped with an electric traveling crane and representative modern machine tools selected with a view to demonstrating manufacturing methods. A part of the work-shop equipment is installed to illustrate the latest practice in production with specialized labor-saving machinery. The students are not expected to become skilled operators of the machines

of this class, but to acquire a general knowledge of their possibilities in the kinds of work to which they are adapted. The equipment is arranged in groups, each under the charge of an instructor who has made a special study of the machinery in his group.

THE INTRODUCTORY ENGINEERING LABORATORY contains the necessary equipment to demonstrate the principal operations in the forge shop, forging (hand and machine), welding, soldering, brazing, etc. The equipment also includes numerous examples of common engineering appliances such as valves, traps, gages, etc., and an example of simple steam engine, a gas engine, and a steam pump. There is also a complete equipment to teach the principles of oxy-acetylene and electric welding.

THE LABORATORIES OF ELECTRICAL ENGINEERING

The equipment of the laboratories of the School of Electrical Engineering is distributed as follows:

THE LECTURE EQUIPMENT. The lecture room is exceptionally well provided with display apparatus and with apparatus especially designed for demonstration purposes. All types of electrical machinery may be operated on the lecture table and a 60,000 volt transformer is provided for insulator testing.

THE DYNAMO LABORATORIES. These laboratories are provided with a great variety of standard and special machines for both direct and alternating current work, along with the necessary meters and control equipment. Among the special pieces of equipment are street car trucks with motor and also a complete outfit for exhibiting in actual operation the multiple unit system of electric car control. The laboratory has recently been provided with a large number of new machines, including an alternating-current generator, which may be connected as a two-phase, three-phase or six-phase machine; a modern rotary converter provided with brush-lifting device; a squirrel-cage and phase-wound induction motor; a sine-wave generating set; also a constant current transformer and a high voltage-testing transformer with a kenotron tube from which 100,000 volts d.c. may be obtained.

THE STANDARDIZING LABORATORY. This laboratory is equipped with the necessary potentiometers, galvanometers and standards for the calibration of instruments, and the testing of materials used in electrical work. G. E. and Westinghouse oscillographs for work on wave form are available.

THE ELECTRICAL COMMUNICATION LABORATORY. This laboratory is well equipped with apparatus to illustrate present day methods of electrical communication. The wire telegraph section includes various types of commercial apparatus illustrative of simple, duplex, quadruplex, and repeater circuits. The telephone section includes representative telephone equipment of various types. A complete machine switching exchange is installed in the laboratory. The radio

section comprises various transmitting and receiving sets including a complete commercial radio broadcasting equipment. Laboratory standards of inductance, capacity and frequency are available for precision tests and measurements.

LIBRARIES: GENERAL AND DEPARTMENTAL

The Cornell University Library comprises about 750,000 volumes, being one of the largest collections of its kind in the country. Most of the books are in a general library building.

For convenience of reference, the University Library maintains DEPARTMENT LIBRARIES—in Lincoln Hall for the School of Civil Engineering, in Sibley Dome for the School of Mechanical Engineering, and in Franklin Hall for the School of Electrical Engineering. These libraries are under the supervision of the authorities of the several schools. They contain the standard reference and text books and the current files of the important engineering periodicals.

Of special importance is the KUICHLING MEMORIAL LIBRARY, of the School of Civil Engineering, a collection of about fifteen hundred books and pamphlets on hydraulic and municipal engineering, formerly the professional library of the late Emil Kuichling, A.B., C.E., of Rochester, N. Y. It was given to the school in 1919 by Mrs. Sarah L. Kuichling, with an endowment of one thousand dollars, the income of which is to be used to extend the collection and to maintain it as a separate library.

The library in Franklin Hall for the School of Electrical Engineering is known as the ALEXANDER GRAY MEMORIAL LIBRARY. The nucleus of the library was the personal library of the late Alexander Gray, for some years Professor of Electrical Engineering at Cornell University and executive head of the School of Electrical Engineering. The McGraw Hill Book Company bought this collection and gave it to Cornell University for the use of the School of Electrical Engineering.

SCHOLARSHIPS: PRIZES: LOANS

The University has no means of remitting the usual tuition charges in any instance except to students of certain classes which are exempted by statute of New York State or the Board of Trustees. Those classes are defined in the General Information Number. There are no undergraduate tuition scholarships available to residents of the State of New York except the Padgham Scholarship (which is described below) and the Cornell Tuition Scholarships, which are awarded annually by the State Commissioner of Education after a competitive examination; and there are none available to non-residents of the State.

More particular information is given about undergraduate scholarships and loans in the General Information Number; about graduate scholarships and fellowships in the Announcement of the Graduate School; and about prizes in a pamphlet entitled Prize Competitions. Any of these publications may be obtained from the Secretary of the University.

FELLOWSHIPS AND GRADUATE SCHOLARSHIPS

Fellowships and graduate scholarships are awarded by the Graduate School. Students interested in them should consult the Announcement of the Graduate School. Blank forms of application are to be obtained from the Dean of the Graduate School, to whom correspondence should be addressed.

OPEN TO GRADUATE STUDENTS IN THE SCHOOL OF CIVIL ENGINEERING

THE MCGRAW FELLOWSHIP: $400 a year and free tuition, offered to graduates of the School of Civil Engineering and similar schools of equivalent rank.

A GRADUATE SCHOLARSHIP: $200 a year and free tuition; offered under similar conditions.

THE ELON HUNTINGTON HOOKER FELLOWSHIP IN HYDRAULICS: $510 a year; offered for research in experimental hydraulics in Europe or America; open to graduates of the School of Civil Engineering and similar schools of equivalent rank. This fellowship was founded in 1919 by E. H. Hooker, a graduate of the School of Civil Engineering of the class of 1894.

OPEN TO GRADUATE STUDENTS IN THE SCHOOL OF MECHANICAL ENGINEERING

THE SIBLEY FELLOWSHIP: $400 a year and free tuition.

THE EDGAR J. MEYER MEMORIAL FELLOWSHIP: $400 a year and free tuition.

OPEN TO GRADUATE STUDENTS IN THE SCHOOL OF ELECTRICAL ENGINEERING

THE CHARLES BULL EARLE MEMORIAL FELLOWSHIP: $400 a year and free tuition.

The John McMullen Research Scholarship

The John McMullen Research Scholarship: Open to graduates in Civil, Mechanical, or Electrical Engineering. These scholarships were founded by a bequest of John McMullen, of Norwalk, Conn., to Cornell University "for the purpose of creating and maintaining free scholarship or scholarships for the education of young men as engineers, the details as to the amounts of said scholarships and the qualifications of the beneficiaries to be left to said institution to determine, said scholarships to be known as the John McMullen Scholarships." With the avails of this bequest the Board of Trustees has established several research scholarships of an annual value varying from $1,500 to $2,400. The scholarships have not been assigned to any particular school of the College, but will be awarded as conditions dictate. Applications should be sent to the Dean.

UNDERGRADUATE SCHOLARSHIPS

The Cornell Tuition Scholarships: Open only to residents of the State of New York; awarded by the State Commissioner of Education. For particulars, see the General Information Number.

The University Undergraduate Scholarships: Eighteen in number, each paying $200 a year for two years; awarded by the University each year to members of the incoming freshman class. For particulars, see the General Information Number.

The Eudorus C. Kenney Scholarships: Two in number, each paying $250 a year for four years; open, annually to *bona fide* residents of the town of Truxton, Cortland County, New York; in case of a vacancy in any scholarship the value of the scholarship may be awarded by the University Faculty's Committee on Scholarships in such manner as it may deem best. For particulars, see the General Information Number.

UNDERGRADUATE SCHOLARSHIPS IN ENGINEERING

The John McMullen Scholarships: Open to undergraduates in Civil, Mechanical, or Electrical Engineering. These scholarships were founded by a bequest of John McMullen of Norwalk, Conn., to Cornell University "for the purpose of creating and maintaining free scholarship or scholarships for the education of young men as engineers, the details as to the amounts of said scholarships and the qualifications of the beneficiaries to be left to said institution to determine, said scholarships to be known as the John McMullen Scholarships." With the avails of this bequest the Board of Trustees has established at the present time more than twenty undergraduate scholarships varying in annual value from $250 to $500 each, and divided them among the three schools of the College of Engineering. Applications should be made to the Director of the school concerned.

The Frank William Padgham Scholarship, founded by Amos Padgham of Syracuse, New York, in memory of his son, Frank William Padgham, M.E. '88, entitles the holder to free tuition and fees in the regular courses in the Sibley School of Mechanical Engineering or in the School of Electrical Engineering. It cannot be held in connection with a New York State Scholarship. It will be awarded to the candidate, if any, who has had his preparatory education in the public schools of Syracuse, New York, and who, having been admitted to the regular course in either of the Schools named, shall be approved by the University

Faculty's Committee on Undergraduate Scholarships. If no candidate from the schools of Syracuse applies, the scholarship may be awarded to a student who has received his preparatory education elsewhere. Application should be made to the Dean of the College of Engineering.

THE FRED LEWIS WILSON SCHOLARSHIP: Open to undergraduates in Mechanical or Electrical Engineering. Mrs. Mary Northrup Wilson bequeathed Cornell University about $4,000 to found and perpetuate one or more scholarships in honor of her son, Fred Lewis Wilson, who was graduated from Sibley College with the class of 1892. These scholarships are awarded, for a period of not more than two years each, to undergraduates who have been at least one year in the University, under the following rule: "Scholarships arising out of this bequest shall be awarded by a committee consisting of the President of the University, the Dean of the College of Engineering, and one other person chosen by them; and in making such awards the following attributes shall be given the weight indicated; scholarship, evidenced by written examination, 30 per cent; character, in the broadest sense, 30 per cent; probable usefulness in the world at large, 30 per cent; proficiency in mechanic arts, 10 per cent; it being understood that these scholarships are intended to assist such students as are in need of financial aid to complete their courses."

THE JOHN LEISENRING WENTZ SCHOLARSHIP: Open to undergraduates in Mechanical or Electrical Engineering; consists of the income of a fund of $5,500, given the University in 1920 by Mrs. Lewis Audenried in memory of John Leisenring Wentz, a member of the class of 1898. It is awarded at the end of each academic year to a member of the incoming senior class who is in need of pecuniary aid; the beneficiary must have maintained a high scholastic standing during his junior year. The award is determined by a committee approved by the President of the University from the Faculty of the College of Engineering, and is reported to the University Faculty for the purpose of record.

THE WILLIAM DELMORE THOMPSON SCHOLARSHIP: Open only to undergraduates in Mechanical Engineering; established in memory of William Delmore Thompson of the class of 1918; pays $50 a year and is for the benefit of self-supporting students of mechanical engineering. It is awarded at the beginning of the junior year, and if the student's work proves satisfactory it is continued through the senior year.

THE JUDSON N. SMITH SCHOLARSHIP: Open to upperclassmen in the School of Civil Engineering; pays $200 a year, the income of a fund given by Mrs. Sarah L. Smith of Saranac Lake, New York, in memory of her son. It is awarded by the Faculty of the School of Civil Engineering at the end of each year to a student of the incoming senior or junior class in that school, of good character and scholarship and needing pecuniary aid. Applications must be made before May 1.

THE MARTIN J. INSULL SCHOLARSHIP FUND was founded in 1929 by Mrs. Martin J. Insull in honor of her husband, Martin J. Insull, M.E. '93, to enable a deserving student or students to pursue a regular undergraduate course of study in the College of Engineering. The persons eligible must be young men of good character who have presented acceptable credentials for admission to the entering class of the College of Engineering, whose preparatory work has given evidence of capability for advanced technical training, and who can not afford a college education. The Scholarship shall be tenable during regular attendance, good behavior, and good academic standing, and may be withdrawn for failure in any of these respects. The President of the University shall award the Scholarship to an eligible candidate nominated by the Dean and the Directors of the College of Engineering. Applications, with certificates in regard to eligibility for the Scholarship, should be made to the Dean of the College of Engineering not later than July 1.

OTTO M. EIDLITZ SCHOLARSHIPS: Open to undergraduates in the College of Engineering. These scholarships were founded in 1929 by a bequest of Otto

M. Eidlitz, C.E. '81, of $25,000 to Cornell University to establish a scholarship fund in the College of Engineering for students who require financial assistance. With the avails of this bequest three scholarships of an annual value of $400 have been established. These scholarships are awarded by the Dean of the College of Engineering to such students who may be most deserving because of their character and intellectual promise.

THE SYLVESTER EDICK SHAW SCHOLARSHIP, the income of a fund of $4,000 given in 1929 by Sylvester Edick of Newfane, is awarded to a student designated by the alumni of Cornell University who are residents of Niagara County at the time of the award. If the alumni fail to make such designation, the award is made by the principal of the Lockport High School, preference being given to the student who is most in need of financial assistance and who is studying Mechanical or Electrical Engineering. The student has the benefit of the scholarship for the entire period of his course, provided his conduct and progress in his work are satisfactory.

THE JOSEPH N. EVANS SCHOLARSHIP, consisting of the annual income from a bequest of $3,000 given by the will of Mrs. Joseph N. Evans in memory of her husband. Open to any undergraduates in the College of Engineering upon application to the Dean.

PRIZES IN THE COLLEGE OF ENGINEERING

THE FUERTES MEDALS: Established by the late Professor E. A. Fuertes; two gold medals, each of the value of one-half the amount of income provided by the endowment fund. One of these medals is awarded annually by the University Faculty to that student of the School of Civil Engineering who is found at the end of the first term of his senior year to have maintained the highest degree of scholarship in the subjects of his course, provided he has been in attendance at the University for at least two years; the other medal is awarded annually by the Faculty to a graduate of the School of Civil Engineering who has written a meritorious paper upon some engineering subject tending to advance the scientific or practical interests of the profession of the civil engineer. It is desired that papers be presented on or before April 15. If a paper is presented in printed form, it will not be received if it has been printed earlier than the next preceding April 15. Neither medal is awarded unless it appears to the Faculty of the School of Civil Engineering that there is a candidate of sufficient merit to entitle him to such distinction. Candidates are recommended to the University Faculty by the School of Civil Engineering annually.

THE FUERTES MEMORIAL PRIZES IN PUBLIC SPEAKING: Founded by the late Charles H. Baker, a graduate of the School of Civil Engineering of the class of 1886. Three prizes, one of $125, one of $35, and one of $20, are awarded annually to members of the junior and senior classes in the Colleges of Engineering and Architecture, for proficiency in public speaking. The conditions of the award are as follows: (1) The competition shall be open to seniors and juniors in the Colleges of Engineering and Architecture. (2) The competition shall be held on the evening of the third Friday in April. (3) A preliminary contest shall be held before a committee of four, representing each of the three Schools of Engineering and the College of Architecture, at such time and place as this committee may decide. Each contestant in this preliminary contest shall (a) submit a letter of not more than 400 words outlining the purpose and argument of his proposed address; (b) speak from a platform, without notes, for not more than five minutes, either on the subject of the proposed address or on some other subject, at the contestant's option. From the contestants at this preliminary contest not more than seven candidates shall be selected by the committee for the final contest. (4) The speeches delivered in the competition must be on technical subjects original in character. Any technical subject may be chosen by the competitor that may seem to him best suited to furnish an opportunity for persuasive argument.

Questions relating to his profession that would naturally come before semi-technical or non-technical commissions, boards of directors, and conventions are of peculiar fitness. In making the award, both the character of the argument and the manner of presentation shall be considered. Each speech shall be limited to fifteen minutes. (5) The delivery must be without notes, but illustrative material such as diagrams, plans, models, or lantern slides may be used. (6) The judges of the final contest shall be six in number—one selected by the College of Architecture, one selected by each of the three Schools of the College of Engineering, one selected by the Department of Oratory and one selected by the President of the University from men prominent in business life in the city of Ithaca. (7) A student who has already received the first prize is not eligible for subsequent competition.

THE CHARLES LEE CRANDALL PRIZES: Founded in 1916 by alumni of the School of Civil Engineering; prizes of $100, $60, $40, and $25. They are awarded each year, by a committee appointed by the Director of the School of Civil Engineering, for the best paper written by seniors or juniors in that school on suitable subjects, provided both the substance and the written form of the papers submitted show real merit. If, in any year, no papers of sufficient merit are presented for these prizes, the income from the fund for that year is added to the principal and the additional income used from time to time to increase the amount of the prizes. The fund was established to provide prizes to encourage original research, to stimulate interest in matters of public concern, and to inspire in the students an appreciation of the opportunities which the profession of civil engineering offers them to serve their fellow men as intelligent and public-spirited citizens. Papers must be submitted to the Director of the School of Civil Engineering on or before May 15 of each year.

THE SIBLEY PRIZES IN MECHANIC ARTS: Awarded to undergraduates in Mechanical or Electrical Engineering. Under a gift of the late Hiram Sibley, made in 1884, the sum of one hundred dollars is awarded annually in five prizes to juniors and seniors in the School of Mechanical Engineering and in the School of Electrical Engineering who have received the highest marks in scholarship in at last three full terms of work required in the course and done in the schools named. The prizes are $30, $25, $20, $15 and $10.

THE J. G. WHITE PRIZE IN SPANISH. Through the generosity of James Gilbert White (Ph.D., Cornell, '85) three prizes, established in 1914, each of the value of $100 are offered annually. One of the three, which is awarded to an English-speaking student for proficiency in Spanish, is open to members of the junior and senior classes in the College of Engineering, who are candidates for their first degree. No candidate is eligible unless he has completed successfully two terms of work in Spanish at Cornell University. The prize is awarded mainly on the basis of linguistic attainments, in determining which a general knowledge of the language, including its grammar and literature, counts one-half, and ability to speak the language fluently and correctly counts one-half. For further details consult "Prize Competitions," a pamphlet published by the Secretary of the University.

LOAN FUNDS: AWARDS: OTHER PECUNIARY AIDS

Cornell University has two general funds that are used to make loans to students. They are (1) the F. W. GUITEAU STUDENT LOAN FUND, established by the will of Frederick William Guiteau and augmented by the will of his sister, Mrs. Nancy Guiteau Howe, both of Irvington-on-Hudson, the income of which fund is by the terms of the bequest available for loans to young men; and (2) THE WOMEN STUDENTS' LOAN FUND, consisting of a former student loan fund, increased in 1913 by $7,000 assigned to this fund by the late President Andrew D. White from funds placed at his disposal by the late Trustee Andrew Carnegie.

Both these funds are administered for the Trustees of the University by a standing committee. Applications for loans are received by the Secretary of the

University for submission to that committee. The benefits of these funds are reserved to undergraduate students who have been in attendance at Cornell University for at least one year, and preference is given to seniors and juniors. Account is taken of the applicant's character, scholastic record, and need of financial assistance. Loans are made ordinarily to assist students who would otherwise be unable to meet the tuition charges. The student must not regard the loan fund as a normal or assured resource. No student should enter upon a year at the University with the expectation of paying a part of the year's expenses with money yet to be borrowed. The use of the loan fund is a privilege reserved to the industrious student of proved merit and earning power whose means are so nearly exhausted and whose training is so nearly completed as to warrant going into debt in order to complete the training without delay. Money borrowed from either of the funds is to be repaid to the fund with interest at five per cent per annum.

THE WURTS LOAN FUND, the gift of Alexander Jay Wurts, in memory of his mother, Laura Jay Wurts, was founded in 1912 to assist needy students of the two upper classes in the Sibley School of Mechanical Engineering. Upon the recommendation of the Dean of the College of Engineering, loans from the income of this fund may be awarded by the Faculty of the College of Engineering, with the approval of the Treasurer, to one or more students each year.

THE ALAN PARK TOMS AWARD was founded in 1924 by Dr. and Mrs. S. W. S. Toms in memory of their son, Alan Park Toms, M.E., 1923, who lost his life in an untimely manner while practicing his profession. The value of the award is about $250 annually and is available only for undergraduates in the Sibley School of Mechanical Engineering. Awards from this fund are made on the recommendation of the Dean of the College and the Director of the Sibley School of Mechanical Engineering and with the approval of the Faculty of Engineering to one or more worthy students each year.

THE CARL RICHARD GILBERT AWARD was founded in 1929 by Mr. and Mrs. A. S. Gilbert in memory of their son, Carl Richard Gilbert, who died during his Junior year. The value of the award is about $250 annually and is available for students in the School of Electrical Engineering. Awards from this fund are made on the recommendation of the Dean of the College and the Director of the School of Electrical Engineering, and with the approval of the Faculty of Engineering, to one or more worthy students each year.

THE MARTIN J. INSULL LOAN FUND was founded in 1924 by Martin J. Insull, M.E., '93, of Chicago, to be used for making loans to deserving students in the Sibley School of Mechanical Engineering who have been pursuing their studies there for at least one year. Loans are made on the unsecured promissory note of the student borrowing, bearing five per cent interest annually, and payable within three years from the time the borrower leaves the University through graduation or otherwise. This fund is administered for the Trustees by the University's standing committee on loans, and applications are received by the Secretary of the University for submission to that committee.

THE ROBERT CRITCHLOW DEWAR LOAN FUND, the joint gift of Mrs. James M. Dewar and the Cornell Society of Civil Engineers, in honor of Robert Critchlow Dewar, C.E., 1909, who lost his life in the performance of his duties as a civil engineer, is available for undergraduates in the School of Civil Engineering upon recommendation of the Director of that school.

THE WILLIAM C. SEIDELL BOOK FUND of $1,000 was founded by Gerrit S. Miller. The income is used for the purchase of books for young men who are working their way through the School of Civil Engineering, and is paid by the Treasurer of the University upon the recommendation of the Director of the school, preference being given to underclassmen.

The Cornell Clubs of BUFFALO and ROCHESTER have each made provision for the loan of a small sum of money each year to an undergraduate student coming from the club's own neighborhood.

ADMISSION TO THE COLLEGE

All correspondence concerning admission to the College of Engineering should be addressed to The Director of Admissions, Cornell University, Ithaca, N. Y., who will forward the necessary blank form of application on request. All credentials relating to the admission of a new student should be sent to the Office of Admissions as early as possible, in no case later than the first day of September. A prospective applicant should read carefully the paragraph headed Rules Governing Admission, a page or so further on. He should also read the General Information Number, for which application should be addressed to The Secretary, Cornell University, Ithaca, N. Y.

ADMISSION TO THE FRESHMAN CLASS

The Requirements for Entrance to the Regular Four-Year Course

For admission to the freshman class in the regular four-year course, the applicant must offer fifteen specific units of entrance subjects, as follows: English, 3 units; History, 1 unit; Elementary Algebra, 1 unit; Intermediate Algebra, 1 unit; Plane Geometry, 1 unit; Solid Geometry, ½ unit; Plane Trigonometry, ½ unit; foreign language equivalent to 3 units in either Greek, Latin, German, French, Spanish, or Italian, or 2 units in each of two of them; and in other entrance subjects, elected by the applicant, 3 or 4 units. Applicants offering fifteen units which do not differ materially from the specific list may present their credentials for consideration.

It is recommended that French or German be offered to satisfy the language requirement for the reason that a knowledge of either of these tongues gives the student immediate access to a large part of the standard literature in the theory and practice of engineering.

The student preparing to enter the college is strongly advised to offer at least three of his elective units in Language and History. His work in the four-year course in engineering will necessarily be almost entirely scientific or technical and will leave him little opportunity for instruction in other fields He will do well, therefore, during his preparatory years, to avoid unnecessary specialization and to make his studies as liberal as possible. Applicants who have not had this broader education are recommended to take either a five-year course or a six-year course, if they can afford the additional time and expense involved.

Students who have had some practical experience in engineering usually gain more than others from the courses offered by the College of Engineering; hence it is recommended that prospective students spend at least one summer vacation in practical work in connection with some kind of engineering.

The applicant must be at least sixteen years of age. Under special circumstances the committee of admissions will admit students who lack not more than one-half unit in Advanced Mathematics, (Solid Geometry, Plane Trigonometry), if fifteen units are offered and all other requirements are met. Such students may so arrange the course as to graduate in four years plus attendance in one Summer Session. More detailed information about courses requiring more than four years for graduation will be furnished upon application to the Secretary of the College of Engineering.

SUBJECTS THAT MAY BE OFFERED FOR ENTRANCE

The subjects that may be offered for admission to the College of Engineering are named in the following list. The figure in parenthesis opposite the name of each subject indicates its value expressed in units and shows the maximum and minimum amount of credit allowed in that subject. A unit represents five prepared recitations a week for one year of study. Two hours of laboratory work are counted the equivalent of one hour of prepared recitation, but in Drawing or Manual Training 300 hours of actual work are required for one unit. If an applicant counts Biology (1) he may not also offer Botany (½) or Zoology (½).

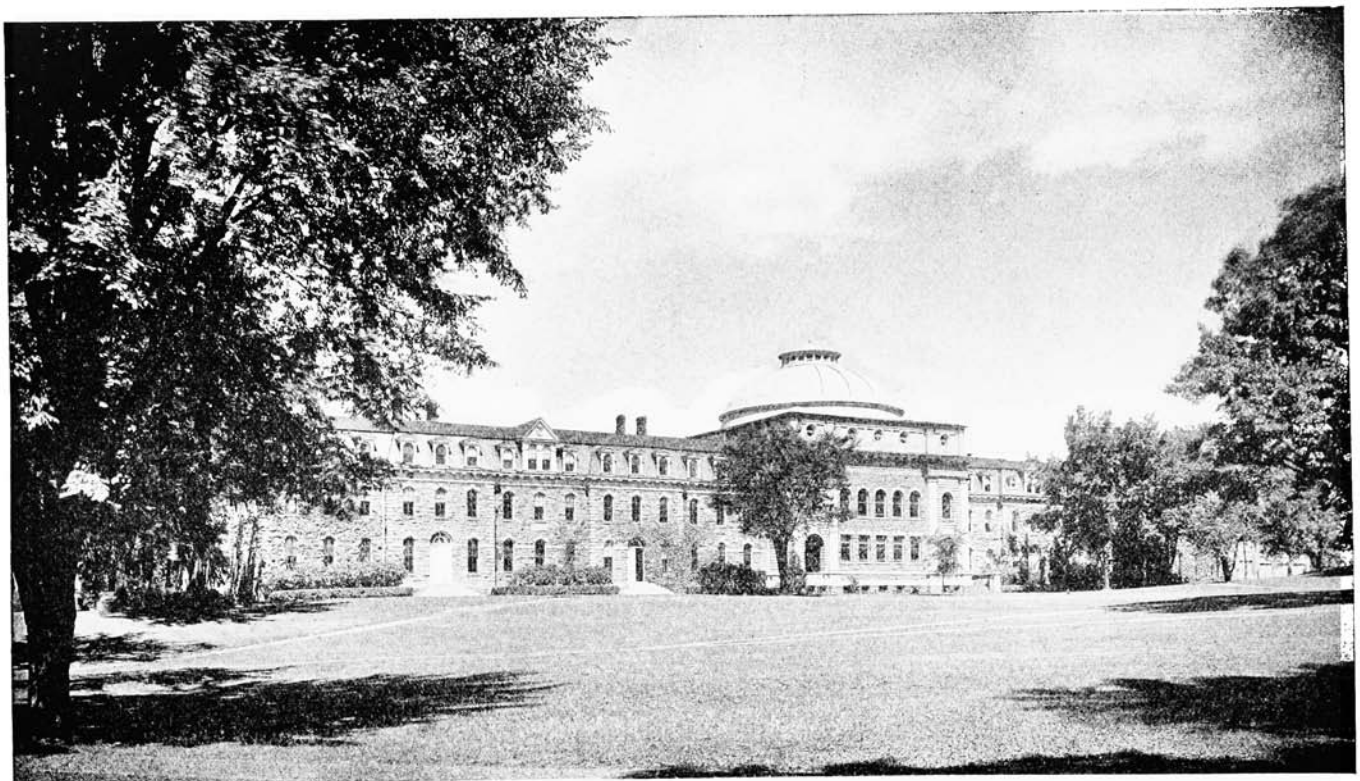
1a. English 1 ..... (1½)
1b. English 2 ..... (1½)
1c. English (elective) ..... (1)
2a. First Year Greek ..... (1)
2b. Second Year Greek ..... (1)
2c. Third Year Greek ..... (1)
3a. First Year Latin ..... (1)
3b. Second Year Latin ..... (1)
3c. Third Year Latin ..... (1)
3d. Fourth Year Latin ..... (1)
4a. First Year German ..... (1)
4b. Second Year German ..... (1)
4c. Third Year German ..... (1)
4d. Fourth Year German ..... (1)
5a. First Year French ..... (1)
5b. Second Year French ..... (1)
5c. Third Year French ..... (1)
5d. Fourth Year French ..... (1)
6a. First Year Spanish ..... (1)
6b. Second Year Spanish ..... (1)
6c. Third Year Spanish ..... (1)
6d. Fourth Year Spanish ..... (1)
7a. First Year Italian ..... (1)
7b. Second Year Italian ..... (1)
7c. Third Year Italian ..... (1)
8a. Ancient History ..... (½-1)
8b. Modern History ..... (½-1)
8c. English History ..... (½-1)
8d. American History, Civics. (½-1)
9a. Elementary Algebra ..... (1)
9b. Intermediate Algebra..... (1)
9c. Advanced Algebra ..... (½)
9d. Plane Geometry ..... (1)
9e. Solid Geometry ..... (½)
9f. Plane Trigonometry ..... (½)
10. Physics ..... (1)
11. Chemistry ..... (1)
12. Physical Geography ..... (½-1)
13. Biology ..... (1)
14. Botany ..... (½-1)
14a. Zoology ..... (½-1)
15. Bookkeeping ..... (½-1)
16. Agriculture ..... (½-1)
17. Drawing ..... (½-1)
18. Manual Training ..... (½-1)
19. Any high school subject or subjects not already used (½-2)

WAYS OF OBTAINING ENTRANCE CREDIT

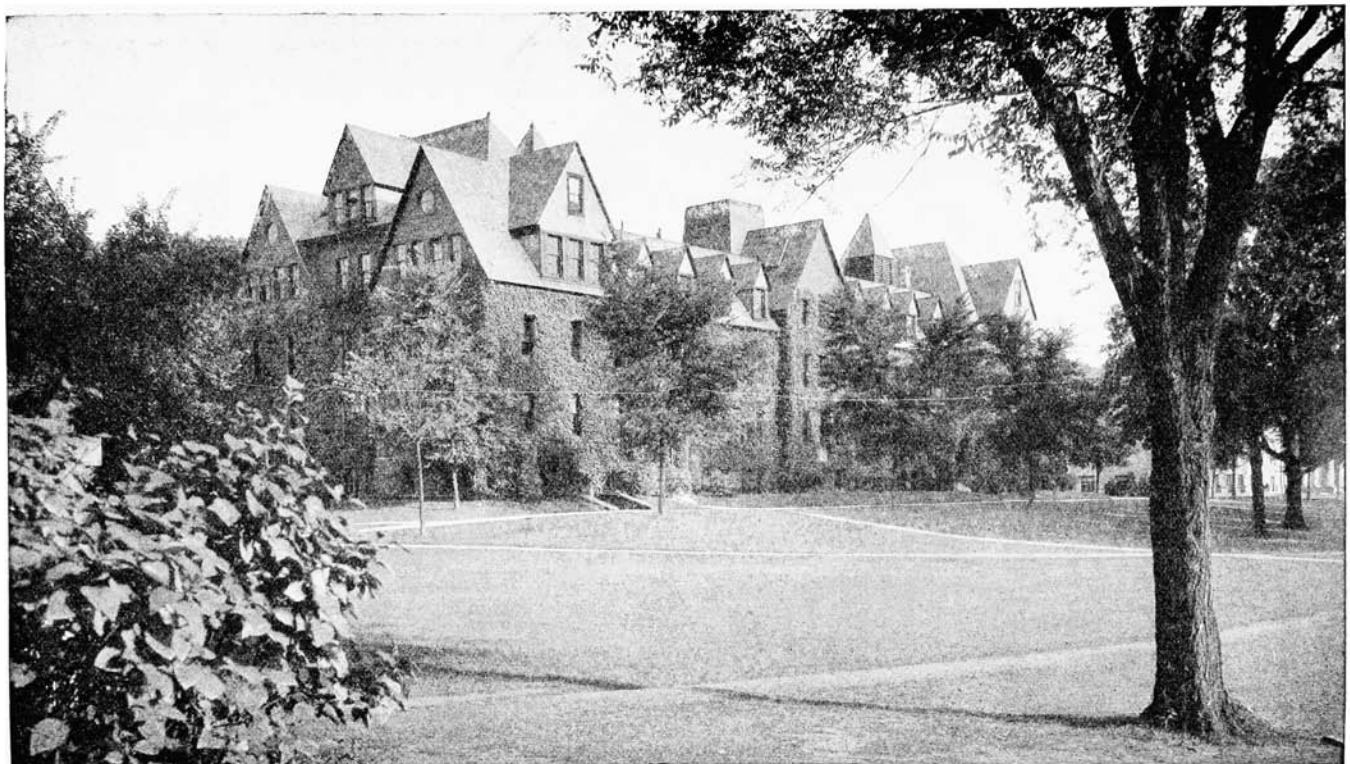
There are four ways in which credit for entrance subjects may be obtained. They are:

1. By passing the required Cornell University entrance examinations held in September in Ithaca and New York City, and in January (for applicants for the College of Engineering only) in Ithaca.

2. By passing the College Entrance Examination Board examinations (the "Comprehensive" examinations are accepted excepting Mathematics Cp.H.) held in June in various places. Address the Secretary of the College Entrance Examination Board, 431 West 117th St., New York City.



THE SIBLEY SCHOOL OF MECHANICAL ENGINEERING



LINCOLN HALL

The Main Building of the School of Civil Engineering

3. By passing the Regents' examinations (for students who have prepared in New York State).
4. By presenting an acceptable school certificate.

RULES GOVERNING ADMISSION

Besides satisfying the entrance requirements, candidates for admission must comply with the following rules:

1. Every candidate for admission to an undergraduate course must deposit twenty-five dollars with the University. Candidates are warned not to send cash through the mails. A check, draft, or order should be payable to Cornell University and should be sent to the Office of Admissions, Cornell University. The deposit must be made not later than June 1 if the candidate is to be admitted in September to the College of Arts and Sciences or the College of Architecture, and not later than August 1 if he is to be admitted in September to any of the other colleges. It must be made not later than January 1 if the candidate is to be admitted in February to any of the colleges.

If the candidate matriculates, the deposit will be credited to his account, $10 for the matriculation fee and $15 as a guaranty fund, which every undergraduate student is required to maintain and which is to be refunded upon his graduation or permanent withdrawal, less any indebtedness to the University.

If admission is denied a candidate, the deposit is refunded in full at any time.

A candidate may withdraw the application for admission, but a charge of $10 is regularly made for accrued expenses unless the application is withdrawn and a refund of the deposit in full is claimed before the due date, which is June 1 in the College of Arts and Sciences and the College of Architecture and August 1 in the other colleges. If an application is not withdrawn until after the due date of the college concerned, but is withdrawn before August 31, the $10 charged for accrued expenses is deducted and $15 of the deposit is refunded. No refund is made to an applicant who withdraws the application after August 31.

In the case of applications for admission in February, a withdrawal after January 1 incurs the regular charge of $10, and no refund is made for withdrawal after January 31.

The winner of a New York State Tuition Scholarship in Cornell University may apply for admission to the University and make the required deposit of $25 immediately after receiving formal notice of his appointment from the Commissioner of Education at Albany.

2. Every candidate for matriculation must submit to the Director of Admissions a satisfactory certificate of vaccination against smallpox, not later than August 1 if he is to be admitted in September, or not later than January 1 if he is to be admitted in February. It will be accepted as satisfactory only if it certifies that within the last five years a successful vaccination has been performed or three unsuccessful attempts at vaccination have been made.

3. Every candidate for admission to an undergraduate course must file with his application at the Office of Admissions either a certificate of good moral character or, if he has attended some other college or

university without graduating from it, a certificate of honorable dismissal from it.

A NECESSARY PRECAUTION

Before coming to the University, the student should consult an oculist and have any defect of vision corrected. Unless he does so, he may begin his work under a disadvantage and run the risk of failure. The large amount of close work that is required in reading and drafting puts a strain on farsighted or otherwise imperfect eyes. Such a weakness, unless discovered and remedied before the student begins his work, may delay his progress and impair his health.

ADMISSION AT THE BEGINNING OF THE SECOND TERM

Certificates and credentials for admission at midyear should be in the hands of the Director of Admissions not later than January 15. Admission at midyear is possible only under the following conditions. (a) A student must meet the regular entrance requirements. (b) If a student enters as a freshman without advanced college credit the time required for his graduation may be more than four years, and may require attendance during one or more Summer Sessions at Cornell University. On application made to the Director of Admissions on or before January 15 in any year, special entrance examinations in any of the University entrance subjects may be arranged for students who must be examined in one or more subjects to complete their requirements for admission to the College of Engineering at midyear. These special entrance examinations are held in Ithaca on or about January 25 of each year.

ADMISSION TO THE COURSE IN ADMINISTRATIVE ENGINEERING

The requirements for admission to this course are the same as those for the regular Four-Year Course, page 33.

ADMISSION TO THE FIVE-YEAR COURSE IN MECHANICAL ENGINEERING

For admission to this course, the entrance requirements are those of the four-year course. The student completes the regular engineering work, spending more time on the advanced engineering work, and adding the equivalent of about one year of liberal arts work. A definite schedule for such a course has so far been laid down only by the Sibley School of Mechanical Engineering, (see p. 77).

ADMISSION TO THE FIVE-YEAR COURSE IN CHEMICAL ENGINEERING

The requirements for entrance to this course are those required for entrance to the B.Chem. course in the College of Arts and Sciences. Application should be made to that College.

ADMISSION TO THE SIX-YEAR COURSE

The six-year course, leading to the degrees of A.B. and C.E., or A.B. and M.E., or A.B. and E.E., requires admission to the College of Arts and Sciences, in which college the student is registered during the first four years. In order to make it possible to obtain the C.E., M.E., or E.E. degree at the end of the sixth year, the student must complete the freshman engineering subjects before the beginning of his fourth year, and must complete the list of sophomore subjects in

Civil Engineering, Mechanical Engineering, or Electrical Engineering before the beginning of his fifth year. Advice and assistance in arranging such a course may be obtained by applying to the Director of the school concerned.

Owing to the large amount of liberal work in the curriculum of the School of Civil Engineering the two degrees of A.B. and C.E. may be obtained in five years plus two summer sessions.

ADMISSION FROM ANOTHER COLLEGE

A student who has attended another college may be admitted to advanced standing, provided he is in good standing in the college from which he comes and provided also that he meets the full entrance requirements of the College of Engineering. An applicant for admission in this way should file by mail with the Director of Admissions of Cornell University, on an official blank to be obtained from him, a formal application for admission stating definitely the branch of engineering desired, along with an official certificate, from the college or university already attended, of his honorable dismissal; his entrance credits in detail; his terms of attendance and the amount of work that he has completed; a detailed statement of the courses pursued; and the drawings and reports for which credit has been secured. He should also send a catalogue of the institution, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he has completed.

SPECIAL STUDENTS

The College of Engineering admits special students, that is, to say, applicants who have not fifteen acceptable units of entrance credit, only under exceptional circumstances. They must have had equivalent training satisfactory to the committee on admissions, and must be at least 21 years of age.

ADMISSION AS A GRADUATE STUDENT

Graduates of this college or other colleges may enter the Graduate School of Cornell University and pursue work in the College of Engineering. Such a student may enter either as a candidate for a degree (M.C.E., M.M.E., M.E.E., M.S., or Ph.D.) or not, according to the character of his previous training. A prospective student should consult the Announcement of the Graduate School and apply to the Dean of the Graduate School. See also page 40.

TUITION AND OTHER FEES

Information about the amount and the manner of payments to be made by a student to the University should be looked for in the General Information Number.

Tuition. The University charges students registered in the College of Engineering tuition at the rate of four hundred dollars a year, payable $220 at the beginning of the first term and $180 at the beginning of the second term.

A student enrolled only for the second term of the academic year is required to pay tuition at the rate of the first term. The installment for any term becomes a liability at once when the student registers.

A Matriculation Fee of $10 is required of every student upon entrance into the University; this fee must be paid at the time of registration. A new undergraduate student who has made the required deposit of $25 with the Treasurer need not make an additional payment of the matriculation fee, because the Treasurer will draw on the deposit for this fee.

A Laboratory Fee is required of all students registered in the College of Engineering, one-half of the fee at the beginning of each term, at the following rates: Freshmen in the College of Engineering, $25 a year; sophomores, juniors, and seniors in Mechanical Engineering and Electrical Engineering, $25 a year; sophomores, juniors, and seniors in Civil Engineering, $8 a year. Students taking a five-year course in the college pay this fee for only eight terms. Students in the College of Engineering who take laboratory courses in other colleges of the University are required to pay to the Treasurer a fee or deposit for materials used in the work. Students not registered in the College of Engineering but taking work in the shops are required to pay a laboratory fee at the rate of $3.50 a record hour. (A student who has taken, while in a non-engineering college of the University, part of the work required for an engineering degree shall, before receiving such technical degree, be required to pay to the University Treasurer such amount as would have been necessary if he had taken all such work while registered in the College of Engineering.)

An Infirmary Fee of $5 a term is required at the beginning of each term, of every student. For a statement of the privileges given in return for this fee, see the General Information Number.

A Willard Straight Hall Membership Fee of $5 a term is required, at the beginning of each term of every student. Its payment entitles the student to a share in the common privileges afforded by the operation of Willard Straight Hall, subject to regulations approved by the Board of Managers of the Hall. A fee of $5 a term is required of all graduate students except those who are members of the instructing staff, for whom membership is optional. The use of the hall is restricted to those who have paid this fee.

A Physical Recreation Fee is required at the beginning of each term of every undergraduate man and of every woman of the freshman and sophomore classes. It is $2 a term for men and $1 a term for women. Its payment entitles the student either to the use of the gymnasium and the University Playgrounds and to the use of a locker, with bathing facilities and towels, in the Gymnasium, the New York State Drill Hall, or the Schoellkopf Memorial Building, or else to the use of the women's gymnasium, recreation rooms, and playgrounds, and to the use of a locker if that is necessary.

A Graduation Fee is required, at least ten days before the degree is to be conferred, of every candidate for a degree. For a first or baccalaureate degree the fee is $10; for an advanced degree it is $20. The fee will be returned if the degree is not conferred.

Tuition and other fees become due when the student registers. The University allows twenty days of grace after the last registration day of each term. The last day of grace is generally printed on the registration coupon which the student is required to present at the Treasurer's office. Any student who fails to pay his tuition charges, other fees, and other indebtedness to the University, or who, if entitled to free tuition, fails to claim it at the Treasurer's office and to pay his fees and other indebtedness, within the prescribed period of grace, is hereby dropped from the University unless the Treasurer has granted him an extension of time to complete payment. For the conditions and terms of any such extension, see the General Information Number.

A tuition fee or other fee may be changed by the Trustees at any time without previous notice.

CHARGES FOR DELINQUENCIES

Every student is held responsible for any injury done by him to any of the University's property.

Assessments are levied upon the student in certain circumstances, under the following rules of the University:

A student desiring to be reinstated after being dropped from the University for delinquency in scholarship or in conduct shall first pay a fee of $25.

A matriculated student desiring to register after the close of registration day shall first pay a fee of $5. [Students in the Graduate School are excepted.]

A student desiring to file his registration of studies after the date set by his college for filing the same shall first pay a fee of $2.

A student desiring to take an examination or other test for the removal of a term condition (including the making up of a mark of "absent" or "incomplete") shall first pay a fee of $2 for each examination or other test.

A student desiring to make an appointment for the required medical examination or conference after twenty days from the last registration day of the term shall first pay a fee of $2.

For reasons satisfactory to the proper authority any of the above-mentioned assessments (except that levied for examination or other test to remove a condition) may be waived in any individual case if the student's failure to comply with the regulation was due to ill health or to other reasons beyond his control. Application for waiver should be made to the dean of the college enrolling the student, except in the case of the medical examination, in which case it should be made to the chairman of the Faculty Committee on Health.

COURSES OF STUDY IN THE COLLEGE

THE REGULAR FOUR-YEAR COURSES

Regular four-year courses are offered in the schools of the college, leading to the degrees of Civil Engineer, Mechanical Engineer, and Electrical Engineer. In addition, the Sibley School of Mechanical Engineering and the School of Electrical Engineering offer four-year courses leading to the degree of Bachelor of Science in Administrative Engineering.

The first year of all the courses is common, except for the work in Drawing, so that no student need make his choice of Mechanical Engineering, Electrical Engineering, or Administrative Engineering until near the end of the first year of residence. The curriculum of the first year is given on page 46 under the head of The Freshman Year.

The last three years of each regular four-year course are spent by the student under the direct supervision of one of the three schools. Further on in this Announcement there will be found, under the appropriate head, a particular statement of the curriculum of the last three years in each school.

In the last year of each course, certain options or electives are offered, so that each student may have a certain amount of freedom in placing the main emphasis of his work upon branches of the profession in which he may be most interested. These options and electives are clearly defined in the announcement of each school, on subsequent pages.

FIVE AND SIX-YEAR COURSES

As already mentioned on page 11 of this Announcement, arrangements may be made in each of the three schools of the College for a six-year course leading to the degree of A.B. and to either the C.E., M.E., or E.E. degree. In addition, the Sibley School of Mechanical Engineering offers a five-year course in Chemical Engineering in conjunction with the Department of Chemistry, and is prepared also to arrange a special five-year course leading to the degree of M.E. only. For details see the Announcements of the three schools in the pages following. Applications for any of these special arrangements should be made to the Director of the School concerned, except for the course leading to the degree of Chemical Engineer, for which application should be made to the Director of the Department of Chemistry.

GRADUATE STUDY IN ENGINEERING

The instructing staffs and the laboratories, libraries, and other facilities of the various departments of the College of Engineering

and those of the other departments of the University are available for students desiring to pursue original graduate study and research in engineering and allied fields. Graduate students in engineering will also find among the regular and elective courses given in the College many suitable for advanced study.

The degrees of Master of Civil Engineering (M.C.E.), Master of Mechanical Engineering (M.M.E.), Master of Electrical Engineering (M.E.E.), Master of Science (M.S.), and Doctor of Philosophy (Ph.D.) are granted for engineering work upon the fulfilment of conditions prescribed by the Faculty of the Graduate School. The requirements for advanced degrees are based, not upon courses or credits, but upon the completion of a definite period of residence, the presentation of a satisfactory thesis or essay, and the passing of an examination. The student is expected to show originality and independence in his graduate work.

In order to become a candidate for an advanced degree, the student who has been admitted to the Graduate School must first choose a field of study. Within that field, the branch of study to which he intends to devote the larger part of his time is termed his *Major Subject;* the other subject, or subjects, which will be necessarily more restricted in their scope and which should be selected with reference to their direct bearing upon the Major Subject, are termed the *Minor Subjects.* A *Special Committee* consisting of the professors under whom the student takes his Major and Minor subjects is in charge of his graduate work.

The Master's degree requires at least one year of graduate residence at the University. The Doctor's degree requires credit for at least three years of resident graduate work, but residence credit for work done elsewhere may be granted in certain cases.

(For more detailed information about the Graduate School, see the Announcement of that school.)

Rules Governing Graduate Study in Engineering

The following rules governing graduate study in engineering are to be considered as supplementing but in no way superseding the general requirements of the Graduate School.

1. Application for admission to Graduate Study should be sent to the Office of the Graduate School. (A blank form for making application will be forwarded upon request.)

The applicant's credentials should include:

(a) An official transcript of his entrance credits and his undergraduate study. (There should be included also a catalogue of the institution from which he graduated, and each subject that he has completed should be clearly marked therein.)

(b) An official statement concerning his previous graduate study, if any.

(c) A detailed statement concerning his practical experience, together with letters from his employers.

In all cases, the applicant should designate as definitely as possible his chosen fields of study, both major and minor, so that he may be advised concerning the facilities and personnel available in those fields.

The credentials submitted by the applicant will be examined and passed upon by a Committee on Credentials, the Credential Committee.

2. All graduate students must register in the Graduate School. In addition, a graduate student in engineering must, at the beginning of each term of residence, register at the office of the Engineering School of whose faculty his major professor is a member.

3. Candidacy for an Advanced Engineering Degree (M.C.E., M.E.E., or M.M.E.) presupposes the substantial equivalent of the corresponding first degree at Cornell University. In the evaluation of a candidate's credits, however, the *quality* of his previous work, his practical experience, and his chosen field of advanced study will be considered in making adjustments for candidates whose undergraduate course has not been the exact equivalent of that of Cornell.

4. A graduate student who wishes to do graduate work in engineering but who does not care to meet all the special requirements for admission to candidacy for one of the degrees M.C.E., M.E.E., M.M.E., may find it advantageous to become a candidate for the degree of M.S. or Ph.D. Whether or not he is prepared to undertake graduate work in a particular field of study shall be determined by the professor or professors in charge of the work in that field.

5. If a student's training is considered short of that required for the first degree at Cornell corresponding to the advanced degree desired, his shortage will be noted.

A minor shortage, not to exceed 6 hours of undergraduate work, may be made up as extra work. A shortage more than this usually will require additional residence. If a student's shortage is more than one term, he will be required to enter an undergraduate school.

In general, a graduate student should remove his shortage before he may enter his chosen field of graduate work. Since it is not always practicable to do this, the student in special cases may receive permission to make up his shortages while doing his graduate work.

In making up a shortage, the student is under the general supervision of the Credential Committee. His graduate work, however, is under the direct supervision of his *Special Committee*.

6. When a candidate for an Advanced Degree in Engineering takes a course specified by the Credential Committee or approved by

his Special Committee, he must register in that course and must conform to all the requirements of that course including the final examination.

7. If, in the opinion of the special committee, a candidate at any time during his residence shows insufficient preparation in any subject or subjects, he may be required to register in and take the work of specified undergraduate courses. His residence requirement will be increased accordingly.

8. In general, for a Master's degree the total time devoted to the minor subject or subjects should be not less than about one-quarter to one-third of the total time normally required for the degree. For the Doctor's degree the total time devoted to the minor subjects should be a little less than one-half of the total time required for the degree. As a rule the major and minor subjects should be chosen in different fields.

9. A working knowledge of French and German is the minimum language requirement for the degree of Doctor of Philosophy. Before beginning his second year of residence, the candidate who chooses his graduate work in engineering must satisfy his Credential Committee that he has fully met the minimum language requirement.

10. Before a student will be recommended to the Faculty of the Graduate School for the degree for which he is a candidate, he must satisfy the Credential Committee in conjunction with his special committee that he has fulfilled all academic requirements.

MILITARY SCIENCE: PHYSICAL TRAINING

All men in the first two years of undergraduate courses must take in addition to the scholastic requirements for the degree, three hours a week in the Department of Military Science and Tactics. This department is a unit of the Reserve Officers' Training Corps of the United States Army. For details of the work in the Department of Military Science and Tactics, see the General Information Number.

All women in the first two years of undergraduate courses, and all men of those two classes who are excused from military drill, must take, in addition to the scholastic requirements for the degree, three hours a week in the Department of Physical Training. For details of this work in the Department of Physical Training, see the General Information Number.

HYGIENE AND PREVENTIVE MEDICINE

All students are required, upon entering, to report to the medical office of the University for a physical examination.

Sophomores also make their appointments for physical examination during the registration days of the first term. Juniors and seniors

make their appointment for physical examination during the registration days of the second term.

All students in the first year of undergraduate courses are required to attend lectures on Hygiene and Preventive Medicine given once a week throughout the college year.

Required Courses

1. **Hygiene.** First term. Credit one hour. Required of all freshmen. One lecture-recitation each week, with preliminary examination and final. The use of a text-book will be required.

Students must report for registration and assignment to section, the men at the *Old Armory,* the women at *Sage Gymnasium.*

Sections for men: M 9, 10, 11, 12; T 9, 11, 12; W 8, 9, 10, 11, 12; Th 8, 9, 11, 12; F 8, 11; S 8, 9, 10, 12.

Sections for women: M 8; T 8, 10; Th 10, 2; F 9, 2; S 11.

2. **Hygiene.** Second term. Credit one hour. Required of all freshmen. One lecture-recitation each week, with preliminary examination and final. The use of a text-book will be required.

Students must report for registration and assignment to section, the men at the *Old Armory,* the women at *Sage Gymnasium.*

Sections for men: M 9, 10, 11, 12; T 9, 11, 12; W 8, 9, 11, 12; Th 9, 11, 12; F 8, 11; S 8, 9, 10, 12.

Sections for women: M 8; T 8, 10; Th 10, 2; F 9, 2; S 11.

Elective Courses

3. **Health Supervision of School Children.** Second term. Credit two hours. Assistant Professor Gould. T Th 12. Histology lecture room, *Stimson.* Registration at Hygiene Office, *Old Armory.*

A practical course of lectures and demonstrations designed to familiarize the student with the facts and methods necessary for making an effective health supervision of school children. Prerequisites suggested but not demanded: Human Physiology and Anatomy. Open to sophomores, juniors, and seniors.

4. **First Aid.** First or second term. Credit one hour. Assistant Professor Showacre. First term: Section 1, T 12, Anatomy lecture room, *Stimson;* Section 2, F 8. Second term: Section 1, W 8, Anatomy lecture room, *Stimson;* Section 2, S 8, Anatomy lecture room, *Stimson.* Registration at Hygiene Office, *Old Armory.* Prerequisites: Hygiene 1 and 2.

This course will include a discussion and practical demonstration of the main methods at hand for preventing accidents and for giving emergency treatment.

5. **Industrial Hygiene.** First term. Credit one hour. Assistant Professor Gould. Th 12. Histology lecture room, *Stimson.* Registration at Hygiene Office, *Old Armory.* Prerequisites: Hygiene 1 and 2.

Factory sanitation, ventilation, and illumination; occupational poisoning and disease; factory legislation; accident prevention; fatigue in industry; preventive medicine in the industries.

6. **School Hygiene.** Professor Young. See Physical Education 24.

7. **Rural and Camp Hygiene.** Second term. Credit one hour. Assistant Professor Smiley. W 12. Anatomy lecture room, *Stimson.* Registration at Hygiene Office, *Old Armory.* Prerequisites: Hygiene 1 and 2.

A general consideration of the health problems peculiar to rural areas with the presentation of practical schemes for the solution of these problems as far as possible.

8. **Mental Hygiene.** First term. Credit one hour. Dr. Alva Gwin. T 2,

Histology lecture room, *Stimson*. Registration at Hygiene Office, *Old Armory*. Prerequisites: Hygiene 1 and 2.

A study of the factors involved in the maintenance of mental health of the individual; i.e., satisfactory human relationships, attitudes, and behavior. Discussion of the causes and mechanisms underlying the more common personality deviations.

THE REQUIREMENTS FOR GRADUATION

The degree of Civil Engineer, Mechanical Engineer, Electrical Engineer, or Bachelor of Science in Administrative Engineering, is conferred on candidates who have fulfilled the following requirements:

1. The candidate must have been in residence and registered in the College of Engineering for at least two terms and must have satisfied the University requirements in Military Training (or Physical Training), in Hygiene and Preventive Medicine, and in the payment of tuition and fees.

2. If admitted to the four-year course, he must have completed to the satisfaction of the Faculty of the College of Engineering all the subjects including elective hours, prescribed in the four-year curriculum as outlined by that faculty.

3. A student who transfers to the College of Engineering, after having spent one or more terms in another college of Cornell University or elsewhere, must conform to the requirements for graduation that would have applied if he had been registered in this college from the time he matriculated in the University.

THE FRESHMAN YEAR

THE SCHEDULE OF STUDIES

There is a single schedule of studies for all students in the freshman year of the College of Engineering, except that freshmen expecting to work for the C.E. degree take Drawing 200 and 201; those expecting to work for the M.E. or E.E. degree take Drawing 120 and 121. The prescribed schedule for freshmen is as follows; the numbers of the courses refer to the lists of courses printed on the next two pages:

	Hours	
	1st Term	*2nd Term*
Analytical Geometry and Calculus, 5a, 5b	5	5
Physics 11, 12	4	4
Chemistry 101, Lectures	3 or 0	0 or 3
Chemistry 105, Recitations and Laboratory	3 or 0	0 or 3
Descriptive Geometry and Drawing 120, 121 or Drawing 200, 201	3	3
Elementary Surveying 110	0 or 3	3 or 0
Woodwork 102	0 or 1	1 or 0
Introductory Engineering Laboratory 103	0 or 1	1 or 0
Introductory Lectures 130	1	0
Hygiene 1, 2	1	1
Total number of hours each term	20 or 19	18 or 19

In addition to taking the courses named in the above schedule, all freshmen must satisfy the University's requirement of three actual hours a week throughout the year in Military Science and Tactics (or in Physical Training; see the General Information Number).

For the schedules of the sophomore, junior, and senior years in Civil Engineering, Mechanical Engineering, Electrical Engineering, or Administrative Engineering, consult the announcement of the appropriate school in following pages.

THE COURSES OF INSTRUCTION, FRESHMAN YEAR

The following courses of instruction are those prescribed for all students in the freshman year of the four-year course leading to the degree of Civil Engineer, Mechanical Engineer, Electrical Engineer, or Bachelor of Science in Administrative Engineering. The courses in Mathematics, Physics, and Chemistry are given in the College of Arts and Sciences; the other courses in the list are given in the College of Engineering.

MATHEMATICS

5a. **Analytical Geometry and Calculus.** First term. Credit five hours. Repeated in second term.

5b. **Analytical Geometry and Calculus.** Second term. Credit five hours. Given also in first term.

Course 5a or 5b may not, without special permission, be taken simultaneously with any of the other courses in Mathematics. Courses prerequisite to 5a or 5b are Solid Geometry, and Trigonometry.

PHYSICS

11. **General Physics.** Required of Freshman Engineering Students. First term. Credit four hours. Prerequisite Mathematics 1 and 3 or the equivalent. Entrance physics is desirable but not required.

One lecture, two recitations and one laboratory period a week as assigned, covering the subjects of mechanics, wave motion, sound and light.

Rockefeller Hall. Assistant Professors GRANTHAM and COLLINS and instructors.

12. **General Physics.** Required of Freshman Engineering Students. Second term. Credit four hours. Prerequisite Mathematics 1 and 3 or the equivalent. It is recommended, though not required, that Physics 11 precede this course.

One lecture, two recitations and one laboratory period a week as assigned, covering the subjects of electricity and heat.

Rockefeller Hall. Assistant Professors GRANTHAM and COLLINS and instructors.

CHEMISTRY

101. **Introductory Inorganic Chemistry.** Lectures. Repeated in the second term. Credit three hours.

Two Sections: M W F 11; T Th S 11. *Main Lecture Room.* Professor BROWNE and Assistant Professor LAUBENGAYER.

Entrance credit in chemistry does not carry with it University credit in Course 101 or 105. If a student entering the University from a preparatory school desires credit for these Courses, he must pass an examination set by the Department of Chemistry. This examination is held in New York City and in Ithaca on the same day in September as the entrance examination. University credit in Courses 101 and 105 that is obtained by passing this examination does not carry with it entrance credit in Chemistry.

Examinations for those who were unavoidably absent from the final examination in Courses 101 and 105 will be held at 2 p. m. on the day before instruction begins in the fall.

105. **Introductory Inorganic Chemistry.** Recitations and laboratory practice. Repeated in the second term. Credit three hours.

Recitations, one hour a week, to be arranged.

Laboratory sections: M F 1:40–4; T Th 1:40–4; W 1:40–4; S 8–10:20; M W 8-10:20. Room 150. Professor BROWNE, Assistant Professor LAUBENGAYER, and assistants.

Chemistry 101 and 105 must be taken simultaneously unless permission is obtained by the student from the Dean of his college and from the Department of Chemistry to take either course alone.

DRAWING, LETTERING, SURVEYING, SHOPWORK, INTRODUCTORY LABORATORY AND INTRODUCTORY LECTURES

120. **Descriptive Geometry** (for M.E. and E.E. students). First term. Repeated in second term. Prerequisite to course 121. One recitation and 2 two and one-half hour drawing periods a week. Instruction and drill in the use of drawing room equipment, lettering and the following essentials of descriptive geometry: the description of points, lines, planes and solids; the description of in-space relations of points, lines, planes and solids, including intersections and tangents; the graphic computation of linear and angular measurements; the development of surfaces. Professor TOWNSEND and Instructors. *East Sibley.*

121. **Mechanical Working Drawing** (for M.E. and E.E. students). Second term. Make-up section first term. Prerequisite course 120. One recitation and 2 two and one-half hour drawing periods a week. This course includes: the purposes of working drawings; the principles of planning drawings to meet their purposes; execution of planning sketches, drawings, tracings, bills of material, drawing lists, etc. Professor TOWNSEND and Instructors. *East Sibley.*

200. **Drawing** (for C.E. students). First term. Credit three hours. Use of instruments, free-hand lettering, titles, geometrical problems, simple projections, conventional signs, tracing, and blue-printing. Professor PARSON and Mr. SPRY.

201. **Drawing** (for C.E. students). Second term. Credit three hours. Lettering—Roman, Gothic, and other styles of letters, with practice in forming the letters and combining them into appropriate titles; orthographic projection with sections; use of different scales, scale drawings, practical problems, using working drawings; plotting contours. Professor PARSON and Mr. SPRY.

110. **Elementary Surveying.** Freshmen. Either term as assigned. Credit three hours. Use of steel tape, level and transit; fundamental surveying methods; measurement of lines, angles, and differences of elevation; land surveying, areas and plotting. Recitations, field work, computations, and mapping. Text-book: Breed and Hosmer's *Elementary Surveying.* First Term, one recitation and two field or computation periods a week; Second Term, three recitations a week for the first six weeks and three field or computation periods a week for the remainder of the term. Professor UNDERWOOD, Assistant Professor LAWRENCE, and Messrs. PENDLETON, BOYLES, SPRY, and ROBERTS. *Lincoln Hall.*

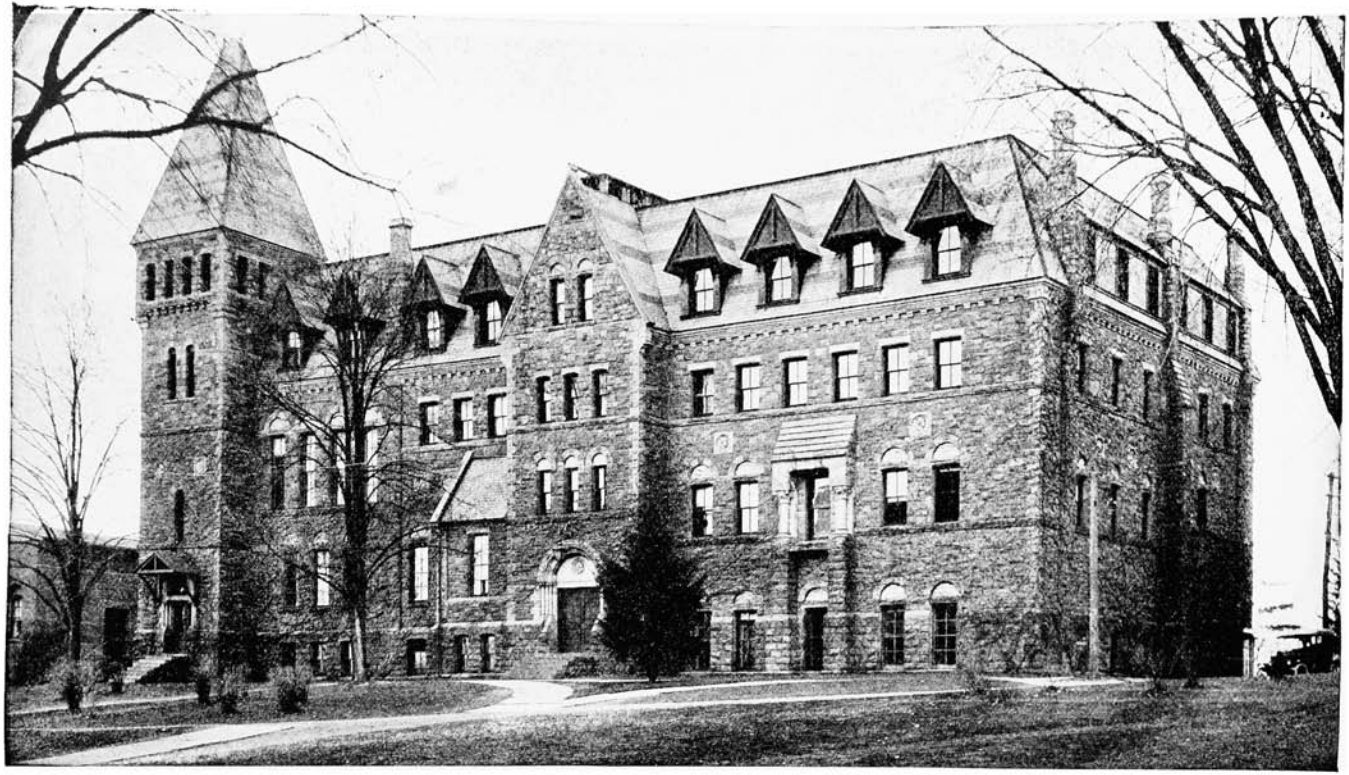
102. **Woodshop.** Freshmen. One hour either term as assigned. Wood working; the use of hand and machine tools for wood working followed by instruction in pattern making, construction of core boxes, etc.; demonstration of form turning. Messrs. HOOPER, BUSH, and YAWGER. *Rand Hall, Third floor.*

103. **Introductory Engineering Laboratory.** Freshmen. One hour either term as assigned. Elementary laboratory work and study of the various materials, processes and machines commonly used in engineering work. Demonstrations, followed usually by practice in forging, welding, hardening, and tempering, drop forging, soldering and brazing, oxy-acetylene cutting and welding, and electric welding. Also study of pipe and pipe fittings, soil pipe and fittings, threaded fastenings, bearings, instruments of measurement, steam engine, gasoline engine, electric motors and steam pump. Assistant Professor MORDOFF and Messrs. HODGES and HEAD.

130. **Introductory Lectures.** Freshmen. Credit one hour. One lecture a week throughout the first term. This course of lectures is designed to introduce the first-year men to the various fields of engineering, and to demonstrate to them some of the simpler and more general methods of engineering construction. It is the purpose of the lectures to awaken the interest of the freshmen in their chosen profession through the aid of vivid description, of stimulating biography, and of personal experience. *Lecture room to be assigned in the fall.*

RAND HALL

Containing the Machine Shop, the Pattern Shop, and an Electrical Laboratory



FRANKLIN HALL

The Main Building of the School of Electrical Engineering

The Senior Electrical Laboratory occupies the second floor of Rand Hall (see plate facing page 48)

SCHOOL OF CIVIL ENGINEERING

OUTLINE OF THE INSTRUCTION

The regular four-year course in Civil Engineering includes instruction in the fundamental subjects of Mathematics, Physics, Chemistry, Drawing and Surveying. This preparatory training is supplemented by required instruction in the allied subjects of Geology, English, Public Speaking, and Economics. In addition to these, instruction is provided in the fundamental principles of Heat-Power and Electrical Engineering, together with cultural additional courses to the extent indicated in the curriculum which may be elected by the student subject to the approval of his class adviser. The purpose of this arrangement is to provide a broad general foundation for the professional work of the civil engineer.

In addition to these subjects, all of which except Surveying are taught in departments or colleges outside of the School of Civil Engineering, the curriculum includes fundamental technical instruction within the School in Materials, Mechanics, Graphics, Hydraulics, Structural Design and Construction, Surveying, and applied or related subjects.

Further provision for elective study in certain technical subjects affords individual opportunity for specialization to as full an extent as experience has shown to be justified under the time limitation of the four-year course. As a result, without neglecting required general instruction in the important branches of Civil Engineering, each student may specially qualify in a branch of engineering to which his ability, interest, and probable future opportunity particularly direct him.

With the assistance of faculty advisers, by following a plan carefully prearranged, emphasis may accordingly be placed upon studies in any one of the following branches of Civil Engineering: Railroad, Highway, Hydraulic, Water Supply, Water Power, Structural, Concrete, Bridge, Municipal, Sanitary, Topographic, Testing or Experimental Engineering.

On the other hand, a general course including subjects from several branches of engineering may be taken. The experience of many of the graduates in Civil Engineering at Cornell University warrants the statement that such a course has proved to be an excellent preparation for work in the fields of business, finance, or engineering contracting.

COURSES LEADING TO THE DEGREE OF CIVIL ENGINEER

1. The Regular Four-Year Course

THE FRESHMAN YEAR

There is a single schedule of studies prescribed for all students alike, except as stated in Drawing, in the freshman year of the College of Engineering, whether they expect to graduate in civil, mechanical, or electrical engineering. That schedule is set forth in full under the head The Freshman Year, beginning on page 46.

THE SOPHOMORE YEAR

	Hours 1st Term	2nd Term
Public Speaking 1	3 or 0	0 or 3
Engineering Geology 501	0 or 3	3 or 0
Field Astronomy 182	0	2
Drawing 202	1	0
Drawing 203	0	1
Descriptive Geometry 205	2	0
Descriptive Geometry 206	0	2
Surveying 211	2	0
Surveying 212	0	2
Mechanics 220	6	0
Mechanics Laboratory 220A	1	0
Mechanics 221	0	4
Mechanics Laboratory 221A	0	1
Engineering Construction 264	3 or 0	0 or 3
Technical Reports 294	0 or 3	3 or 0
Total number of hours each term	18	18
Summer Survey 213 (four weeks in summer vacation)		4
Railroad Location 260A (one week in summer vacation)		1

In addition to these courses, sophomores are required to take Military Drill.

THE JUNIOR YEAR

Introduction to Economics 3	3 or 0	0 or 3
Materials 225	0 or 3	3 or 0
Materials Laboratory 226	0 or 3	3 or 0
Hydraulics 240	4	0
Municipal Sanitation 252	0	4
Railroad Surveying and Drawing 260B	3 or 0	0 or 3
Structural Design and Bridge Stresses 270	4	0
Structural Design 271	0	3
Concrete Construction 280	0 or 3	3 or 0
Foundations 281	3 or 0	0 or 3
Total number of hours each term	17	16

Students, desiring to specialize in a field requiring it, may, subject to the approval of their class adviser, defer certain courses of the junior year not fundamental or prerequisite to the senior work until the senior year in order to take elective or required courses of the senior year in the junior year. A student may not, however, anticipate the work of the curriculum by more than one year.

THE SENIOR YEAR

Heat Power Engineering 341	3 or 0	0 or 3
Essentials of Electrical Engineering 417	0 or 4	4 or 0
Engineering Problems 223	0 or 2	2 or 0
Water Supply 230	0 or 3	3 or 0
Highway Engineering 265	3 or 0	0 or 3
Engineering Law 290	3 or 0	0 or 3
Cost-Keeping and Management 293*	0 or 3	3 or 0
Elective**	9 or 6	6 or 9
Total number of hours each term	18	18

*Accounting 21a, given in the Arts College, or Accounting 502a, given in the Sibley School of Mechanical Engineering, may be substituted for this course.

**Of the elective hours, at least six must be taken in the School of Civil Engineering. The elective courses taken outside the School of Civil Engineering must be selected from among those not open to freshmen, unless the course selected has the special approval of the class adviser.

Not more than four hours credit in Advanced Military Science and Tactics will be accepted toward meeting the requirements for the C.E.. degree.

2. A Six-Year Course Leading to the Degrees of A.B. and C.E.

The requirements for admission to this course are those of the College of Arts and Sciences, in which the student is registered for the first four years. The student must complete the freshman engineering subjects before beginning his fourth year, and he must complete the sophomore subjects in Civil Engineering before beginning his fifth year. By attending two Summer Sessions, this combined course may be completed in five years. Advice and assistance in arranging the six-year course may be obtained by applying to the Director of the School of Civil Engineering.

LIST OF THE COURSES OF INSTRUCTION

The courses in the following list are designed for sophomores, juniors, and seniors. Those courses which are designed for freshmen are described under the head The Freshman Year, page 46. The following courses in Geology, Economics, and Public Speaking are given in the College of Arts and Sciences.

GEOLOGY

501. **Engineering Geology.** Required of Sophomores in Civil Engineering. Either term as assigned. Credit three hours. Registration by special permission. Lectures and laboratory work. The practical application of geologic principles and the occurrence of such economic materials as are of importance to engineering students, the whole subject being treated with reference to their needs. *McGraw Hall.* Professor Ries.

ECONOMICS

3. **Introduction to Economics.** Repeated in second term. Credit three hours. A survey of the existing economic order, its more salient and basic characteristics, and its operation. Assistant Professor O'Leary.

PUBLIC SPEAKING

1. **Public Speaking.** Either term. Credit three hours. *Goldwin Smith* 24. Designed to give the student the fundamentals of speech preparation and to help him acquire a simple, direct manner of speaking. Original speeches and interpretation of selections. Professor DRUMMOND.

MECHANICAL ENGINEERING

341. **Heat-Power Engineering.** Required of all seniors in Civil Engineering. For a description of this course see page 86 of this Announcement.

ELECTRICAL ENGINEERING

417. **Essentials of Electrical Engineering.** Either term. Required of all seniors in Civil Engineering. For description of this course see page 97 of this Announcement.

ASTRONOMY

180. **Introduction to Astronomy.** Elective. First term. Credit three hours. Lectures and recitations: Section (a) M W at 10; Section (b) M F at 10; Section (c) T Th at 10; Section (d) T S at 10. *Lincoln 31.* Laboratory: Section (l) M 2 to 4; Section (m) T 2 to 4; Section (n) Th 2 to 4; Section (o) F 2 to 4. *Observatory.* Also observations at the Observatory three assigned evenings before Thanksgiving. Professor BOOTHROYD and Mr. ROBERTS.

181. **The Solar System.** Elective. Second term. Credit three hours. Lectures and recitations: Section (a) M W F 10; Section (b) T Th S 10. *Lincoln 31.* Professor BOOTHROYD and Mr. ROBERTS.

Courses 180 and 181 together satisfy the requirements of Group 4 in the College of Arts and Sciences. Course 180 gives a general idea of the science of astronomy together with its history as illustrating the gradual development of the scientific method. Course 181 gives a more complete treatment of the solar system together with an understanding of current methods of research which are leading to the solution of the new problems being revealed continually by expanding knowledge.

182. **Elements of Field Astronomy.** Sophomores. Second term. Credit two hours. Prerequisite Surveying 110. Before Easter vacation two laboratory periods each week and after Easter vacation one computing period and one observing period each week.

The course is designed to acquaint the student with the principles underlying the practical applications of Astronomy in Surveying and Navigation and to train him in methods of making the observations and computations necessary in determining time, latitude, longitude, and azimuth with the sextant and the surveyor's transit. Professor BOOTHROYD and Mr. ROBERTS.

183. **Astrophysics and Stellar Astronomy.** Elective. First term. Credit three hours. Prerequisite courses, Astronomy 181 and Physics 3 and 4 and Mathematics 4b, or the equivalents. An elementary exposition of spectroscopic, photometric, radiometric, and other methods as applied to the varied problems which sun, planets, comets, stars, nebulae, and stellar systems present. Lectures, assigned readings, and discussions. Professor BOOTHROYD.

184. **Geodetic Astronomy.** Elective. First term. Credit three hours. Prerequisite courses, Mathematics 4b and Astronomy 180 or 182, or the equivalents. A study of precise methods of determining time, latitude, longitude, and azimuth, together with practice at the observatory in determining the instrumental constants and in making and reducing the observations. Chiefly laboratory practice with just enough theory to give a complete understanding of the procedure. Hours to be arranged. Professor BOOTHROYD.

DESCRIPTIVE GEOMETRY AND DRAWING

200 and 201. **Drawing.** Freshmen. Credit three hours each term. See page 48.

202. **Drawing.** Sophomores. First term. Credit one hour. Isometric drawing, line shading, topographic signs, including practice with the different standard topographic signs for mapping. Professor PARSON and Mr. SPRY.

203. **Drawing.** Sophomores. Second term. Credit one hour. Projections, and intersections, using practical problems, practice with water colors in the rendering of flat and curved surfaces, and in the use of crayon. Professor PARSON and Mr. SPRY.

204. **Advanced Drawing.** Elective. Juniors and seniors. Second term. Credit three hours. Perspective drawings, rendered in pencil, ink, and washes, of architectural buildings (exterior and interior), concrete bridges, dams, and other engineering works; building details of window frames, doors, cornices, molding, stairs, and other simple details, to give the student some insight into detailing parts of plans, and to familiarize him with reading working drawings; engineering drawings, rendered in crayon and color, to enable the student to supplement ordinary working drawings with artistic representations so portrayed as to be readily intelligible to non-technical committees, etc. Professor PARSON.

205. **Descriptive Geometry.** Sophomores. First term. Credit two hours. A study of the representation of lines, planes, surfaces, and solids, with practical applications. Two two-hour exercises each week. Assistant Professor POND.

206. **Descriptive Geometry.** Sophomores. Second term. Credit two hours. A continuation of Course 201. A study of surfaces and solids; tangencies, intersections, and developments; warped surfaces; perspective. When feasible practical problems are introduced throughout the course. Two two-hour exercises each week. Assistant Professor POND.

207. **Advanced Descriptive Geometry.** Elective. Juniors and seniors. Either term. Credit three hours. A continuation of courses 201 and 202. Problems in intersections, developments, warped surfaces, shade, shadows, and perspective. A considerable portion of the time is devoted to stereotomy, with practical problems in stone cutting and the making of accurate templet drawings. Assistant Professor POND.

SURVEYING

110. **Elementary Surveying.** Freshmen. Either term. Credit three hours. See page 48.

211. **Advanced Surveying.** Sophomores. First term. Credit two hours. Prerequisite course 110. City, topographic, and mine surveying; surveys of the United States Public Lands; precise measurements; subterranean surveys; city planning; earth volumes. Professor UNDERWOOD, Assistant Professor LAWRENCE, and Mr. BOYLES.

211-A. **Advanced Surveying.** For students in Forestry and Landscape Architecture. Second term. Credit three hours. Prerequisite course 110. Topographic, hydrographic, mine and geodetic surveying and field astronomy; United States Public Land Surveys; precise measurements; transit and stadia; plane table; sextant; stream measurement; topographic reconnaisance; road location; circular curves; triangulation for the control of local surveys; base lines; field determinations of time, latitude, and azimuth. Recitations and field work. Textbook: Breed and Hosmer's *Higher Surveying.* Professor UNDERWOOD and Assistant Professor LAWRENCE.

211-B. **Advanced Surveying.** For students in Landscape Architecture. Second term. Credit two hours. Prerequisite, course 110. Topographic surveying; stadia measurements; transit and stadia methods; plane table; triangulation; road location; circular curves; profile leveling; cross-sectioning; precise taping; photographic surveying. Recitations and field work. Textbooks: Breed and

Hosmer's *Elementary Surveying,* Vol. I, and *Higher Surveying,* Vol. II. Given in alternate years. (Will be given in 1932–33.) Assistant Professor LAWRENCE.

212. **Advanced Surveying.** Sophomores. Second term. Credit two hours. Prerequisite course 211. Topographic, hydrographic, and geodetic surveying; transit and stadia; plane table; sextant; soundings; triangulation; base lines; precise leveling. Recitations, and field and office work. Textbook: Breed and Hosmer's *Higher Surveying.* Professor UNDERWOOD, Assistant Professor LAWRENCE, and Mr. BOYLES.

213. **Summer Survey; Topographic, Hydrographic, and Geodetic Survey; Camp.** Sophomores. (Attendance for five weeks is required for 213 and 260-A, four weeks for 213 and one week for 260-A.) Credit four hours. Date of beginning to be announced in second term. Prerequisite course 212. Open also to students in Forestry and Landscape Architecture who have had Course 211-A, for whom the work is modified to meet their special needs. Practical experience in surveying under field conditions. An extensive topographic survey with the transit and stadia and the plane table, and a hydrographic survey of a portion of Cayuga Lake are executed, and field maps are made. Triangulation and precise leveling control the topographic and hydrographic work. A base line is measured with invar tapes. Solar observations for azimuth and time are made and results computed. Each student takes part in all branches of the work. Field and office work six days a week. Professors UNDERWOOD, BOOTHROYD, and CONWELL, Assistant Professors LAWRENCE, O'ROURKE, PERRY, THATCHER, and Mr. SPRY.

214. **Mapping.** Elective. Upperclassmen. Required of students in Forestry. First term. Credit two hours. The construction of a final topographic map of the area covered by the field work of Course 213 during the preceding summer. The field sheets are combined for this purpose, reduced in scale from 1:4800 to 1:12000, and reproduced, using the triangulation system as a base for the work. Lectures and drawing. Professor UNDERWOOD.

215. **Problems in the Adjustment of Observations.** Elective. Upperclassmen. Second term. Credit one hour. Prerequisite course 213. A series of examples in the adjustment of typical surveying work such as leveling, direct measurement of lines and angles, and simple triangulation figures, using the method of least squares. Lectures and problems. Textbook: Leland's *Notes on the Adjustment of Observations.* Professor UNDERWOOD.

216. **Least Squares; Adjustment of Observations.** Elective. Second term. Credit two hours. Prerequisites, Calculus and Physics. Lectures and recitations. The course is designed for students who have experimental investigations in view. Applications are made to problems in physics, astronomy, mechanics, hydraulics, surveying, etc., with some attention given to the derivation of empirical formulae. Two hours a week, as may be arranged. Professor UNDERWOOD.

217. **Advanced Topographic Surveying.** Elective. Upperclassmen. Second term. Credit two hours. Prerequisite course 213. Economics of surveying methods. Surveys for special purposes such as extensive construction work; storage and distribution of water for irrigation; earthwork on a large scale; lines of communication; topographic reconnaissance, etc.; photographic surveying. Lectures, recitations, and assigned readings. Two hours a week. Professor UNDERWOOD.

218. **Geodesy and Geodetic Laboratory.** Elective. Upperclassmen. First term. Credit three hours. Prerequisite courses 182 and 212. A course for the consideration of special problems in geodetic work. Precise leveling; deflection of the plumb line; figure of the earth; use and investigation of geodetic instruments and apparatus such as circles, levels, micrometer microscopes, standards of length, thermometers, pendulums, magnetic apparatus, etc. Subject to arrangement to meet the special needs of students. Lectures, reading, discussions, and laboratory work. Three periods a week. Professor BOOTHROYD.

219. **Photographic and Aerial Surveying.** Elective. Upperclassmen. Second term. Credit three hours. Prerequisite, Advanced Surveying, Course 212 or Course 211-A. The principles of photographic surveying; surveys with camera stations on the ground, including stereoscopic methods; aerial surveys and the making of maps from such surveys; ground control. Recitations, lectures, and collateral reading. Three hours a week. Professor UNDERWOOD.

MECHANICS OF ENGINEERING

220. **Mechanics of Engineering.** Sophomores. First term. Credit five hours. Repeated in one section, second term. Prerequisite course, Mathematics 5b. (See Course 220-A below.) Statics of a material point and of rigid bodies and structures by algebraic and by graphic methods of analysis; chains and cords; centers of gravity; moments of inertia; kinetics and dynamics of a material particle; centrifugal and centripetal forces; dynamics of collections of material particles forming rigid bodies; pendulums; friction, work, power, measurement of power; the general theorem of work and energy applied to collections of rigid members forming machines; impact, impulse and momentum. Five recitations a week. Emphasis is placed upon the theory as well as upon the use of consistent units and correct numerical work. Facility in the use of the slide rule is essential. Professors GEORGE and RETTGER and Assistant Professor HOWELL.

220-A. **Mechanics Laboratory.** Sophomores. First term. Credit two hours. One two and one-half hour period in the laboratory together with a write-up period of equal length outside. Courses 220 and 220-A are closely correlated and must be taken concurrently. This course consists of experiments (both qualitative and quantitative) designed to illustrate the principles of mechanics covered in Course 220. In general, the experiments are performed by the students themselves, and a complete, well-arranged report on each experiment is required of each student. Instruction in the use of the slide-rule and of the planimeter is included in the work. Professors GEORGE and RETTGER and Assistant Professor HOWELL.

221. **Mechanics of Engineering.** Sophomores. Second term. Credit four hours. Continuation of Mechanics 220. Prerequisite course, Mechanics 220. Mechanics of materials including stress and strain, tension, shearing, compression, torsion, flexure; elastic curves; safe loads; columns; flexure of beams by semigraphic treatment. Review problems showing application of principles in Engineering Design. Four recitations a week. Professors GEORGE and RETTGER, and Assistant Professor HOWELL.

221-A. **Mechanics Laboratory.** Credit one hour. One two-and-one-half hour period a week. Experiments designed to illustrate the principles of mechanics studied in Course 221. Courses 221 and 221-A are closely correlated and must be taken concurrently. Professors GEORGE and RETTGER, and Assistant Professor HOWELL.

222. **Advanced Mechanics.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite courses 220 and 221. Linear arches; curved beams; special cases of flexure; problems in the mathematical theory of elasticity; thick hollow cylinders and spheres; plates; Castigliano's theorem of least work; internal work and its derivatives. Recitations, three hours a week. Professors GEORGE and RETTGER, and Assistant Professor HOWELL.

223. **Engineering Problems.** Seniors. Either term. Credit two hours. Prerequisite courses 220, 221 and 240. The object of this course is to provide a review involving additional practice in using the principles and methods of applied mechanics. A series of problems, such as occur in ordinary engineering practice, and covering a wide range of topics, is given out for solution. Computations and reports. Five hours a week. Professors GEORGE and RETTGER, and Assistant Professor HOWELL.

MATERIALS OF CONSTRUCTION

225. **Materials of Construction.** Juniors. Either term. Credit three hours. Prerequisite course 221. The materials studied are: Lime, cement, stone, brick, sand, timber, ores, cast iron, wrought iron, steel, and some of the minor metals and alloys. The chemical and physical properties, uses, methods of manufacture, methods of testing, and unit stresses of each material are considered, particular emphasis being laid on the points of importance to engineers. Three recitations a week. Textbook: Mills's *Materials of Construction.* Professors SCOFIELD and Mr. VANDERLIP.

226. **Materials Laboratory.** Juniors. Either term. Credit three hours. Prerequisite course 221 and must be taken with or preceded by 280. Experimental determination of the properties of materials by mechanical tests. Study of testing machines (their theory, construction, and manipulation); calibration of testing machines and apparatus; commercial tests of iron and steel; tensile, compressive, torsional, shearing, and flexure tests of metal and various woods with stress-strain observations; tests of cement, concrete aggregate, concrete, plain and reinforced, and of road material and paving brick. The course is planned to supplement Course 225 with its study of the properties of materials by the actual handling of the materials and by observations of their behavior under stress. Laboratory work five hours a week. Professor SCOFIELD and Mr. VANDERLIP.

HYDRAULIC ENGINEERING

230. **Water Supply.** Seniors. Either term. Credit three hours. Prerequisite course 240. Three recitations a week from assigned texts and the working of assigned problems. About half of the term is devoted to the methods of making the preliminary investigations for a hydraulic development involving the use of a stream or the ground water; general hydrology; water resources of a basin; methods of systematic stream gaging; stream characteristics; working up data; use of mass curves in storage studies; percolating waters; probable dependable draft; flow into wells, etc. The second half of the term is devoted to a review of the methods of developing public water supplies from the several sources; typical structures; a study of the working conditions and fundamental data for designing conduits; distributing reservoirs; and a network of street mains; particular attention being given to the requirements for fire protection and the economics of pumped supplies. In the problems applications of the text are made to particular localities, the topographic maps of cities and drainage basins forming the bases of the problems. Students contemplating extensive election of courses in hydraulics should arrange to take this course the first term. Courses, 231, 232, and 233 are elaborations of details in this course. Professor SEERY.

231. **Hydraulic Construction.** Elective. Seniors and graduates. First term. Credit three hours. Repeated second term. Should be taken after, or concurrently with Water Supply 230. One recitation from assigned texts and two long computing periods a week for working problems. The course is devoted largely to a study of water storage and the engineering investigations and design of structures associated with stream regulation for the public water supplies, water power, irrigation, or navigation. Extensive problems are worked out involving the preliminary investigation of a project, exploration of dam sites, surveys of reservoir sites, the economics of storage, manipulation of storage and pondage, the preparation of an estimate of quantities, costs, plan of progress in construction, etc., for a particular project. The stability of weir dams by graphics, and the analytic design of high masonry dams by Wegmann's method, together with a study of all the factors affecting the stability and form of section of a dam, and the methods of construction are fully covered by text and in problems. Earthen dams and embankments, timber weirs, movable dams, and flashboards are also considered. Professor SEERY.

232. **Water-Power Engineering.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite course 240, and must be taken after or concurrently with Course 230. Recitations from assigned text and the working of lengthy problems. The course is devoted to a general study of the problems of water power development, the factors affecting the economics of a project, the engineering and commercial feasibility of developing power and the value of a mill site. A detailed study of the characteristics of modern turbine types, the selection of mechanical equipment suited to the conditions of installation and operation, the effects of load factors, pondage, storage and steam auxiliary on the capacity and costs; together with an analysis of the power capacity of a low-head mill site, the speed regulation of a plant under medium head fed by a long penstock, and a thorough study of the phenomena of unsteady flow and surging, with and without surge tanks, are covered by the text and incorporated into numerical problems taken from existing plants. Professor SEERY.

234. **Hydraulic Engineering.** Elective. Seniors and graduates. First term. Credit three hours. Lectures, recitations, and readings. This course is an elementary course dealing with the hydraulic, engineering, and economic problems relative to navigable waterways, river improvements, and harbor construction. Professor SEERY.

236. **Hydraulic Power and Pumping Stations.** Elective. Seniors and graduates. Second term. Credit three hours. A computing period three afternoons a week for the term, devoted to the solution of problems arising in the design of hydraulic power plants and pumping stations. Required to be taken simultaneously with or after Courses 230 and 232.

THEORETICAL AND EXPERIMENTAL HYDRAULICS

240. **Hydraulics.** Juniors. First term. Credit four hours. Prerequisite courses 220 and 221. Two recitations and two computing periods a week; some of the computing periods are utilized for experimental demonstrations. Hydrostatic pressure; manometers; strength of pipes; stability of dams; immersion and flotation; flow of liquids through orifices, nozzles, Venturi meters, and pipes, and over weirs; time required to empty tanks and reservoirs; simple, compound, branching and looping pipes; elementary power calculations in common pumping and fire protection problems; flow of water in open channels; pressure on stationary solids due to deviated flow. Elementary consideration of modern water wheels. Professors SCHODER and WALKER.

241. **Advanced Hydraulics.** Elective for juniors and seniors. Second term. Credit three hours. Prerequisite course 240. One recitation and two long periods a week. One period is devoted to problems and the other to laboratory work and preparation of reports. The recitations and problems take up topics in stability of flotation; overflow dams, free and submerged; backwater and variable flow in open channels; standing waves; water hammer and surges; flow of air in pipes; impulse wheels and turbines; centrifugal pumps; hydraulic rams; logarithmic plotting. The laboratory experiments include gage testing, orifices, nozzles, pipes, current meter rating, Pitot tubes, Venturi meters. Professor SCHODER.

242. **Hydraulic Measurements.** Elective for seniors and graduates. First term. Credit three hours. Prerequisite course 240. Three periods a week in laboratory or computing room. In addition to more thorough experimental investigations on some of the laboratory topics mentioned under Course 241 (e.g. weirs, Pitot tubes, pipes and current meters), the work includes fire hose and nozzles, ordinary water-meters, floats in open channels, actual measurement of river discharge (on a week-end trip) and such occasional tests as opportunity offers in the laboratory or the immediate neighborhood of Ithaca. Professor SCHODER.

243. **Experimental Hydraulic Motors and Pumps.** Elective for seniors and

graduates. Second term. Credit three hours. Prerequisite course 240. Three periods a week. The determination of efficiency, capacity, and characteristics of hydraulic machinery by tests. Professor SCHODER.

MUNICIPAL AND SANITARY ENGINEERING

250. **Sanitary Biology.** Elective. Juniors and seniors. Second term. Credit three hours. The course is designed to familiarize the student with current standard practice in the bacteriological control of water and sewage treatment plants. The use of the microscope; preparation of media; bacteriological analyses of water, sewage, sewage effluents and sewage sludge; efficiency of disinfectants; and that part of the science of bacteriology related to sanitary engineering. Textbook: Buchanan's *Household Bacteriology.* One recitation and two laboratory periods a week. Professor WALKER.

251. **Sanitary Biology.** Elective. Juniors and seniors. First term. Credit two hours. The collection and microscopical examination of the various forms of algae most prevalent in water supplies; the methods of their identification and control; and a study of the biological forms most prevalent in sewage wastes and sludges. Lectures, notes, and various references. One laboratory period a week. Professor WALKER.

252. **Municipal Sanitation.** Juniors. Second term. Credit four hours. Prerequisite course 240. Three recitations and one computing period a week. Sewer design and construction, and sewage disposal. Problems illustrating the matter taken up in the recitations such as problems on sewage flow, both domestic and storm water; hydraulic problems; construction problems dealing with various details of disposal plants. Textbook: Babbitt's *Sewerage and Sewage Disposal* Four sections. Professors OGDEN and WALKER.

253. **Purification and Control of Water Supplies.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite course 230. Examination of water (physical, chemical, and bacteriological); normal quality of surface and subterranean waters, with effects of storage; communicable diseases and water supplies; epidemics of typhoid fever and cholera with studies of etiology, etc.; purification of water, sedimentation, and coagulation; slow sand filtration (theory, construction and operation, with examples); rapid sand filtration (theory, construction, and operation, with examples); miscellaneous purification processes (aeration, softening, iron removal, sterilization, distillation, and purification by chemicals). Professors OGDEN and WALKER.

254. **Sewerage Works.** Elective. Seniors and graduates. First term. Credit three hours. Prerequisite course 252. Three hours a week for fifteen weeks, divided between lectures and recitations. The work is upon the construction and operation of sewers and sewage disposal works, illustrated by lantern slides and by reference to recent descriptions of sewage-disposal plants in the current literature. There are, generally speaking, three recitations or one week's work on each of the following topics: disposal by dilution (salt and fresh water); chemical precipitation; broad irrigation, with special reference to institutions; natural and artificial filtration beds; sedimentation and septic tanks; Imhoff tanks; contact beds; sprinkling filters; and activated sludge. It is intended to differentiate this course from the junior work by making the latter chiefly a discussion of principles involved, while the senior course is a detailed investigation of the methods of construction with the reasons involved. Textbook: Metcalf and Eddy's *Sewage Disposal.* Professor OGDEN.

255. **Treatment of Wastes.** Elective. Seniors and graduates. First term. Credit three hours. Prerequisite course 252. The treatment of municipal and industrial wastes such as from garbage plants, tanneries, slaughter-houses, mines, canning factories, sugar factories, dye plants, pulp mills, creameries, cheese factories, milk bottling stations, and condensaries is considered.

Flow or process charts for each industry are used to show the general character, and composition of the wastes; and methods of treatment applicable, including results of experimental work, are considered. Professor WALKER.

256. **Municipal Engineering.** Elective. Seniors and graduates. First term. Credit three hours. A study of the relationships that exist between the practising municipal engineer and the various state and city commissions and other organizations with which he comes in contact. Financing of municipal operations including bond issues and sinking funds; special assessments; the limitations and restrictions placed by State Departments on municipal enterprises; town planning and public utilities; municipal housekeeping. Lectures, reports, and readings. Professor OGDEN.

257. **Purification of Water.** Elective. Graduates. Credit three hours. Specific problems in water purification; control of watersheds; effect of sedimentation on waters of different compositions; treatment of waters for particular requirements, such as removal of hardness, sediment, bacteria, etc. A report on some existing water system will be required from each student. Professor OGDEN.

258. **Conference on Present Methods of Sewage Disposal.** Elective. Graduates. Credit three hours. A critical study of the construction and operation of plants now in existence. Inspections and reports. Professor OGDEN.

259. **A Laboratory Course for Graduates.** Devoted to some special problem of sewage or water, such as the operation of a water-filtration plant, a sewage-disposal plant, the purification of trade wastes, the value of disinfection, etc. Professors OGDEN and WALKER.

RAILROAD AND HIGHWAY ENGINEERING

RAILROAD ENGINEERING

260-A. **Railroad Location.** Juniors. See Course 213. One week during summer vacation, opening date to be announced. Credit one hour. Each section is required to make complete preliminary and location surveys for a line two or three miles long. In this work the section is divided into level, transit, topography, and cross-section parties, as the different phases of the work are encountered. Finally structure and right of way surveys are made. The assignments of the men are changed every day so that each student receives practice in the various kinds of field work. Professors BARNES and CONWELL, Assistant Professors PERRY and THATCHER.

260-B. **Railroad Surveying and Drawing.** Juniors. Either term. Credit three hours. One recitation and two field or drawing periods a week. Prerequisite courses 213 and 260-A. The recitations cover the theory of simple, transition, and vertical curves, and earthwork computation; with applications to practical problems for purposes of illustration. The field periods take up about two-thirds of the term and are devoted to computing, laying out and checking simple, transition, and vertical curves. The section is divided into parties of three so that each student obtains more individual instruction, more practice in handling instruments, and a more intimate knowledge of the problems than he would in larger parties. The drawing periods take up the remaining third of the term and in them each student makes a pencil map of the preliminary line surveyed by his section in 260-A and prepares a detailed "paper location" report based on these data. A tracing and profile of the final location as run in the field is then required, also a computation of part of the earthwork as determined by the cross sections. Professors BARNES and CONWELL, Assistant Professors PERRY, CRANDALL, and THATCHER.

261. **Railroad Maintenance of Way.** Elective. Seniors and graduates. First term. Credit three hours. Prerequisite course 260. The subjects treated are track materials (with special reference to the section, method of manufacture

and composition of steel rails, to the economics of tie preservation and the use of metal ties, and to the effect of quality of ballast upon maintenance); machine and other methods of grading for second track; drainage; track laying both by machine and hand methods; ballasting and bringing new track to line and grade; turnouts and switches; derailing switches; side tracks and yard tracks; sorting and terminal yards; track maintenance; track tools, work trains; action of car wheels on curves; widening of gage; double tracking; separation of grades; and improvement in grades and alinement. Lectures and recitations three hours a week. Professor BARNES and Assistant Professor PERRY.

262. **Railroad Operation and Management.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite course 260. Under organization the following subjects are treated: general principles underlying organization and the effect of each on efficiency; principal departments of railway service with a brief outline of the work of each; departmental and divisional systems of organization, with examples on various roads and discussion of adaptability of each. The duties of officers and the work of the different departments are taken up in considerable detail. The most important laws affecting railroads are given in discussing the work of the legal department. Freight traffic, freight houses, classification yards, car service rules, accounting, etc., are among the topics considered under operation. Signaling and interlocking and train rules are also considered. Lectures and recitations three hours a week. Professor BARNES and Assistant Professor PERRY.

263. **Railroad Location.** Elective. Seniors and graduates. Second term. Credit three hours. A detailed study is made of the economic principles governing the location of new railroads, both steam and electric, and the revision or relocation of existing lines to make them most efficient as transportation machines. Some of the topics treated are estimation of revenue, expenses and rates and steam and electric locomotive performance and train operation; gradients, distance and curvature; line and grade revisions; grade crossing elimination and additional facilities; location surveys and estimates. Lectures and recitations with problems involving investigations of projects, revisions and comparisons of alternate locations. Three hours a week. Professor BARNES.

264. **Engineering Construction.** Sophomores. Either term. Credit three hours. A course in the fundamentals of construction with special reference to field methods, equipment and tools, plant layouts, and costs. The course includes estimates and analyses of costs with reference to planning, preparatory and construction periods; earth and rock excavation; haulage; tunneling; foundations; masonry; trestles; falsework, etc. The foregoing are applied to the various types of engineering construction to which they are best adapted. Frequent problems are given to bring out these applications and lantern slides are used to illustrate current practice. Attention is also given to the economic selection of structures, etc. Lectures, recitations, and problems, three hours a week. Professors BARNES and CONWELL, Assistant Professors PERRY, CRANDALL, and THATCHER.

HIGHWAY ENGINEERING

265. **Highway Engineering.** Seniors and graduates. Either term. Credit three hours. Prerequisite courses 260-A and 260-B. The course consists of recitations and lectures on highway economics, economics of location, subgrade soils, drainage, selection of type of surface, and the methods of construction and maintenance of earth, sand-clay and top-soil roads, gravel, waterbound macadam and new types of low cost roads; character of non-bituminous and bituminous highway materials; surface treatments, construction and maintenance of bituminous macadam, bituminous concrete, sheet asphalt, Portland cement concrete, brick, wood-block, stone-block pavements, etc. In addition to the class work there is assigned a highway design problem requiring about sixty hours of work. Professor CONWELL and Assistant Professor THATCHER.

266. **Highway Laboratory.** Elective. Seniors and graduate students. Either term. Credit three hours. Prerequisite course 265, or may be taken concurrently with Course 265. This course includes tests for the liquid limit, plastic limit, centrifuge moisture equivalent, etc., to examine the properties of subgrade soils; the standard tests of asphalts and tars used for highway construction and maintenance; sampling aggregates and examination of their suitability for non-bituminous and bituminous highways; and trial mixtures and stability tests of sheet asphalt pavements. Professor CONWELL and Assistant Professor THATCHER.

267. **Advanced Highway Engineering.** Elective. Seniors and graduate students. Second term. Credit three hours. Prerequisite Course 265. This course is conducted as a seminar. Meetings are held once each week during an afternoon or evening. The topics for assignment and discussion include the economics of highway engineering, design, construction, and maintenance of highways, the latest research programs and reports, labor and plant organization for various kinds of highway contracts with especial emphasis on the economics of contracting, highway finance, legislation, regulation, etc. Professor CONWELL.

268. **Advanced Highway Laboratory.** Elective. Seniors and graduate students. Either term. Credit three hours. Prerequisite Courses 265 and 266. Testing of non-bituminous and bituminous highway materials and a study of their characteristics; testing of aggregates, soils, bituminous concrete, sheet asphalt, and asphalt paving block mixtures; study of specifications Special investigations and tests are made to determine the properties of various combinations of materials and the effects of modifications in design. Two laboratory periods a week. Professor CONWELL and Assistant Professor THATCHER.

STRUCTURAL ENGINEERING

270. **Structural Design and Bridge Stresses.** Juniors. Either term. Credit four hours. Prerequisite courses 220 and 221.

Structural Design. The recitations cover the graphic analysis of simple beams and roof trusses. The computations and drawings include complete detail designs and working drawings of wooden joints to resist large tensile stresses, and of a wooden roof truss for given specifications. The object of the course is to show how to apply the principles of mechanics to the design of every detail of the simple structures named, and to study the forms and strength of joints and fastenings used in heavy timber framing. The computations required are to be arranged in systematic order in the form of reports. Textbook: Jacoby and Davis's *Timber Design and Construction.* Computation and drawing, two and one-half hours a week.

Bridge Stresses. Stresses due to dead, live and wind loads, initial tension, and impact; panel loads and locomotive axle loads; determination of the position of live loading for greatest stresses; maximum and minimum stresses; analytic and graphic methods are used. The principal types of simple trusses employed in modern construction are considered, in several cases both with and without counterbalancing; historical notes on truss bridges. The solution of many numerical examples taken from practice forms a prominent part of the class work. Three recitations a week. Professor URQUHART, Assistant Professors BURROWS and O'ROURKE and Messrs. CHAWNER and PFISTERER.

271. **Structural Design.** Juniors. Either term. Credit three hours. Prerequisite course 270. An elementary course in Steel Design. Complete design, detail drawing, bill of material and estimate of weight of a steel roof truss and of a through and deck railroad plate girder bridge. Textbook: Urquhart and O'Rourke's *Design of Steel Structures.* Three computation and drawing periods a week. Professor URQUHART, Assistant Professors BURROWS and O'ROURKE, and Messrs. CHAWNER and PFISTERER.

272. **Higher Structures.** Elective. Seniors and graduates. Either term. Credit three hours. Prerequisite courses 220, 221 and 270. Determination of the loading and stresses in continuous girders and trusses, and metallic arches.

The arches include arch ribs and trussed arches with three and two hinges respectively. Both analytic and graphic methods are used; the latter include displacement diagrams to find the deflection of trusses and the reactions of statically indeterminate structures, and the use of influence lines to find their loading and stresses. Recitations three hours a week. Professor URQUHART and Assistant Professor O'ROURKE.

273. **Steel Buildings.** Elective. Seniors and graduates. First term. Credit three hours. Prerequisite courses 220, 221, and 271. This course comprises the design of the steel framework for buildings of the prevailing type used in power house or shop construction. Dead, snow, and wind stress diagrams are drawn for the roof trusses. Provision is made for an electric crane moving the full length of the building and the stresses in the framework due to the movement of the crane are determined. The effect of the wind and the eccentric load due to the crane girder are considered in the design of the columns. Textbook: Ketchum's *Steel Mill Buildings*. Reports and drawings. Three two-hour periods a week. Assistant Professor BURROWS.

274. **Bridge Design.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite course 271. Computations and drawings for the complete design of a railroad bridge of six or seven panels or a heavy highway bridge. The computations to determine the stresses and sections of all members, pins, pinplates, splices, and other details as well as of connecting rivets are to be written up in the form of systematically arranged reports. The drawings consist of general detail plans showing the location of all rivets as well as the composition and relation of all members and connections. The final report is to give a full list of shapes and plates, and a classified analysis of weight for the span. Textbook: Urquhart and O'Rourke's *Design of Steel Structures*. Computation and drawing, three two-hour periods a week. Assistant Professor BURROWS.

275. **Investigation of Existing Bridges.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite course 271. Inspection of existing structures for the determination of sizes and conditions of plates and shapes. After full data have been obtained in the field, computations will be made to determine either the unit stresses under a specified load, or the safe load according to standard specifications. Assistant Professor BURROWS.

280. **Concrete Construction.** Juniors. Either term. Credit three hours. Prerequisite courses 220, 221, and 225. Concrete materials, properties of plain concrete, its making and deposition; elementary theory of reinforced concrete as applied to columns, rectangular beams and slabs; T-beams and beams reinforced for compression; direct stress combined with flexure. Three two-hour periods a week. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures*. Professor URQUHART, Assistant Professor O'ROURKE, and Messrs. CHAWNER and PFISTERER.

281. **Foundations.** Juniors. Either term. Credit three hours. Prerequisite courses 220 and 221. Piles and pile driving, including timber, concrete, tubular and sheet piles; cofferdams; box and open caissons; pneumatic caissons for bridges and buildings, caisson sinking, and physiological effects of compressed air; pier foundations in open wells; freezing process; hydraulic caissons; ordinary bridge piers; cylinders and pivot-piers; bridge abutments; spread footings for building foundations; underpinning buildings; subterranean explorations; unit loads. Textbook: Jacoby and Davis's *Foundations of Bridges and Buildings*. Recitations, collateral reading in engineering periodicals, and illustrated reports. Three hours a week. Professor URQUHART and Assistant Professor O'ROURKE.

282. **Reinforced Concrete Building Design.** Elective. Seniors and graduates. Either term. Credit three hours. Prerequisite course 280. Design of a reinforced concrete flat-slab building and investigation of various other types of floor systems for commercial buildings. Complete detail design for one building, including stairway, elevator shafts, penthouses, etc. Working drawings and steel schedules. Seven and one-half hours a week. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures*. Professor URQUHART and Assistant Professor O'ROURKE.

283. **Reinforced Concrete Arch.** Elective. Seniors and graduates. First term. Credit three hours. Prerequisite course 280. The design of an arch of reinforced concrete and its abutments; investigation of the arch ring in accordance with the elastic theory (the live loading for maximum unit-stresses in the arch ring, as well as the direction and magnitude of abutment thrusts, being determined by the influence-line method). Computation and drawing. Seven and one-half hours a week. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures*. Mr. CHAWNER.

284. **Highway Bridges.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite course 280. Design of short span bridges and their abutments. Comparison of the economy of steel and reinforced concrete superstructures for bridges of this type. Reports and drawing. Mr. CHAWNER.

285. **Reinforced Concrete Design.** Elective. Seniors and graduates. Either term. Credit three hours. Prerequisite course 280. Theory and design of gravity, cantilever, and counterfort retaining walls. Design of footings: single and multiple columns of reinforced concrete, I-beam grillages. Design of bins and tanks, subsurface and supported on towers. Reports and sketches. Three two-hour periods a week. Professor URQUHART and Assistant Professor O'ROURKE.

SPECIFICATIONS, DESIGNS, ETC.

286. **Building Construction.** Elective. Seniors and graduates. First term. Credit three hours. Lectures and quizzes. The general plan includes one lecture each week by a practicing engineer or architect well known in his particular field. This is followed by a supplementary lecture by a member of the University staff.

In 1931–32, the field covered included: The Field of the Consulting Engineer; Legislation and Licensing; Building Codes; Testing Laboratories and Inspection; Foundations; Concrete; Reinforced Concrete; Steel Frame Buildings; Steel Erection; Welding; Exterior Finish; Interior Finish; The Conception and Execution of a Building Project; Synchronizing Operations. Professor URQUHART.

The non-resident lecturers in 1931–32 were:

T. H. MCKAIG, Consulting Engineer, Buffalo, N. Y.
A. L. BROCKWAY, Architect, Syracuse, N. Y.
RUDOLPH MILLER, Consulting Engineer, New York City.
A. R. ELLIS, Pittsburgh Testing Laboratories, Pittsburgh, Pa.
LINTON HART, The Gow Company, New York City.
R. B. YOUNG, Hydro-Electric Power Commission of Ontario, Toronto.
M. J. ROACH, Turner Construction Company, New York City.
H. G. BALCOM, Consulting Engineer, New York City.
G. E. J. PISTOR, McClintic-Marshall Corporation, New York City.
F. A. MCKIBBEN, General Electric Company, Schenectady, N. Y.
STANLEY W. HAHN, Architect, Chicago, Ill.
T. L. COLLUM, Contractor, Syracuse, N. Y.
F. L. ACKERMAN, Architect, New York City.
JOHN PARKE, Marc Eidlitz and Son, New York City.

290. **Engineering Law.** Seniors. Juniors admitted only by special permission of the faculty. Also open to seniors in Architecture, Mechanical and Electrical Engineering, Chemistry, and other seniors submitting acceptable qualifications. Either term. Credit three hours. Basic essentials of contracts and contract principles; agency, tort and independent contractor; laws regulating acquisition, use and conveyance of lands and waters, including irrigation law, real estate documents, boundary lines, wills, eminent domain and title searches; corporations, partnerships and other contracts of association; sales and transportation contracts; negotiable instruments; bankruptcy, mechanics liens, patents, trademarks, copyrights, courts, and laws of insurance. The course culminates with the preparation of a set of contract documents for an assigned construction job, including advertisement, surety bond, form of proposal, information to bidders, agreement form, general conditions and specifications with full discussion of im-

portant clauses such as payments, time limit, arbitration, extras, liquidated damages and abandonment of contract. Tucker's "Contracts in Engineering" is used as a text, supplemented liberally from other sources. Lectures and recitations three hours a week. Professor BARNES, Assistant Professors CRANDALL, PERRY, and THATCHER.

291. **Engineering Design.** Elective. Seniors. Credit three or more hours. The student may make complete designs in one of the following sub-divisions, subject to approval. Hours to be arranged.

(a) **General Civil Engineering.** Either term. Problems in practical design may be taken in any department, the work to be supervised by the department concerned in cooperation with the Department of Structural Engineering in regard to structural features.

(c) **Hydraulic Engineering.** Second term. Prerequisite courses 240 and 223. For best results Hydraulic Design should be preceded by Course 230, but the two may be taken concurrently. Courses 231 or 232 may be substituted for Engineering Design. One or both of these courses should be elected by the student specializing in hydraulics unless he has a good reason for electing independent design instead. The purpose of the course is not to duplicate in large part work regularly given in Courses 231, 232, and 241 or in the courses in structural engineering. Professor SCHODER.

(d) **Sanitary Engineering.** First term. This course must be preceded by or taken at the same time as Course 254, and may not be elected otherwise. The following problems indicate the scope of the work: (1) Computations, design, and detail drawings for the wooden forms needed for brick or concrete sewers of various diameters and forms of cross sections. (2) Computations, design, and detail drawings for a pile foundation to support sewers from three to ten feet in diameter. (3) Design and detail drawing for patterns of cast-iron manhole covers. (4) Computations, designs, and detail drawings for flap valve as outlet of settling tank, the design involving a lifting device. (5) Design and detail drawings of a sewage screen, involving a device for raising screen for cleaning. (6) Computations, designs, and a detail drawing for an inverted siphon for sewage flow; the problem involves a flushing gate and overflow as well as manholes. (7) Design of disposal plant for a small community as an asylum or school. Professor OGDEN.

(e) **Railroad Engineering.** Either term. The problems are those encountered in the location and construction of railroads, and include the following subjects: Economic location of railroads; culverts; bridges; retaining walls; tunnel and subway design; small depot buildings; freight houses; water supply and coaling plants; icing stations; turntables and engine-houses; gravel washing plants; track layouts with details of signals and interlocking; yard and terminal design, etc. Bills of material and estimates of cost are usually required. The field is so broad that the interest of the student is given consideration in assigning problems. Professor BARNES and Assistant Professor PERRY.

(f) **Bridge Engineering.** Second term. Course 271 is required as general preparation for engineering design in bridges and buildings. Course 272 is required in preparation for designs relating to draw, cantilever, suspension, and metallic arch bridges. Course 280 is similarly required for designs of bridges and buildings in reinforced concrete. Professor URQUHART and Assistant Professor BURROWS.

(g) **Highway Engineering.** Second term. The problems are those encountered in the location and construction of highways and include the following: Economic location; selection and design of different types of highway surfaces for various traffic conditions; culverts, bridges, retaining walls, and other highway structures. Bills of materials and estimates of cost are usually required, also plant layouts and methods of executing work. Professor CONWELL and Assistant Professor THATCHER.

292. **City and Regional Planning.** Elective. Open to selected seniors and graduates in Civil Engineering, Architecture and Landscape Architecture. Second term. Credit three hours. Lectures, recitations and reports. The lectures are given by several members of the faculty of Civil Engineering, Architecture and Landscape Architecture, supplemented by a number of prominent non-resident lecturers. Emphasis is laid on the necessity of coordination of the work of the

civil engineer, architect, landscape architect, and others in order to secure a proper solution of the economic and aesthetic phases of regional planning. Topics covered include explanation of the field of city and regional planning, history and progress of planning, legal phases, base maps, the broad planning phases of highways, parkways, bridges, water supply, water power, sanitation, parks, zoning, excess condemnation, airports, railroad and navigation facilities, public buildings, forestry, gas, electric and telephone utilities, preparation of planning reports; publicity and future administration of the plan are also treated. Assistant Professor CRANDALL and special lecturers.

293. **Costkeeping and Management.** Seniors. Either term. Credit three hours. Also open to properly qualified seniors from other university departments. The material covered in the course falls into three general divisions, namely: General Policies of Management, Cost Keeping, Bookkeeping and Financial Reports. Topics included under the first division are personal attitude of the manager, selection and training of employees, specialization of duties, organization charts, coordination, motion studies, pay periods, pay incentives, vacation systems, periodic reports, research, standardization, labor turnover, accident prevention, trade unions, purchasing, welfare work, machines and plant, forecasting, etc. The Costkeeping division covers the fundamental methods used on such work, amply illustrated by forms and systems from actual practice. Many of the examples are from civil engineering construction jobs, although illustrations are given of the wider application of the principles involved. Students are required to prepare actual cost forms, codes, and systems for assigned situations. The division devoted to Bookkeeping and Financial Reports covers the fundamentals of double entry bookkeeping, mercantile systems of account and corporation financial reports, the student being required to work problems and prepare balance sheets. Professor BARNES and Assistant Professor CRANDALL.

294. **Technical Writing.** Credit three hours. This course is intended to aid the student in finding the application of his high school training in English to writing technical reports. One lecture, one recitation, and one exercise for the discussion of written work each week. Textbook: Park's *English Applied in Technical Writing* and Greever and Jones's *Century Collegiate Handbook*. Mr. BOYLES.

295. **Valuation Engineering.** Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite courses 264 and 290 or taken concurrently with 290. Lectures, recitations and reports. Theory and practice of valuation or appraisal for purposes of utility rate making, purchase or sale, eminent domain or condemnation cases, mergers or joint ownership, taxation and assessment, issuance of securities, bank loans, insurance, uniform system of accounting and improved management. Topics considered include scientific systems of real estate assessment, federal railroad valuation, rate disputes, court rulings, computation of actual rates for gas, telephone, electrical supply and street railways, valuation of land, mines, water power, factories, railroads, toll bridges, buildings, and all kinds of property both tangible and intangible. Detailed examples of forms and methods with outline of typical valuation reports. Assistant Professor CRANDALL.

296. **Earthwork Computations.** A special course for students in landscape architecture. Not open to students in civil engineering. See Announcement of the College of Architecture. Assistant Professor LAWRENCE.

297. **Engineering Research.** Elective. Seniors and graduates. Credit three or more hours. Research may be taken in one of the following subdivisions or two or more departments may cooperate in the assignment of special problems. Hours to be arranged.

(a) **Geodetic Astronomy.** Second term. Prerequisite courses 184 and 216. Investigations of instrumental errors; variation of latitude and azimuth; any and all questions relating to work of the highest precision connected with astronomical problems and geodetic operations. The field is so broad that the interest of the student is given consideration as to the actual research undertaken. Professor BOOTHROYD.

(b) **Engineering Materials.** Either or both terms. Credit one hour for forty hours of actual work. A project may be started during the junior year for completion in the senior year. Prerequisite courses 225 and 226 or their equivalents. Special investigations of an advanced nature of the properties of structural units and the materials of construction. The aim of the course is to secure results by proper investigational methods which are of the caliber and scope deemed essential for publication. Professor SCOFIELD.

(c) **Experimental Hydraulics.** Either term. Prerequisite course 240 or its equivalent. The subject and scope of the investigations should be selected by conference at the beginning of the term if not previously arranged. It is often desirable and is permissible for two students to work together on the same investigation. Written reports are required but the text need not be typewritten in thesis style. These reports are kept by the department. In most cases it is necessary to arrange a definite schedule for work in the laboratory to avoid conflicts. Professor SCHODER.

(d) **Sanitary Engineering.** Either term. Prerequisites for work in this field will depend upon the particular problem to be pursued, but in general will include work in water analysis, bacteriology, and courses in Hydraulics and Sanitary Engineering dealing with the field in which the work is to be undertaken. Hours, credit for work, prerequisites and other questions relating to contemplated research in this field will be arranged by conference. Professors OGDEN and WALKER.

(e) **Railroad Engineering.** Either term. Special problems in the economics of location, construction, maintenance and operation of railroads, comparison of transportation agencies, traffic studies and economics of various systems of transport. Professor BARNES.

(f) **Bridge Engineering.** Second term. Students wishing to pursue one particular branch of bridge engineering further than can be done in any of the regular courses may elect work in this field. The prerequisite courses depend upon the nature of the work desired. The work may be in the nature of an investigation of existing types of construction or theoretical work with a view to simplifying present methods of design or proposing new methods. Professor URQUHART.

(g) **Highway Engineering.** Either term. The laboratory for testing and investigating bituminous materials is available for research, and other materials may be tested in the laboratories in Lincoln Hall. Special problems in location and design and in economic selection of types of surfaces give opportunity for a wide variety of research. Professor CONWELL.

SPECIAL AND GRADUATE COURSES

All the elective courses are suitable for graduate and advanced students, and may be taken by them in the regular classes. Other special courses will be arranged to suit the requirements of graduate students. These courses are intended to be pursued under the immediate direction of the professor in charge, the student usually being free from the restriction of the classroom, and working either independently or in conjunction with others taking the same course.

SIBLEY SCHOOL OF MECHANICAL ENGINEERING

OUTLINE OF THE INSTRUCTION

The instruction in Mathematics, Chemistry, Physics, English, and Economics is given in the College of Arts and Sciences. All other regular subjects in the course are of an engineering nature and are given in the Sibley School of Mechanical Engineering in the following departments: (1) Mechanic Arts; (2) Machine Design; (3) Mechanics of Engineering; (4) Power Engineering; (5) Experimental Engineering; (6) Industrial Engineering; (7) Administrative Engineering; or in the School of Electrical Engineering.

The following is a brief outline of the scope and purposes of instruction in the various departments of the School of Mechanical Engineering.

1. Mechanic Arts

The object of the instruction in this department is not only to familiarize the student with modern shop operations and processes, and with the workability of materials used in engineering construction but more particularly to give him instruction in the principles of manufacturing and duplication of parts, and in the selection and arrangement of shop equipment.

The work of the freshman year in the shops is given in a laboratory course and in the wood shop. The laboratory course is designed to familiarize the student with current engineering terms and common engineering appliances. This course also includes some work in the forge shop illustrating the principal forge shop operations, like welding, hot working, etc.

Instruction in wood-working is given with the object not only of familiarizing the student with wood-working tools and machines and their use, but more especially to teach him pattern and core-box making. Instruction is also given in large pattern work and sweep-work.

In the sophomore year the student receives instruction in the foundry in molding, core making, mixing of metals, operation of cupola, the uses of moulding machines, etc., with consideration given to the methods and appliances for sweep-work, large work, and production in quantities.

In the junior year the principles of manufacturing are taught, supplemented by work of an illustrative character in the machine shop, where carefully graded instruction is given in the use of measuring instruments, hand tools, and machine tools, including semi-automatic and automatic machines, and in the use of jigs and special fixtures for manufacturing in large quantities. The administration of this shop in particular is intended to illustrate as far as possible approved methods of shop management and operation, and to give

the student a general idea of time keeping, piece work, premium plan, and other wage systems. The instruction is given to a great extent in connection with the construction of commercial machines.

2. Machine Design

In this department, instruction is given in empirical design, kinematics, and machine design, to sophomores and juniors in mechanical and electrical engineering. The department also offers elective courses open to sophomores, juniors, seniors, and graduates and a senior group of studies in general engineering design.

Instruction is given by means of recitations and work over the drawing board. First, a study is made of the common machine parts and their uses and the empirical proportioning and assembling of such parts. The study of kinematics is then taken up and applied to the solution of cam, gear, linkage, instant center, velocity, and acceleration problems. These courses are followed by recitations and drawing room courses in general machine design. The theory and principles developed are applied to the solution of many short problems and to the design of complete machines in the drawing room. Only such machines as lend themselves to rational analysis to the greatest degree are selected. The calculations are regarded as an important part of the work and the student's design is criticized from the standpoint of appearance, cost, convenience and economy of shop operations, lubrication, accessibility, ease of assembly, economy of upkeep, etc.

The general engineering option offered by the department is intended to meet the requirements of seniors in mechanical engineering who do not wish to devote the year to specialized design work. A fundamental grounding in structural work, foundations, reinforced concrete, etc., is given.

3. Mechanics of Engineering

In this department instruction is given in theoretical and applied mechanics and hydraulics, beginning with a course for sophomores in the fundamental principles of statics, kinetics, and the strength of materials. An effort is made to teach students to think rather than to memorize. With this in view the free-body method is used in the solution of problems involving forces, and students are required to work from fundamental definitions and principles rather than from formulas.

For juniors a course in hydraulics is given. A broad knowledge of the fundamental principles is deemed of more value than familiarity with special formulas or numerical coefficients. For seniors elective courses on hydraulic power plants are offered. While the theory of turbines is outlined, stress is laid upon the practical side of the subject, the object being to make the course of definite value for those expecting to take up hydro-electric work. The laboratory instruction in hydraulics is given in the Department of Experimental Engineering.

4. Heat-Power Engineering

Instruction in this department is given to all students of Mechanical Engineering in their junior and senior years, with the object of training them in the methods of solution of problems involved in the theory, design, performance, and economics of heat engines and their auxiliary apparatus, considered both separately and in combination in power plants.

The work begins with lectures and recitations on the elements of Heat-Power Engineering, including the study of the elementary thermo-dynamics of gases and vapors, ideal and actual cycles, air compressors, internal combustion engines, and steam engines. This is followed by a study of steam turbines, fuels and combustion, furnaces, steam generating units, draft apparatus, heat transmission, condensers, feed-water heaters and other power-plant auxiliaries, the flow of gases and vapors, the utilization of waste heat, refrigeration, and other topics.

In addition to taking these required courses, the student in his senior year may specialize in power plants by taking the lecture and computing courses specially devoted to that subject. He may also attend special lecture courses on steam turbines, steam boilers, internal combustion engineering, pumping and pneumatic machinery.

5. Experimental Engineering

A. MECHANICAL LABORATORY

Instruction in this department begins in the sophomore year with the study of materials of engineering, their manufacture, properties, and uses.

Throughout the junior and senior years the student receives instruction in the very completely equipped mechanical laboratories (described on page 22), not only to familiarize him with the various types of testing apparatus and to give him skill in their use, but to teach him the best methods of research. Briefly, the courses include: the use of computing machines; the testing of engineering materials, with determination of influences of composition and heat treatment; the calibration and use of indicators, gauges, thermometers, dynamometers, etc.; tests of lubricants; fuel calorimetry; steam calorimetry; valve setting; tests of boilers, steam engines, turbines, pumps, heaters, condensers, injectors, and other steam apparatus; tests of air compressors and refrigerating machines; tests of external and internal combustion gas and oil engines; and tests of hydraulic machinery.

B. ENGINEERING RESEARCH

Engineering research by graduate and undergraduate students is carried on in this department under the supervision of a separate corps of specialists who devote their entire time to this work. Students who have shown proficiency in experimental engineering may have opportunity to conduct original investigations under expert guidance, and as occasion offers, may assist in commercial tests, made

at the University or elsewhere, of materials, prime movers, power plants, etc. The equipment of every department is available for this work and the specialists in any department may be consulted.

In case the investigation or research is sufficiently extended, the student is encouraged to embody the work in a thesis. Research, or Thesis, may be elected during the senior year by a limited number who have shown special ability for investigation. Arrangements for this work should be made with the department during the junior year if possible.

This department will cooperate in every way to assist graduate students in mechanical, electrical, and industrial engineering, and will aid in providing apparatus and other facilities for graduate work.

6. Industrial Engineering

Until recently the field of the mechanical engineer was a comparatively narrow one, comprising little more than the design, construction, and operation of machinery. As industry has developed, however, many technically trained men have entered the fields of manufacturing, selling, and administration. This is a natural and increasing tendency, since industrial development rests mainly upon a scientific basis. There are few lines of human activity today that are not connected in some way with applied science, and this is particularly true of those lines known by the general term of engineering.

The success of the engineer in times past in meeting these commercial requirements, for which he had received no special training, was probably due to the method of attack characteristic of the engineer and to superior knowledge of the technical side of the work. But the commercial demands upon the engineer are now becoming so great that special training is necessary to equip him more completely for this larger field. This becomes more evident when it is considered that a large number of the graduates of mechanical engineering colleges go into the commercial side of engineering.

Therefore, in addition to training in the fundamental principles of engineering, every student in the regular courses in the School of Mechanical Engineering has some work in industrial organization and administration and industrial accounting before he is graduated; but in the Department of Industrial Engineering a more complete provision is made in the senior year for those who wish to specialize in manufacturing or the commercial side of engineering.

The work of the department begins in the junior year, when all students in the School take a course of instruction in the basic principles of industrial organization. In the Senior year all students take a course in Industrial Accounting; and in addition an elective group of studies is offered in the senior year for those who wish to specialize somewhat in this line of work. These electives comprise courses in plant arrangement, industrial organization and administration, time and motion study, industrial accounting, corporation finance, industrial relations, etc.

7. Administrative Engineering

It is a well established fact that the major part of the graduates of engineering schools eventually find their way into administrative positions. A number of reasons for this tendency has been advanced. Industry is becoming increasingly scientific in its background and practices, in many cases so much so as to require technical training for the comprehension of its processes. Scientific and engineering methods of thought have invaded the fields of factory location, production and general administration, and now are reaching into the problems of personnel management. These changed conditions have made an ever widening opportunity for the engineer in managerial fields, but aside from this opportunity the engineer has been found to be very effective as an industrial and commercial administrator, simply because of the mental processes and methods of attack upon administrative problems that follow from his training in pure and applied science.

On the other hand, engineers as a rule are lacking in certain accomplishments which often prevent them from attaining as high a place in industry and business as their opportunities warrant. Many engineering graduates who have been successful in administrative positions have complained that their college course did not contain certain liberalizing subjects that would have been of marked value to them in their capacity as administrators. Further an investigation by the Society for the Promotion of Engineering Education reveals the fact that from the viewpoint of many alumni, engineering courses are lacking in economic and historical content.

The problem can, of course, be solved in a very satisfactory manner by five or six year courses, such as are now offered as optional programs to the regular engineering courses. In the majority of cases, economic reasons if no other, make a compulsory five or six year program inexpedient at the present time.

Cognizant of these facts, and also that there is no background so suitable and effective for the training of future executives as courses in pure and applied science that are to be found in an engineering curriculum, the Schools of Mechanical and Electrical Engineering are now offering a course in Administrative Engineering, leading to the degree of Bachelor of Science in Administrative Engineering.

The curricula of these courses reveal the fact that they are very strong in engineering content, so strong in fact, that with the addition of one year of study they will enable the student to obtain the regular Mechanical Engineering or Electrical Engineering degree.

Analysis shows that the make up of the curricula contains approximately 60% of technical subjects and 40% of economic and liberalizing subjects. The freshman year is the same as that of the standard engineering course thus enabling the new student to defer his choice, if he so desires, to the beginning of his sophomore year.

Non-Resident Lecturers

Supplementing the regular course of instruction, lectures are delivered from time to time by non-resident specialists in the profession on various subjects relating to the many branches of mechanical engineering. Seniors are required to attend these lectures. The student may also attend the many public scientific lectures given in other departments of the University by non-resident lecturers.

COURSES LEADING TO THE DEGREE OF MECHANICAL ENGINEER

1. The Regular Four-Year Course

One hour of credit in the following schedules corresponds to about three hours of actual work a week for the term of fifteen weeks. Thus, from two and one-half to three hours a week of actual work in shop, laboratory, computing room, or drawing room count as one hour of credit, and each recitation hour assumes about two hours of outside preparation.

THE FRESHMAN YEAR

There is a single schedule of studies prescribed for all students alike, except as stated in Drawing, in the freshman year of the College of Engineering, whether they expect to graduate in civil, mechanical, or electrical engineering. That schedule is set forth in full under the head The Freshman Year, beginning on page 46.

THE SOPHOMORE YEAR

	Hours	
	1st Term	*2nd Term*
Mechanics 330a, 331a	5	4
Physics 21, 22	3	3
Empirical Design 311	3	0
Kinematics Recitations 314	0	3
Kinematics Drawing 315	0	2
Economic Organization 500	5 or 0	0 or 5
Engineering Chemistry 775	0 or 2	2 or 0
Foundry 300	0 or 2	2 or 0
Pattern Making 302	0 or 1	1 or 0
Materials 360	2	2
Total number of hours each term	18 or 18	19 or 19

THE JUNIOR YEAR

Heat Power 340a, b	3	3
E. E. Theory 415, 416	3	3
Machine Design 318a, b	2	2
Machine Design 319a, b	2	2
Mechanical Laboratory 365, 366	4	4
Hydraulics 334	0 or 2	2 or 0
Accounting 502a	3	0
Machine Shop 305	3 or 0	0 or 3
Industrial Organization 380	0	2
Total number of hours each term	20 or 19	18 or 19

THE SENIOR YEAR

In the Senior Year the student selects one of the following groups of studies. The major part of the work is the same in all of the groups, the difference lying only in the time devoted to certain special courses. After the selection is once made at the beginning of the first semester, no shift in the group selected will be permitted.

GROUP A

POWER PLANT ENGINEERING

The object of the special courses in this group is to acquaint the student with the design and application of the various types of steam power-plant equipment and to train him in problems connected with the layout, construction and equipment of the plant as a whole. After studying the details of the design and the selection of steam prime movers and their auxiliaries, the time is devoted to consideration of load curves, station factors, variable load economy, cost of equipment and of power, principles of economic selection of machinery with respect to the load curve and local conditions, arrangement of equipment, plant location, and similar topics.

The work is taught by lectures supplemented by a computing and design course in which the student first makes layouts of the more important machines and constructs their characteristic curves, after which he takes up a power plant project.

In addition to the prescribed courses, the student may elect such related courses as Boiler Design, Steam Turbines, Internal Combustion Engines, Pumping and Pneumatic Machinery, Motor Car Construction and Industrial Administration; or he may elect courses in other colleges.

	Hours	
	1st Term	*2nd Term*
Heat-Power Engineering 345a, b	3	3
Mechanical Laboratory 370, 371	4	4
Electrical Laboratory 435, 436	2	2
Heating, Ventilating, and Refrigeration 373	3 or 0	0 or 3
Steam Power Plants Lectures 346	2	2
Computing and Design 347	2	2
Nonresident Lectures 391	0	1
Electives	3 or 6	5 or 2
Total number of hours each term	19	19

For suggested electives see list on page 76.

GROUP B

INDUSTRIAL ENGINEERING

This group is intended for those who wish to enter the commercial side of engineering or who are particularly interested in industrial organization and administration. In the special courses relating to this option the following topics are discussed: Modern time-keeping and cost-finding systems; methods of planning work and insuring production; time and motion studies; purchasing; problems in administration, plant locating; heating; lighting; powering; safety engineering; fire protection and similar subjects. In the drafting and designing courses the graphical work includes the application of these fundamental principles to planning industrial enterprises. Students expecting to elect this option are advised to read for preparation as much industrial history and kindred subjects as possible.

	Hours	
	1st Term	*2nd Term*
Heat-Power Engineering 345a, b	3	3
Mechanical Laboratory 370, 371	4	4
Electrical Laboratory 435, 436	2	2
Heating, Ventilating, and Refrigeration 373	3 or 0	0 or 3
Industrial Engineering 382	2	1
Industrial Engineering Problems 383	2	1
Industrial Relations 386	2	0
Cost Accounting 509	0	2
Nonresident Lectures 391	0	1
Electives	1 or 4	5 or 2
Total number of hours each term	19	19

For suggested electives, see list on page 76.

Group C

Automotive Engineering

The wide variety of theoretical and practical problems arising in automotive design and operation, and the great industrial importance of this field of engineering, make the analysis of automotive machinery one of the most interesting of ways to introduce a student to engineering work. The "Automotive group" for seniors makes a study of the fundamentals of construction and operation of automotive vehicles. First term work studies the vehicle as a whole, the functions of steering, driving, braking; load distributions, framing, body design; and makes detailed analysis of power required for operation. Second term work studies power plant theory, design and operation. Two lectures are given a week, and two computing periods; the latter may also be used for drawing, or for laboratory work or demonstration.

	Hours	
	1st Term	*2nd Term*
Heat-Power Engineering 345a, b	3	3
Mechanical Laboratory 370, 371	4	4
Electrical Laboratory 435, 436	2	2
Heating, Ventilating, and Refrigeration 373	3 or 0	0 or 3
Motor Car Construction, lectures 328a, b	2	2
Motor Car Construction, computations 329a, b	2	2
Nonresident Lectures 391	0	1
Electives	3 or 6	5 or 2
Total number of hours each term	19	19

For suggested electives, see list on page 76.

Group D

General Engineering

The construction and operation of modern power and industrial plants and enterprises present a great variety of problems. While most of the problems confronting the mechanical engineer fall within this field, they often present aspects and features demanding a knowledge of the elements of structural and concrete work and of building construction. It is the purpose of this option to cover this border land between the distinct fields of Civil and Mechanical Engineering.

The lectures and recitations of the group are devoted to a discussion of graphics and structural design relating to columns, beams, crane frames, girders, trusses, walls and floors, and to concrete construction as applied to foundations and industrial buildings. The drawing room work consists of deflection and continuous beam problems, the design of a plate girder, crane frame, roof truss and building

bent, and problems in reinforced concrete. In addition a short problem in dynamics is taken up and a few lectures are given on commercial balancing.

	Hours	
	1st Term	*2nd Term*
Heat-Power Engineering 345a, b	3	3
Mechanical Laboratory 370, 371	4	4
Electrical Laboratory 435, 436	2	2
Heating, Ventilating, and Refrigeration 373	3 or 0	0 or 3
Steel and Concrete Construction 324a, b	2	2
Steel and Concrete Constr. Problems 325a, b	4	4
Nonresident Lectures 391	0	1
Electives	1 or 4	3 or 0
Total number of hours each term	19	19

For suggested electives see list on page 76.

Group E

Hydraulic Power Plant Engineering

The work of the water power engineer includes subjects from the fields of civil, mechanical, and electrical engineering. The special courses in this group aim to cover all topics essential to an intelligent cooperation between those engineers engaged in either the design, construction, or operation of water power developments or in the transmission and distribution of energy. Special emphasis is placed upon financial and economic phases of the work. Those elements of design and construction which affect economical operation are carefully discussed. Courses in electrical engineering cover the electrical power plant and the transmission and distribution engineering. The object is to present a complete picture of the problem from the water in the stream to the sale of energy to the ultimate consumer. As opportunity offers, the students in this option are taken on inspection trips to water power plants under construction or completed. These trips are not compulsory.

Those students who can spend five years are urged to combine this option with the course in electrical engineering. Since the present day power system usually includes thermal plants also, elective courses in the Department of Heat-Power Engineering are recommended. In the five-year period both the M.E. and E.E. degrees may be obtained. For details of this combination, the student should consult the Directors of the Schools of Mechanical and Electrical Engineering as early as possible, preferably before beginning the third year.

	Hours	
	1st Term	*2nd Term*
Heat-Power Engineering 345a, b	3	3
Mechanical Laboratory 370, 371	4	4
Electrical Laboratory 435, 436	2	2
Heating, Ventilating, and Refrigeration 373	3 or 0	0 or 3
Hydraulic Power Plant Lectures 336	2	2
Hydraulic Power Plant Computations 337	2	2
Electric Power Plant Design 441	3	0
Electric Transmission and Distribution 464	0	3
Nonresident Lectures 391	0	1
Electives	0 or 3	2 or 0
Total number of hours each term	19	19 or 20

For suggested electives see list page 76.

GROUP F

ELECTIVE GROUP

Under this group a student may specialize somewhat in such fields as Physics, Chemistry, Mathematics, Aeronautics, Metallurgy, Materials Handling, Structural Engineering, Mining and Geology, Electrical Engineering, Civil Engineering etc., by selecting appropriate courses from the general list of elective subjects given on page 76. In some cases, subject always to the approval of the Class Advisers, the work of the earlier years may be rearranged so as to include necessary prerequisites and to extend the specialization over more than one year.

	Hours	
	1st Term	*2nd Term*
Heat-Power Engineering 345a, b	3	3
Mechanical Laboratory 370, 371	4	4
Electrical Laboratory 435, 436	2	2
Heating, Ventilating, and Refrigeration 373	3 or 0	0 or 3
Nonresident Lectures 391	0	1
Electives*	7 or 0	9 or 6
Total number of hours each term	19	19

*The electives taken in this group must be approved by the M.E. Petition Committee in advance of registration day and the major portion of the credit hours must consist of Engineering subjects or subjects closely related thereto.

For suggested electives see list on page 76.

ELECTIVE SUBJECTS

SCHOOL OF MECHANICAL ENGINEERING

	Hours	
	1st Term	*2nd Term*
Mechanical Technology 320 (Not open to seniors)	0 or 3	3 or 0
Steel and Concrete Construction 324a, b	2	2
Advanced Kinematics and Kinetics 321	0	3
Materials Handling 322	0	2
Elements of Structural Work 323	3 or 0	0 or 3
Motor Car Construction 328a, b	2	2
Ordnance Problems 333	2	2
Hydraulic Power Plants 336a, b	2	2
Aerodynamics 339	2 or 0	0 or 2
Steam Power Plants 346a, b	2	2
Steam Turbines 350	0	2
Internal Combustion Engines 351	2	0
Steam Boilers and Boiler Plants 352	0	2
Pumping and Pneumatic Machinery 353	0	2
Engineering Research 375	1 to 3	1 to 3
Applied Metallography 376	2	0
Industrial Engineering Lectures 382a, b	2	1
Industrial Relations 386	2	0
Graphical Computations and Representations 392	0	2
Corporation Finance 504	0	3
A.S.M.E. Credit 393	0	1
Sibley Journal Credit 390	0 or 2	2 or 0

FOR GRADUATES AND ADVANCED STUDENTS

Engineering Research 375	As assigned	
Special Hydraulic Power Plant Problems 338	2 or 5	2 or 5
Advanced Industrial Engineering 387	1 to 3	1 to 3
Advanced Heat Power Engineering 359	1 to 5	1 to 5

ELECTIVE SUBJECTS IN OTHER SCHOOLS AND COLLEGES

	Hours	
	1st Term	*2nd Term*
Advanced Hydraulics 241	0	3
Hydraulic Measurements 242	3	0
Foundations 281	0 or 3	3 or 0
Engineering Law 290	0 or 3	3 or 0
Electrical Power Plants 441	3	0
Elements of Elect. Ry. Practice 461	2	0
Industrial Applications and Control 462	0	2
Transmission and Distribution 464	0	3
Illumination 466	0	2
Elementary Differential Equations 41	0 or 3	3 or 0
Advanced Calculus 42	3	3
Introductory Qualitative Analysis 210	0 or 3	3 or 0
Introductory Quantitative Analysis 225	0 or 3	3 or 0
Introductory Physical Chemistry (Lect.) 405	3	3
Introductory Physical Chemistry (Lab.) 410	3	3
Introductory Chem. Microscopy (Lect. & Lab.) 530	0 or 3	3 or 0
Metallography 545	2	0
Gas and Fuel Analysis 250	0 or 4	4 or 0
Physics courses dependent upon prerequisites (Consult the Department)		
Introductory Geology 100	3 or 0	0 or 3
Engineering Geology 501	4 or 0	0 or 4
Money and Banking 11	3 or 0	0 or 3
Industrial Hygiene 5	1	0
Public Speaking 1a	3 or 0	0 or 3

For other subjects such as Languages, History, Philosophy, Psychology, Government, Astronomy, Biology, Botany, Archaeology, Music, see announcements of the colleges concerned.

2. A FIVE-YEAR COURSE LEADING TO THE DEGREE OF M.E.

The requirements for admission to this course are the same as those for the four-year course, and the work of the first two years is the same. Without detailing the liberal arts electives, the rest of the course is tentatively as follows. Minor changes can be made after personal conference with the director of the school.

	Hours	
III	*1st Term*	*2nd Term*
Heat-Power Engineering 340a, b	3	3
Mechanical Laboratory 365, 366	4	4
Machine Design 318a, b	2	2
Machine Design Drawing 319a, b	2	2
Machine Shop 305	0	3
Accounting 502a	3	0
Electives	5	5
Total number of hours each term	19	19
IV		
Electrical Engineering 415, 416	3	3
Industrial Engineering 380	2	0
Hydraulics 334	0	2
Mechanical Laboratory 370, 371	4	4
Heat-Power Engineering 345a, b	3	3
Electives	6	6
Total number of hours each term	18	18

V

Group Lectures	2	2
Group Design	2	2
Electrical Engineering 435, 436	2	2
Heating, Ventilating and Refrigeration 373	3 or 0	0 or 3
Nonresident Lectures 391	0	1
Electives	10 or 13	12 or 9
Total number of hours each term	19	19

3. A Five-Year Course Leading to the Degree of B.Chem. and Chemical Engineer

The requirements for admission to this course are those set by the College of Arts and Sciences for admission to the degree of B. Chem. The student registers for four years in that college, and upon the completion of the work outlined below for the first four years, receives the degree of B.Chem. The fifth year is taken under the joint control of the Department of Chemistry in the College of Arts and Sciences and of the Sibley School of Mechanical Engineering. The degree of Chemical Engineer is conferred upon the successful completion of the entire course.

For description of the courses in engineering, see the pages following; for description of the courses in Chemistry consult the Announcement of the Department of Chemistry.

FIRST YEAR			*Hours* 1st Term	2nd Term
Introductory Inorganic Chemistry	Chem.	101	3	0
Inorganic Chemistry Laboratory	Chem.	105	3	0
Introductory Qualitative Analysis	Chem.	205	0	3
Qualitative Analysis Laboratory	Chem.	206	0	3
Analytic Geometry, Calculus	Math.	5a, 7	5	5
Introductory Experimental Physics	Physics	3, 4	3	3
English 1			3	3
Total number of hours each term			17	17
SECOND YEAR				
Introductory Organic Chemistry	Chem.	305	3	3
Organic Chemistry Lab	Chem.	310	3	3
Introductory Quantitative Analysis	Chem.	220	3	0
Quant. Analysis Laboratory	Chem.	221	3	0
Gas and Fuel Analysis	Chem.	250	0	4
Intro. Chem. Spectroscopy	Chem.	505	0	3
General Physics	Physics	30, 31	2	2
Physical Measurements	Physics	34	2	2
Drawing 125			3	0
			19	17
THIRD YEAR				
Introductory Physical Chemistry	Chem.	405	3	3
Physical Chemistry Laboratory	Chem.	410	3	3
Advanced Quantitative Analysis	Chem.	230	4	0
Mechanics 330 and 331			6	5
Introductory Engineering Lab. 103			1	0
Materials 360			2	2
Introduction to Economics	Econ.	3	0	3
Elementary Mineralogy	Geology	311	0	3
			19	19

FOURTH YEAR			
Introductory Industrial Chemistry.....Chem. 705		3	3
Heat-Power Engineering 343		3	3
Mechanical Laboratory 368, 369		3	3
Chemical Microscopy.....Chem. 530		3	0
Adv. Inorganic Chem.....Chem. 130		3	3
Research		4	4
Industrial Organization 380		0	2
		19	18
FIFTH YEAR			
Electrical Engineering 415, 416		3	3
Electrical Engineering Lab. 435, 436		2	2
Mechanical Engineering Lab. 372		2	0
Chem. Eng'g. Lab.....Chem. 710		0	4
Machine Design 316		2	0
Machine Design 326		1	0
Chemical Plant Design.....Chem. 730		3	3
Electives		5	5
		18	17

4. A Six-Year Course Leading to the Degrees of A.B. and M.E.

The requirements for admission to this course are those of the College of Arts and Sciences, in which the student is registered for the first four years. The student must complete the freshman engineering subjects before beginning his fourth year, and he must complete the sophomore subjects in Mechanical Engineering before beginning his fifth year. Advice and assistance in arranging the six-year course may be obtained by applying to the Director of the Sibley School of Mechanical Engineering and to the Dean of the College of Arts and Sciences.

5. A Four-Year Course in Administrative Engineering Leading to the Degree of B.S. in A.E. With Special Reference to Mechanical Engineering

The requirements for admission to this Course are the same as for the regular four-year M.E. Course, see page 33.

It is possible by an additional year of study to receive the Mechanical Engineering degree, although it is highly desirable that if a student wishes both degrees he signify this intention at the beginning of the Sophomore Year.

FRESHMAN YEAR	Hours	
	1st Term	*2nd Term*
Mathematics 5a, 5b	5	5
Physics 11, 12	4	4
Chemistry 101	3 or 0	0 or 3
Chemistry 105	3 or 0	0 or 3
Descriptive Geometry and Drawing 120, 121	3	3
Surveying 110	0 or 3	3 or 0
Wood Shop 102	0 or 1	1 or 0
Engineering Laboratory 103	0 or 1	1 or 0
Introductory Lectures 130	1	0
Hygiene 1, 2	1	1
Total number of hours each term	20 or 19	18 or 19

SOPHOMORE YEAR

	Hours 1st Term	2nd Term
Mechanics 330a	5	0
Mechanics and Hydraulics 332	0	5
Empirical Design 310	2	0
Kinematics Recitations 312	0	2
" Drawing 313	0	1
Physics 21, 22	3	3
Materials 360	2	2
Engineering Chemistry 775	0 or 2	2 or 0
Foundry 301	1 or 0	0 or 1
Pattern Making 302	1 or 0	0 or 1
Economic Organization 500	5	0
Business and Industrial Management 501	0	4
Total number of hours each term	19	19

JUNIOR YEAR

	Hours 1st Term	2nd Term
Mechanical Laboratory 368, 369	3	3
Machine Design Recitations 316	2	0
" " Drawing 317	2	0
Heat Power 343a, b	3	3
Machine Shop 306	0	2
English	3	3
Accounting 502a, b	3	3
Money and Banking 503	3	0
Corporation Finance 504	0	3
Industrial Relations 386	0	2
Total number of hours each term	19	19

SENIOR YEAR

(Not given until 1933–34)

	Hours 1st Term	2nd Term
Mechanical Laboratory 372	2	0
Electrical Laboratory 417	0	4
Industrial Engineering Lectures 381a, b	1	1
Industrial Engineering Problems 383a, b	2	1
Business Statistics and Forecasts 505	3	0
Investments 506	0	2
Engineering Business Law 507a, b	2	2
Industrial Marketing 508a, b	3	3
Cost Accounting 509	0	2
Public Speaking 1a	3	0
Nonresident Lectures 391	0	1
Electives	3	3
Total number of hours each term	19	19

DESCRIPTION OF COURSES

For Freshmen

A description of the course of instruction for freshmen is given under the head The Freshman Year, beginning on page 46.

For Sophomores, Juniors, and Seniors

The following courses in Physics, Chemistry and English, are given in the College of Arts and Sciences. The rest are given in the College of Engineering.

For information about examinations for the removal of conditions in Mathematics, Physics, or Chemistry, students are referred to the Announcement of the College of Arts and Sciences or told to inquire of the department in which the examination is given.

PHYSICS

21. **General Physics.** Required of candidates for the degree of M.E. or E.E. Either term. Credit three hours. Prerequisite Physics 11 and 12 and Mathematics 5a and 5b.

One class-room period and one laboratory or computing period a week as assigned. Theory, problems, and laboratory work covering selected topics in wave motion, sound, light and heat.

Rockefeller Hall. Assistant Professor Grantham and instructors.

22. **General Physics.** Required of candidates for the degree of M.E. or E.E. Either term. Credit three hours. Prerequisite Physics 11 and 12 and Mathematics 5a and 5b.

One class-room period and one laboratory or computing period a week as assigned. Theory, problems and laboratory work covering selected topics in electricity and magnetism.

Rockefeller Hall. Assistant Professor Grantham and instructors.

CHEMISTRY

775. **Engineering Chemistry.** Repeated in second term. Two lectures a week. Credit two hours. Prerequisite courses Chemistry 101 and 105. Chemistry in its relation to engineering. Among the topics discussed in this course are heat insulators and refractories, wood preservation, boiler water softening, the corrosion of iron and steel, paints and varnishes, the refining of petroleum, the manufacture of coal tar products, etc. Mr. Lewis.

ELECTRICAL ENGINEERING

Courses 415, 416, 435, 436, are required of all candidates for the M.E. degree. For a description of these courses, see pages 97–98 of this Announcement.

MACHINE CONSTRUCTION

(For courses in Wood Working and Introductory Engineering Laboratory, see Courses 102 and 103 under courses offered to freshmen, page 48.)

300. **Foundry Work.** Required of M.E. sophomores. Either term. Credit two hours. Two two and one-half hour periods a week. Moulding, core making, mixing, and casting of metals; use of moulding machines. Demonstrations of large work and production in quantities. Messrs. Patterson and Sanderson.

301. **Foundry Work.** Required of A.E. sophomores. Either term. Credit one hour. One two and one-half hour period a week. Moulding, core making, mixing, and casting of metals; use of moulding machines. Demonstrations of large work and production in quantities. Messrs. Patterson and Sanderson.

302. **Pattern Making.** Required of M.E. and A.E. sophomores. One hour either term as assigned. Pattern making: the use of hand and machine tools, followed by instruction in pattern making, construction of core boxes, etc.; demonstration of form turning. Messrs. Hooper, Bush, and Yawger. *Rand Hall, Third Floor*

305. **Machine Work.** Required of M.E. juniors. Credit three hours one term. Nine hours of work a week. Prerequisite courses 102, 103, 300, and 302. Use of measuring instruments, hand and machine tools, fitting, and assembling; operation and use of jigs and other manufacturing fixtures; operation of semi-

automatic and automatic machines, and the illustration of manufacturing methods generally. Professor WELLS, Messrs. HOWE and SCHALLOWITZ.

306. **Machine Work.** Required of E.E. sophomores, prerequisites 102 and 103. Required of A.E. juniors, prerequisites 102, 103, 301, and 302. Credit two hours one term. Six hours of work a week. Use of measuring instruments, hand and machine tools, fitting, and assembling; operation and use of jigs and other manufacturing fixtures; operation of semi-automatic and automatic machines, and the illustration of manufacturing methods generally. Professor WELLS, Messrs. HOWE and SCHALLOWITZ.

DRAWING

(For the course in Descriptive Geometry and Engineering Drawing, see Courses 120 and 121 under courses offered to freshmen, page 47.)

125. **Drawing.** This course is given in the College of Engineering, but is designed only for students registered as candidates for the degree of Bachelor of Chemistry. First term. Credit three hours. One recitation and two two and one-half hour drawing periods a week. Lettering, machine sketching, working drawings including conventions, tracing, isometric projection, etc. Professor TOWNSEND and instructors. *East Sibley*

MACHINE DESIGN

310. **Empirical Design.** Sophomores in Administrative and Electrical Engineering. First term. Credit two hours. Prerequisite courses 120 and 121. Two two and one-half hour drawing periods and one recitation period a week throughout the term. The course consists of further work in mechanical engineering drawing, the study and use of standard parts, the application of the empirical method to the proportioning of common machine parts, and the assemblying of such parts. Professor ROGERS and Messrs. MORRIS, MILLARD, KNIGHT, and JACKOSKI.

311. **Empirical Design.** Sophomores in Mechanical Engineering. First term. Credit three hours. Prerequisite courses 120 and 121. Three two and one-half hour drawing periods and one recitation period a week throughout the term. The course consists of further work in mechanical engineering drawing, the study and use of standard parts, the application of the empirical method to the proportioning of common machine parts, and the assemblying of such parts. Professor ROGERS and Messrs. MORRIS, MILLARD, KNIGHT, and JACKOSKI.

312. **Kinematics.** Sophomores in Administrative and Electrical Engineering. Second term. Credit two hours. Must be taken with Course 313. Prerequisite courses, Physics 11 and 12 and courses 310 and 330. Two recitations a week throughout the term on the theory of motion; the transmission of motion; the instant center method of determining linear and angular velocities; cams; rolling curves and friction gearing; gears; gear cutting; linkwork and miscellaneous mechanisms; belt, rope, and chain drives; and trains of mechanism. Professor ROGERS and Messrs. MORRIS, MILLARD, KNIGHT, and JACKOSKI.

313. **Kinematic Drawing.** Sophomores in Administrative and Electrical Engineering. Second term. Credit one hour. Must be taken with Course 312. Prerequisite courses, Physics 11 and 12 and courses 310 and 330. One two and one-half hour drawing period a week throughout the term making drawing board applications of the theory and principles of course 312. Professor ROGERS and Messrs. MORRIS, MILLARD, KNIGHT, and JACKOSKI.

314. **Kinematics.** Sophomores in Mechanical Engineering. Second term. Credit three hours. Must be taken with Course 315. Prerequisite courses, Physics 11 and 12 and courses 311 and 330. Three recitations a week throughout the term on the theory of motion; the transmission of motion; the instant center method of determining linear and angular velocities; cams; rolling curves and friction gearing; gears; gear cutting; linkwork and miscellaneous mechanisms; belt, rope and chain drives; and trains of mechanism. Professor ROGERS and Messrs. MORRIS, MILLARD, KNIGHT, and JACKOSKI.

315. **Kinematic Drawing.** Sophomores in Mechanical Engineering. Second term. Credit two hours. Must be taken with Course 314. Prerequisite courses, Physics 11 and 12 and courses 311 and 330. One three and one two and one-half hour drawing period a week throughout the term, making drawing board applications of the theory and principles of course 314. Professor ROGERS and Messrs. MORRIS, MILLARD, KNIGHT, and JACKOSKI.

316. **General Machine Design Theory.** Juniors in Administrative and Electrical Engineering and fifth year students in Chemical Engineering. First term. Credit two hours. Prerequisite courses, 310, 312, 313, 330, and 331 for Administrative and Electrical Engineers and 125, 330, and 331 for Chemical Engineers. Two recitations a week throughout the term on the theoretical and practical applications of kinematics, mechanics, and technology to the design of machines and machine elements with due regard to such considerations as lubrication, safety, suitability of materials, construction, etc. Professor ALBERT, Assistant Professors GARNER and KOSHKIN, and Messrs. TERRY and KINGSTON.

317. **Machine Design.** Juniors in Administrative and Electrical Engineering. First term. Credit two hours. Must be taken with Course 316. Prerequisite courses 310, 312, 313, 330, and 331. One three hour and one two and one-half hour drawing and computing periods a week throughout the term. The student for the first time undertakes the design of a complete machine and makes all the necessary computations and drawings. Orderly, systematic computations are insisted upon, and such layout and detail drawings are made as are found necessary to complete an assembly drawing of the machine. Professor ALBERT, Assistant Professors GARNER and KOSHKIN, and Messrs. TERRY and KINGSTON.

318a, b. **General Machine Design Theory.** Juniors in Mechanical Engineering. Throughout the year. Credit two hours each term. Prerequisite courses 311, 314, 315, 330, and 331. Two recitations a week throughout the year on the theoretical and practical applications of kinematics, mechanics, and technology to the design of machines and machine elements with due regard to such considerations as lubrication, safety, suitability of materials, construction, etc. Professor ALBERT, Assistant Professors GARNER and KOSHKIN, and Messrs. TERRY and KINGSTON.

319a, b. **Machine Design.** Juniors in Mechanical Engineering. Throughout the year. Credit two hours each term. Must be taken with Course 318. Prerequisite courses 311, 314, 315, 330, 331. One three and one two and one-half hour drawing period a week throughout the year. The student for the first time undertakes the design of a complete machine and makes all the necessary computations and drawings. Orderly, systematic computations are insisted upon, and such layout and detail drawings are made as are found necessary to complete an assembly drawing of the machine. In the second term, more advanced design problems are taken up. Professor ALBERT, Assistant Professors GARNER and KOSHKIN, and Messrs. TERRY and KINGSTON.

320. **Mechanical Technology as Related to Design.** An elective for sophomores and juniors in engineering. Either term. Credit three hours. Thirty-five recitation and discussion periods, six lectures, and four written examinations. The purpose of the course is to show how the various mechanical processes are related to design and production. The course is based on textbooks, dealing principally with the processes of fashioning metals by machining, cutting, grinding, shearing, punching, drawing, rolling, hammering, pressing, moulding, etc. Each period is devoted to an oral quiz and informal discussion of the day's assignment, with occasional lectures on the general and particular relations of processes to design work. Professor ALBERT.

321. **Advanced Kinematics and Kinetics.** An elective for juniors, seniors and graduates. Second term. Credit three hours. Prerequisite courses, 310, 312, and 313, or 311, 314, and 315. Two lectures and one three-hour drawing period a week throughout the term. Graphical and semi-graphical treatment of linear and angular velocities and accelerations and of the resulting forces, stresses, and strains due to the form and mass of the moving parts of mechanisms and machines.

Vibration and critical speeds and the theoretical basis and use of balancing machines for securing static and running balance of machine parts, will be treated so far as time permits. Professor ALBERT or Assistant Professor KOSHKIN.

322. **Material Handling.** An elective for juniors and seniors. Second term. Credit two hours. Prerequisite courses 312 and 313, or 314 and 315. Two lectures a week throughout the term. Treatment and analysis of the known methods of handling different kinds of materials and of the principles and considerations involved in a proper choice of the method of handling any given kind of material. Assistant Professor KOSHKIN.

323. **Elements of Structural Work.** An elective for juniors and seniors who are not taking or do not intend to take Group D. Either term. Credit three hours. Prerequisite courses 312 and 313, or 314 and 315 and 330 and 331. One recitation period and two three-hour drawing periods a week throughout the term, with a lecture hour taken out of one of the drawing periods. Elements of structural steel work. Graphical and algebraic determinations of forces and stresses in trusses and frame work. Design of tension and compression members, trusses, girders, crane frames, etc. Professor ALBERT.

324a, b. **Steel and Concrete Construction.** Required of seniors in Group D. Two recitation and discussion periods a week throughout the year. Credit two hours a term. Prerequisite courses 316 and 317, or 318 and 319. Elements of structural work, of building construction, of foundations, and of reinforced concrete work. Graphical and algebraic determination of stresses, influence diagrams, structural members and details, trusses, building bents and steel framing, plate girders, crane frames, chimneys, foundations, plain and reinforced concrete, etc. Professor ALBERT.

325a, b. **Steel and Concrete Construction, Drawing.** Required of seniors in Group D. Two lectures and two three-hour drawing periods a week throughout the year. Credit four hours a term. Prerequisite courses 316 and 317, or 318 and 319. Notes, computations, and drawing board work. Practical solution of certain problems discussed in 324; deflection and continuous beam problems, design of plate girder, jib-crane frame, roof truss, building bent, reinforced concrete building element, dynamics of a hoist, etc. Professor ALBERT.

326. **Machine Design.** Seniors in Chemical Engineering. First term. Credit one hour. Must be taken with course 316. Prerequisite courses, 125, 330, and 331. One three-hour period a week throughout the term. The work of the term includes a problem illustrative of the design of pressure vessels and the design of a single-cylinder, plunger pump fitted with a flywheel. Orderly, systematic computations are insisted upon, and such layout and detail drawings are made as are found necessary to complete an assembly drawing of the pump. Professor ALBERT and Assistant Professor GARNER.

AUTOMOTIVE ENGINEERING

328a, b. **Motor Car Construction.** Credit two hours each term. Two lectures a week, illustrated. Two preliminary examinations, term problem, and a final examination. Either term's lectures may be used as a senior elective. First term work deals with design of chassis and body, and power requirements for operation; second term deals with power plant design and operation. Professor UPTON.

329a, b. **Motor Car Construction.** Drawing room, computing, or laboratory work paralleling the lecture courses 328a, b. Two preliminary examinations and a final examination. Professor UPTON.

MECHANICS OF ENGINEERING

330a. **Theoretical and Applied Mechanics.** Sophomores. First term. Credit five hours. Five recitations a week. Prerequisite courses, Mathematics 5a and 5b. Motion of a Particle: displacement, velocity, acceleration; graphs; force, mass, and acceleration; equations of motion; curvilinear and rectilinear motion; rotation about an axis; moments. Systems of Particles: external and internal

forces; general equations of motion; parallel forces; center of gravity. Statics: single pieces, cords, pulleys, structures and mechanisms. Motion of a Rigid Body: translation: rotation, moment of inertia of solids; plane motion. Work and energy: friction: brakes, dynamometers; power, efficiency, and regulation of machines. Professors WOOD and CORNELL, Assistant Professors PERKINS and WOOD.

331a. **Strength of Materials.** Sophomores. Second term. Credit four hours. Four recitations a week. Prerequisite course 330a. Stress; strain; strength and elastic properties of materials in tension, compression and shearing; riveted joints; torsion of shafts; helical springs; shear, moment, safe loading and deflection of simple beams; special beams; eccentric loads; columns; combined loads; resultant stresses; curved bars; continuous beams; impact loads. Professors WOOD and CORNELL, Assistant Professors PERKINS and WOOD.

332. **Strength of Materials and Hydraulics.** Sophomores in Administrative Engineering. Second term. Credit five hours. Prerequisite course 330a. Stress, strain; strength and elastic properties of materials in tension and compression and shearing; riveted joints; torsion of shafts; helical springs; shear, moment, safe loading and deflection of simple beams; eccentric loads; columns; impact loads. Hydrostatics: pressures and centers of pressure. Hydrokinetics: general equation of energy; orifices, weirs, nozzles, Venturi meters, etc.; losses of head; flow in pipes and open channels. Hydrodynamics: forces on stationary and moving bodies. Professors WOOD and SWITZER.

333. **Ordnance Problems.** Two lectures a week throughout the year. Credit two hours each term. Prerequisite courses 330a and 331a. Captain HIRSCH.

334. **Hydraulics.** For juniors in Mechanical Engineering. First or second term. Credit two hours. Prerequisite courses 330 and 331. Two recitations a week. Hydrostatics: pressures and centers of pressure. Hydrokinetics: general equation of energy; orifices, weirs, nozzles, Venturi meters, etc.; losses of head; flow in pipes and open channels. Hydrodynamics: forces on stationary and moving bodies. Professor SWITZER.

339. **Aerodynamics.** An elective for juniors and seniors. First term. Repeated in second term. Credit two hours. Two recitations a week. Prerequisite courses Mechanics 330 and 331. An introductory course in airplane design emphasizing fundamental principles of Mechanics and Hydrodynamics. Wind tunnels, hydrodynamic theory of airfoils, airfoil characteristics, equilibrium and stability of an airplane, parasite resistance, propellers, airplane performance, criteria for selection of airfoils, materials and construction, dynamic loads, elements of stress analysis, layout problem. Assistant Professor WOOD.

339.5. **Aerodynamic Problems.** An elective for juniors and seniors. Second term. Credit two hours. One afternoon computing period a week as assigned. Prerequisite course 339. Student may elect a major problem either a design problem, making the drawings and calculations necessary for Department of Commerce approval of a design for an airplane or other heavier than air machine, or a research problem, submitting a report on some specialized phase of aeronautical research. One hour every other week devoted to seminar. Attendance at the national aeronautical exposition and a visit to an airplane factory is expected of students enrolling in this course.

WATER-POWER ENGINEERING

336a, b. **Hydraulic Power Plants.** Lectures throughout the year. Credit two hours each term. Prerequisite courses 330, 331, and either 334 or 335. Power Development: description, design, and cost of reservoirs, dams, headworks, water conduits, surge chambers, power house, tail race, construction plant. Hydraulic Turbines: construction, installation, operating characteristics including effects of water hammer in long pipe lines and variable head, selection of equipment, testing, governing, and speed regulation. Power Study: market for power, competition and rates, hydrology, head, economics of pondage and storage, power available and usable within the load curve, economy of auxiliary power. Water

power legislation and the Federal Power Commission. During the entire course considerable emphasis is placed upon the financial problems of construction and operation of the water power plant alone and as part of a large power system. Some time is devoted to elementary concrete design and foundations. Professor SWITZER.

337a, b. **Hydraulic Power Plant Problems.** Computation periods throughout the year. Credit two hours in first term, three hours in second term. Must be accompanied by course 336a, b. Problems are assigned involving the principles taken up in course 336a, b. Design problems are given to show the applications of the fundamental principles of mechanics, machine design, and hydraulics, to the solution of problems in the water power field. The characteristics of hydraulic turbines are studied through the use of experimental data on turbine performance, and these results are applied to specific problems in power plant practice. Problems in stream flow, pondage and storage, power available and its use under specified load conditions conclude the work. Professor SWITZER.

338. **Special Hydraulic Power Plant Problem.** Elective for seniors and graduates. Either term. Credit two to five hours as arranged. Must be preceded by or taken with 336a, b. Selected topics from course 337 and other special problems to meet the individual needs of each student. Students who have completed course 337a, b, or equivalent, may elect this course for more advanced work. Professor SWITZER.

HEAT-POWER ENGINEERING

340a, b. **Heat-Power Engineering.** Required of all juniors in Mechanical Engineering. Throughout the year. Credit three hours a term. Prerequisite courses, Physics 21 and 22 and M.E. 311, 314, 330a and 331a. Two recitations and one lecture a week throughout the year. Thermodynamics of gases and vapors; ideal cycles and their application in air compressors, internal combustion motors, steam engines, turbines and power plants; modifications in actual machines; efficiencies and performances; study of engine losses and the usual means of reducing them; compound, unaflow, binary, and other types of steam engines; types of air compressors, internal combustion engines. On account of the importance of a thorough understanding of this subject, the student is required to solve a large number of problems in the classroom. Professor ELLENWOOD, Assistant Professor MACKEY, and Mr. ———.

341. **Heat-Power Engineering.** Required of seniors in Civil Engineering and A.E. Seniors in Electrical Engineering. Either term. Credit three hours. Not open to students in Mechanical or Electrical Engineering. Prerequisite courses, Physics 11 and 12 (or the equivalent), Chemistry 101 and 105, C.E. 220 and 221. One lecture and two recitations a week. Elementary consideration of behavior of gases and vapors as applied to heat engines; study of air compressors, internal combustion motors, steam boilers, engines, turbines, and condensers; contractors' plants; cost of energy; and similar topics. This course is recommended for all students who wish to obtain a general basic knowledge of Heat-Power Engineering without great technical detail. Professor ELLENWOOD and Mr. FAIRCHILD.

343a, b. **Heat-Power Engineering, for Electrical Engineers.** Required of juniors in Electrical Engineering. Not open to students in Mechanical Engineering. Throughout the year. Credit three hours a term. One lecture and two recitations a week. Prerequisite courses, Physics 21 and 22 and M.E. 310, 330a and 331a. The first term is an abridged treatment of substantially the same ground as Course 340. The second term is an abridgement of Course 345. The longer course 340 and 345, may be substituted for 343a, b. Assistant Professors HOOK and CLARK.

345a, b. **Heat-Power Engineering.** Required of all seniors in Mechanical Engineering. Throughout the year. Credit three hours a term. Prerequisite course 340a, b. One lecture and two recitations a week. An extension of course 340a, b. Valve gears and governors; evolution of engine and turbine types; steam turbine theory, development of present forms, performance, economy, suitability for particular service; fuels and fuel resources; combustion, theoretical and in

the actual furnace and engine; steam generating units and their performance; boilers, superheaters and economizers, air preheaters, stack losses; draft; heat transfer; feed water heaters, condensers, cooling towers and subsidiary apparatus; feed water treatment. Consideration of the economical combination of elements in plants. Professor ELLENWOOD, and Assistant Professors HOOK and CLARK.

346a, b. **Steam-Power Plants.** Lectures throughout the year. Credit two hours a term. Prerequisite courses 318, 319, and 340a, b, and must be accompanied or preceded by Course 345a, b. Steam prime movers, boilers, condensers, and auxiliary equipment; elements of design; selection; installation and operation; load curves; station factors; variable load economy; cost of equipment and power; principles of economic selection of machinery with respect to the load curves and local conditions; selection and arrangement of main units and auxiliaries; piping; coal and ash storage and conveying machinery; plant location; plant layout; comparison of steam and other types of plants; and similar considerations. Professor BARNARD and assistant.

347a, b. **Computing and Design.** Throughout the year. Credit two hours a term. Must be accompanied by 346a, b. Two drawing periods a week. The practical solution of problems discussed in 346. Professor BARNARD and assistant.

350. **Steam Turbines.** Elective for seniors. Second term. Credit two hours. Prerequisite course 340a, b, or 343a, b. Two lectures a week. Classification of turbines and description of leading features of the various types; mechanical and thermal considerations underlying the action of steam in turbines; calculations involved in turbine design; discussion of building, erecting, and testing; adaptability to special conditions of service; economic results of the use of turbines in engineering practice. Assistant Professor CLARK.

351. **Internal Combustion Engines.** Elective. Seniors. First term. Credit two hours. Prerequisite courses 318a, b, 319a, b, and 340a, b, or 343a, b. Two lectures a week. Fuels; general theory and salient points in the design and operation of internal combustion engines; description of existing commercial types, study of relative advantages, and consideration of questions of economy. Assistant Professor CLARK.

352. **Steam Boilers and Boiler Plants.** Elective. Seniors. Second term. Credit two hours. Prerequisite courses 318a, b, 319a, b, and 340a, b, or 343a, b. Lectures on fuels, combustion, types of boilers, general proportions, materials, design of boiler details, settings, stokers, accessories, and the equipment and arrangement of boiler plants. Assistant Professor HOOK.

353. **Pumping and Pneumatic Machinery.** Elective. Second term. Credit two hours. Prerequisite course 340 or 343. Principles involved in the pumping of liquids and the compression of air and other gases; study of the various types of commercial machines commonly used. Professor ELLENWOOD.

359. **Advanced Heat-Power Engineering Research.** Elective for those who have completed the equivalent of the design subjects in Senior Group A. Work and credit as arranged with Professors BARNARD and ELLENWOOD.

EXPERIMENTAL ENGINEERING

The work in this department is given in two divisions: (A) Courses that are required of all students for graduation, and (B) research courses that are elective.

A. MECHANICAL LABORATORY

360. **Manufacture and Properties of Engineering Materials.** Required of sophomores. Throughout the year. Credit two hours each term. Prerequisite courses Chemistry 101 and 105. Two lectures a week. Metallurgy of iron and steel, etc. Professor DIEDERICHS.

365. **Mechanical Laboratory—Properties of Engineering Materials.** M.E. Juniors. First term. Credit four hours. Prerequisite courses 360, 330a and 331a. One laboratory period a week. Mechanical strength of materials; tension, torsion, transverse, and compression tests; the variation of the mechanical strength with

differences in composition or heat treatment; demonstration of different methods of tempering, annealing, forging, etc. The student is required to write and submit one report each week upon the experiment of the previous week. Professor DAVIS and instructors.

366. **Mechanical Laboratory—Introductory Experimental Engineering.** M.E. Juniors. Second term. Credit four hours. Prerequisite courses, Mechanics 330a and 331a, Chemistry 101 and 105, Physics 21 and 22. One laboratory period a week as assigned; one written report a week. Calibration of indicator springs, steam gauges, thermometers, and dynamometers; flue gas analysis and calculations; viscosity and friction tests of lubricants on various testing machines; tests of heating values of coals; steam quality tests, with various forms of calorimeters; tests of ignition and carburetion of gasoline engines, etc. Reports are required and must include all the data and results of the various tests, together with conclusions. The preparation of the report is considered an important part of the course. Professor DAVIS and instructors.

368. **Mechanical Laboratory—Properties of Engineering Materials.** E.E. and A.E. Juniors. First term. Credit three hours. Contents practically as course 365.

369. **Mechanical Laboratory—Introductory Experimental Engineering.** E.E. and A.E. Juniors. Second term. Credit three hours. Contents practically as course 366.

370. **Mechanical Laboratory—Experimental Engineering.** For seniors in Mechanical Engineering. First term. Credit four hours. Prerequisite courses 366, 340a, b and 334. One laboratory period a week. Efficiency tests of gas and gasoline engines, steam injectors, steam turbine, blowing fan, hydraulic turbine, and centrifugal pump. A written report is required for each experiment. Reports must be full and complete, and include data and results of each test, the testing methods used, the basic theory of the apparatus, and the performance results expressed numerically and graphically, with discussion. Professor GAGE, Assistant Professor ANDRAE, and instructors.

371. **Mechanical Laboratory—Experimental Engineering.** For seniors in Mechanical Engineering. Second term. Credit four hours. One laboratory period a week alternating with one computing period. A written report is required on each experiment. Detailed study of methods of testing and methods of computation in the following subjects: testing of engines and boilers, air compressors, ice machines; measurement of flow of water and air, etc. Reports required as in 370. Professor GAGE, Assistant Professor ANDRAE, and instructors.

372. **Mechanical Laboratory.** Required of seniors in Electrical Engineering and in Administrative Engineering. First term. Credit two hours. Prerequisite courses, 369 and 343a, b, 334. Selected experiments from Course 370. Professor GAGE, Assistant Professor ANDRAE, and instructors.

373. **Heating, Ventilating, and Refrigeration.** Required of seniors in Mechanical Engineering. Either term. Credit three hours. Lectures or recitations covering the methods of design and construction of various forms of heating and ventilating apparatus, and the principles of refrigeration. Professor SAWDON.

B. ENGINEERING RESEARCH

375. **Engineering Research.** Elective. Either or both terms. Credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates who have available at least two laboratory periods a week and who have shown proficiency in engineering subjects. Special problems and investigations which are in general carried on in the laboratories under the immediate direction of the members of this department, but which may be carried on in any department of the College under the general supervision of this department. Professors DIEDERICHS, SAWDON, UPTON, GAGE, and DAVIS.

376. **Applied Metallography.** Elective. First term. Credit two hours. Prerequisite course 360. Covers in historical sequence the development of knowledge of the internal structure of metals, and the relation of structure and properties;

the technique of metallographic research, study of application of the laws of physical chemistry to interpretation and correlation of results. Study of stable and metastable conditions; heat treatment theory and practice. The practical aim of metallography is constantly emphasized. Professor UPTON.

INDUSTRIAL ENGINEERING

380. **Industrial Organization.** Required of all juniors in Mechanical and in Electrical Engineering. Either term. Credit two hours. Open only to upperclassmen except by special arrangement. A course of lectures on modern industrial tendencies and the principles that underlie modern methods of production. The treatment includes not only the reasons for our changed methods of production but also discussion of the principal features of such industrial factors as factory legislation, factory welfare work, and modern methods of administration. Professor KIMBALL.

382a, b. **Industrial Engineering.** Two lectures or recitations a week throughout the first term, one lecture or recitation second term. Credit two hours first term, one hour second term. Prerequisite course 380. A discussion of modern time-keeping and cost-finding systems, methods of planning work and of insuring production, administrative reports, time and motion study, purchasing, etc.; plant location and arrangement; heating, lighting, and powering of plants, safety engineering, fire protection, and workmen's compensation laws. Must be accompanied by 383a, b. Professor LEE and Assistant Professor KIMBALL.

383a, b. **Industrial Engineering Problems.** Six hours of drawing, computing or time study a week throughout the first term, three hours throughout the second term. Credit two hours first term, one hour second term. Must be accompanied by 382a, b. Prerequisite courses 318 and 319. Design and layout of a plant, including the selection and location of the machinery necessary to manufacture some small assembly such as an automobile transmission. A rather detailed solution of problems in costing, planning, routing, scheduling, etc., in connection with this plant, including the development of organization charts and administrative and other forms. The work also includes a detailed study of the use of the machine rate method of distributing overhead expense and a thorough practice in the making and using of time studies and rate tables. Professor LEE and Assistant Professor KIMBALL.

386. **Industrial Relations.** Two lectures or recitations a week during the first term. Credit two hours. Prerequisite course 380. A discussion of the more important problems which arise from the relation of employer and employee under present conditions of industry. Such features are considered as the effect of organized labor, employment methods, methods of wage payment, committee systems, industrial education and personnel service activities in general. Professor LEE and Assistant Professor KIMBALL.

387. **Advanced Industrial Engineering.** Open to graduates and seniors who have completed the equivalent of 382 and 383. Professors KIMBALL, WELLS, and LEE.

ADMINISTRATIVE ENGINEERING

500. **Economic Organization.** Lectures, collateral reading, and discussion periods. Either term. Credit 5 hours. Required of all Sophomores in mechanical, Electrical, and Administrative Engineering.

The origins and development of the arrangements by which specialization and coordination in economic effort are secured and the product apportioned. The structure and working of our existing system. Its imperfections. The possibilities of their reduction or elimination through evolutionary development of the existing system. Radical criticisms which are brought against the system. Movements for change by revolution. Professor GARRETT.

501. **Business and Industrial Management.** Second term. Credit 4 hours. Required of all Sophomores in Administrative Engineering. Four lecture-discussion periods a week with regularly assigned problems.

This course is intended as a survey of the problems of business and industrial organization. It deals with the establishment of business policies, types of business and industrial ownership, together with the functions of finance, control, machine production, personnel and marketing. Elementary consideration will be given to the problems of the selection of plant site, time and motion study, wage systems and the selection of personnel, all of which will be developed in greater detail in subsequent courses. Professor BANGS.

502a. **Accounting.** First term. Credit 3 hours. Required of all students in Mechanical and Administrative Engineering. Two recitations and one 2½ hour computing period a week.

Theory of debits and credits; the journal and ledger; the development of books of original entry; the voucher system; analysis of financial statements; budgetary control; modern mechanical methods of performing the accounting function. Professor BANGS and Mr. HANSELMAN.

502b. **Accounting.** Second term. Prerequisite course 502a. Credit 3 hours. Required of all students in Administrative Engineering. Two recitations and one 2½ hour computing period a week.

This course continues the work of the first term, covering the extension of proprietorship; bond and stock issues and valuation; consolidations, mergers and holding companies; good will; depreciation; reserves; sinking funds; actuarial science; controversial and debatable accounting subjects; consolidated statements; statement analysis. Professor BANGS and Mr. HANSELMAN.

503. **Money and Banking.** First term. Credit 3 hours. Prerequisite course 500. Required of all Juniors in Administrative Engineering.

A study of the history and theory of money and banking. Professor REED.

(Note: This course will not be given before the first term of 1932–33.)

504. **Corporation Finance.** Second term. Credit 3 hours. Required of all juniors in Administrative Engineering, elective for upperclassmen in Mechanical Engineering. Prerequisite, courses 500, 502a.

A study of the financial problems of the business corporation from the points of view of the management, the investor and the public. Assistant Professor O'LEARY.

505. **Business Statistics and Forecasts.** First term 3 recitations a week. Credit 3 hours. Required of all seniors in Administrative Engineering. Prerequisite, course 500.

Elements of the technique of statistical analysis. The collection, preparation, and use of business statistics. The sources of information. Business indices and business barometers. Professor GARRETT.

(Note: This course will not be given before the first term of 1933–34.)

506. **Investments.** Second term. Credit 2 hours. Required of all students in Administrative Engineering. Elective for students in Mechanical Engineering. Prerequisite, Corporation Finance 504 and Accounting, 502a, 502b.

The course will deal with the methods and procedure used in analyzing corporate securities from the point of view of the investor. Each student will be expected to prepare several reports dealing with the securities of specific corporations. Assistant Professor O'LEARY.

(Note: This course will not be given before the second term of 1933–34.)

507a, b. **Engineering Business Law.** First and second terms. Credit 2 hours a term. Required of all seniors in Administrative Engineering. Two recitations a week throughout the year. The first term covers the ordinary legal aspects of common business transactions, emphasizing contracts, agencies, negotiable instruments, sales, etc.

The second term deals with the industrial and engineering phases of law covering the employers liability for employee injury, together with legal aspects of safety, wages, hours, working conditions and collective bargaining. Registration limited. Professor BANGS and Mr. HANSELMAN.

(Note: This course will not be given until the first term of 1933–34.)

508a, b. **Industrial Marketing.** First and second terms. Required of all seniors in Administrative Engineering. Credit 3 hours a term. Three lecture-discussion periods a week with regularly assigned problems. Prerequisite, courses 500 and 501.

The work of the first term deals with such subjects as product analysis, market analysis, marketing agencies, organized exchanges, cooperative agencies, types of middlemen, consumer demand, sales principles and sales organization.

The second term covers the changing field of distribution, reducing the cost of distribution, a study of business cycles and their application in forecasting demand for business and industry. Registration limited. Professor BANGS.

(Note: This course will not be given before the first term of 1933–34.)

509. **Cost Accounting.** Second term. Credit 2 hours. Required of all students in Administrative Engineering. One recitation and one 2½-hour computing period. Prerequisite, course 502a.

A rather detailed study of manufacturing cost systems dealing with order costs, process costs and standard costs. The distribution of Manufacturing Expense and the study of Depreciation are made a special issue. Professor BANGS, Assistant Professor KIMBALL and Mr. HANSELMAN.

(Note: This course will not be given until the second term of 1933–34.)

English. First and second terms. Required of all juniors in Administrative Engineering. Credit 3 hours a term. One lecture and two recitations a week. Lectures and readings to be a survey course of English and American Literature. Professor R. P. SIBLEY.

ELECTIVE COURSES OUTSIDE THE CURRICULUM

390. **Sibley Journal Credit.** Undergraduate members of the Sibley Journal Board may receive not to exceed two hours of University credit in each term of their senior year (i. e. a maximum credit of four hours) for work satisfactorily done for The Sibley Journal, provided they are elected to the Board during or before their sophomore year, and continue active members to the end of the term in which credit is desired.

391. **Non-resident Lectures.** Required for graduation of all seniors in Mechanical and Administrative Engineering. These lectures are given at some hour in the day specially set aside in the senior schedules. Seniors may also be required to attend certain of the non-resident lectures given in E.E. 491. Notices of the lectures will be posted on the bulletin board of the Sibley School of Mechanical Engineering. A notebook showing a résumé of each lecture attended (not more than one page for each lecture) must be handed in at the Director's office during block week at the end of the second term.

392. **Graphical Computation and Representation.** Elective. Second term. Credit two hours. Prerequisite courses 318a, 319a, 340a. Slide rules; construction of net work charts and alignment charts for the solution of equations; representation of statistics; and derivation of empirical equations from experimental curve. Assistant Professor MACKEY.

393. **A.S.M.E., Student Branch.** Members of the junior and senior classes in Mechanical Engineering may obtain one hour elective credit in one, or both years, by joining the Student Branch of the American Society of Mechanical Engineers, and by attending all of the Branch Meetings during the year. Application for membership should be made at the Director's office in October of each year, or to Professor C. O. MACKEY, Honorary Chairman of the Student Branch.

SCHOOL OF ELECTRICAL ENGINEERING

OUTLINE OF THE INSTRUCTION

The regular four-year course in Electrical Engineering is planned to give the thorough grounding in electrical engineering required by engineers connected with the design, construction, and operation of the electrical part of engineering properties. The curriculum forms a balanced course of study along broad lines, and a moderate amount of special work is provided for by elective courses. A large proportion of the work in Mechanical Engineering is also taken by those who elect Electrical Engineering, so that the student is not limited in his outlook nor in his choice of work after graduation. For those desiring a still broader training, which shall include more of the liberal arts, a six-year course leading to the degrees of A.B. and E.E., is offered. (See page 94.)

The instruction in Mathematics, Physics, Chemistry, and English is given in the College of Arts and Sciences. All other subjects in the regular curriculum are given in the various departments of the Sibley School of Mechanical Engineering, the School of Civil Engineering, and the School of Electrical Engineering.

The instruction in the School of Electrical Engineering is distributed among the following departments: (1) Fundamental Elements, (2) Advanced Theory and Research, (3) Electrical Laboratories, (4) Electrical Design, (5) Electrical Communication, and (6) Electrical Transportation.

Instruction in Electrical Engineering begins in the sophomore year, and is based on the required courses in Physics and Mathematics. Emphasis is placed on the fundamental principles, and the subject is developed by elaborating these principles. Both direct and alternating current circuits and machinery are taken up. The theory is given in experimental lectures and in recitations, and is applied to short problems in the computing room. In the laboratory, the student handles machinery, selects his own instruments and control apparatus, and makes the necessary tests to check the theoretical work.

The principal part of the work for seniors in Electrical Engineering is given in a balanced course in which advanced theory, problem work, design, and laboratory practice are combined to give the student a broad training. The electrical laboratory, being flexible, lends itself particularly to the development of resourcefulness and initiative on the part of students. A moderate amount of special work is provided for by elective courses in electrical power stations, electrical design, electrical communication, electric traction, illumination, etc., in which the classes are small and more time is devoted to these subjects than is possible in the more general courses.

Instruction in Electrical Engineering is also provided for students in Chemistry, Civil Engineering, and Mechanical Engineering, and

is adapted in each case to meet the respective requirements in those branches.

COURSES LEADING TO THE DEGREE OF ELECTRICAL ENGINEER

1. The Regular Four-Year Course

One hour of credit in the following schedules corresponds to about three hours of actual work a week for the term of fifteen weeks. Thus, from two and one-half to three hours a week of actual work in shop, laboratory, computing room, or drawing room count as one hour of credit, while each recitation hour assumes about two hours of outside preparation and counts as one hour of credit.

THE FRESHMAN YEAR

There is a single schedule of studies prescribed for all students in the freshman year of the College of Engineering, whether they expect to graduate in civil, mechanical, or electrical engineering. That schedule is set forth in full under the head The Freshman Year, beginning on page 46.

THE SOPHOMORE YEAR

	Hours	
	1st Term	*2nd Term*
Mechanics 330a, 331a	5	4
Physics, Recitations 22, 21	3	3
Empirical Design 310	2	0
Kinematics, Recitations, 312	0	2
Kinematic Drawing 313	0	1
Materials 360	2	2
Economics 500	5	0
Engineering Chemistry 775	2	0
Machine Shop 306	0	2
Electrical Engineering 410	0	4
Total number of hours each term	19	18

In addition to taking the courses named in the above schedule, all sophomores must satisfy the University's requirement of three hours a week throughout the year in Military Science and Tactics (or in Physical Training; see the General Information Number).

THE JUNIOR YEAR

	Hours	
	1st Term	*2nd Term*
Electrical Engineering 411a, 412a	5	3
Electrical Laboratory 431, 432	2	2
Heat-Power Engineering 343a, b	3	3
Mechanical Laboratory 368, 369	3	3
Machine Design, Recitations, 316	2	0
Machine Design, Drawing, 317	2	0
Hydraulics 334	0	2
Industrial Organization 380	2	0
Mathematical Applications 485	0	3
English or Public Speaking	0	3
Total number of hours each term	19	19

THE SENIOR YEAR

	Hours 1st Term	2nd Term
Electrical Theory, Lectures, 421, 422	2	2
Electrical Theory, Recitations and Comp. 423, 424	3	3
Electrical Laboratory 433, 434	3	4
Central Stations 441	3	0
Medium and High Frequency Phenomena 451	3	0
Mechanical Laboratory 372	2	0
Nonresident Lectures 491	0	1
Electives*	3	9
Total number of hours each term	19	19

*Of the elective hours, at least four must be taken in an approved technical course during the second term of the senior year. The remainder of the elective hours may be taken in any department of the University, provided the student has the necessary preparation and the approval of his class adviser.

ELECTIVE COURSES OF STUDY

A student may elect any course of study offered by any department of the University, provided he have the necessary preparation for that course and the approval of his class adviser.

Not more than four hours credit in Advanced Military Science, in addition to the required military training of the freshman and sophomore years, will be accepted toward meeting the requirements for the E.E. degree.

Following is a list of the technical electives to be given in the School of Electrical Engineering; they are for seniors and graduate students only:

Electrical Design 442	0	4
Electrical Communication Engineering 452	0	4
Elements of Electric Railway Practice 461	2	0
Industrial Applications and Control 462	0	2
Electrical Transmission and Distribution 464 (for E.E.)	0	3
Current Electrical Topics 471, 472	2	2
Engineering Mathematics 481, 482	2	2
Special Electrical Engineering Problems 483, 484	1–3	1–3
Special and Non-resident Lectures, 491, throughout the year	0	1
The Economics of Public Utilities 444	0	2
A. I. E. E. 492	0	1

PHYSICS OPTION

For some time there has been a demand for a course in Electrical Engineering with a much broader training in Physics than is possible in the regular four-year course. While no rigid curriculum is given, any sophomore with high scholastic grades in Mathematics and Physics may, upon petition, be permitted to substitute a limited amount of Physics for some of the prescribed subjects in the regular Electrical Engineering curriculum.

2. A Six-Year Course Leading to the Degrees of A.B. and E.E.

The requirements for admission to this course are those of the College of Arts and Sciences, in which the student is registered for the first four years. The student must complete the freshman engineering subjects before beginning his fourth year, and he must

complete the sophomore subjects in Electrical Engineering before beginning his fifth year. Advice and assistance in arranging the six-year course may be obtained by applying to the Director of the School of Electrical Engineering and to the Dean of the College of Arts and Sciences.

3. A Four-Year Course in Administrative Engineering Leading to the Degree of B.S. in A.E. With Special Reference to Electrical Engineering

The object of this course is given under the heading "Administrative Engineering" on page 71.

The requirements for admission are the same as for the regular four-year E.E. course, see page 33.

It is possible by an additional year of study to receive the Electrical Engineering degree, although it is highly desirable that if a student wishes both degrees he signify this intention at the beginning of the Sophomore Year.

FRESHMAN YEAR

	Hours 1st Term	2nd Term
Mathematics 5a, 5b	5	5
Physics 11, 12	4	4
Chemistry 101	3 or 0	0 or 3
Chemistry 105	3 or 0	0 or 3
Descriptive Geometry and Drawing, 120, 121	3	3
Surveying 110	0 or 3	3 or 0
Wood Shop 102	0 or 1	1 or 0
Engineering Laboratory 103	0 or 1	1 or 0
Introductory Lectures 130	1	0
Hygiene 1, 2	1	1
Total number of hours each term	20 or 19	18 or 19

SOPHOMORE YEAR

	Hours 1st Term	2nd Term
Mechanics, 330a	5	0
Mechanics and Hydraulics 332	0	5
Empirical Design 310	2	0
Kinematics, Recitation, 312	0	2
" Drawing, 313	0	1
Physics, 21, 22	3	3
Materials, 360	2	2
Engineering Chemistry, 775	0 or 2	2 or 0
Machine Shop, 306	2 or 0	0 or 2
Economic Organization 500	5	0
Business and Industrial Management 501	0	4
Total number of hours each term	19	19

JUNIOR YEAR

	Hours 1st Term	2nd Term
Electrical Engineering 415, 416	3	3
Mechanical Laboratory 369	0	3
Machine Design, Recitation 316	2	0
" " , Drawing 317	2	0
Heat Power 341	3	0
English	3	3
Accounting 502a, b	3	3
Money and Banking 503	3	0
Corporation Finance 504	0	3
Industrial Relations 386	0	2
Elective	0	2
Total number of hours each term	19	19

SENIOR YEAR
(Not given until 1933–34)

	Hours 1st Term	2nd Term
Electrical Engineering 401, 402	3	3
Electrical Laboratory 435, 436	2	2
Mechanical Laboratory 372	2	0
Business Statistics and Forecasts, 505	3	0
Investments 506	0	2
Engineering Business Law, 507a, b	2	2
Industrial Marketing, 508a, b	3	3
Cost Accounting 509	0	2
Public Speaking, 1a	3	0
Non-resident Lectures, 491	0	1
Electives	1	4
Total number of hours each term	19	19

A LIST OF THE COURSES OF INSTRUCTION

For Freshmen

A description of the courses of instruction for freshmen is given under the head The Freshman Year, beginning on page 46.

For Sophomores

Description of courses given to sophomores in Electrical Engineering and to students in Administrative Engineering by the various departments of Mechanical Engineering, as well as descriptions of courses in Physics and Chemistry common to both schools will be found in the list of courses of instruction of the Sibley School of Mechanical Engineering beginning on page 81.

For Juniors and Seniors

The courses in the following list are given in the School of Electrical Engineering. Information about other theoretical, electrical, and illumination courses will be found under Mathematics and Physics in the Announcement of the College of Arts and Sciences.

401. **Industrial Applications of Electrical Power.** Required of seniors in Administrative Engineering in Electrical Engineering. Three hours a week. A study of the principles underlying the economic application of electricity to industrial problems such as motor drives and control; electric heating and the use of electric

furnaces and ovens; transportation and handling of materials; illumination and its effect on economic production. (Not given in 1932–33.)

402. **The Economics of Public Utilities.** Required of seniors in Administrative Engineering in Electrical Engineering. Second term only. Three recitations a week. A study of the Origin and Development of Public Utilities, Franchises, Regulation and Legislation, Valuation, Rates and Rate Structures, Public Ownership and Public Relations. (Not given in 1932–33.)

410. **Elements of Electrical Engineering.** Required of sophomores in Electrical Engineering. Second term only. Credit four hours. Prerequisite Physics 21. Two lectures and two computing periods a week. An introductory study of d. c. electric and magnetic circuit fundamentals and their application to d. c. electrical machinery and equipment. Assistant Professor STRONG, and Messrs. MESERVE and COTNER.

411a. **Elements of Electrical Engineering.** Required of juniors in Electrical Engineering. First term only. Credit five hours. Prerequisite E.E. 410. Two lectures, one recitation and two computing periods a week. An introductory study of a.c. circuit fundamentals. Assistant Professor STRONG and Messrs. MESERVE and COTNER.

412a. **Elements of Electrical Engineering.** Required of juniors in Electrical Engineering. Second term only. Credit three hours. Prerequisite E.E. 411a. One lecture, one recitation and one computing period a week. A continuation of E.E. 411a. Application of circuit fundamentals to a.c. machinery and equipment. Assistant Professor STRONG and Messrs. COTNER and MESERVE.

415, 416. **Principles of Electrical Engineering.** Required of juniors in Mechanical Engineering. Throughout the year. Credit three hours a term. Prerequisite courses, Physics 28a, 29a; Mechanics 330a, 331a. Two lectures and a recitation-computing period a week. First term: Electric and magnetic circuits, and direct-current machinery. Second term: Alternating-current circuits and machinery. A study of the fundamental electrical principles and their practical application to commercial electrical circuits and machinery, with a view primarily towards enabling the student to choose intelligently the proper type of electrical equipment for various service requirements met with in ordinary engineering practice. Assistant Professor STRONG and instructors.

417. **Essentials of Electrical Engineering.** Required of seniors in Civil Engineering and Chemistry. One term only; given both terms. Credit four hours. Two lectures and one laboratory experiment with report each week. The purpose of the course is threefold: (1) To review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with and give practice in the handling of electrical machinery; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice. Professor BALLARD and Messrs. JONES and HOEFER.

421, 422. **Advanced Electrical Theory.** Required of seniors in Electrical Engineering. Throughout the year. Credit two hours a term. Prerequisite courses 411, 412, and 431, 432. Two lectures a week. The work of the first term covers chiefly the laws of the electric and the dielectric circuits; representation of alternating currents by vectors and by complex quantities; the nature and effects of inductance and capacity; theory of transmission lines and transformers. The second term is devoted to the laws of the magnetic circuit, and the theory of transformers, generators, motors, and synchronous converter. The lectures are as far as possible correlated with the work in Course 423 and 424. Professor KARAPETOFF, Dr. MALTI, and instructors.

423, 424. **Advanced Electrical Theory.** Required of seniors in Electrical Engineering. Throughout the year. Credit three hours a term. Prerequisite courses 411, 412, 431, and 432; must be accompanied by 421, 422. Two recitations and one computing period a week. Problems on the work covered by Course 421, 422. Professor KARAPETOFF, Dr. MALTI, and instructors.

431, 432. **Electrical Laboratory for E. E. Juniors.** Required of juniors in Electrical Engineering. Throughout the year. Credit two hours a term. Prerequisite courses, Physics 28a, 29a; Mechanics 330a, 331a, E.E. 410, and must be accompanied by 411, 412. One laboratory period and report each week during both terms. Experimental work on the subjects taken up in 411, 412, 413. Assistant Professor B. K. NORTHROP and instructors.

433, 434. **Advanced Electrical Laboratory.** Required of seniors in Electrical Engineering. Throughout the year. Credit three hours first term, four hours second term. Must be accompanied by 421, 422, 423, and 424. Laboratory experiment, one recitation, and one report a week. Special and commercial tests on direct and alternating generators and motors, transformers, synchronous converter, and other apparatus; work on instruments and on electrical materials in the standardizing laboratory. About half of the second term may be devoted to an elaborate piece of experimental work which is carried out as a research problem. Professor CHAMBERLAIN, Assistant Professor BURCKMYER, and Mr. PAIGE.

435, 436. **Electrical Laboratory for M.E. Seniors.** Required of seniors in Mechanical Engineering. Throughout the year. Credit two hours a term. Prerequisite courses, Physics 28a, 29a, Mechanics 330 and 331, and E.E. 415, 416. Similar in scope to 431, 432. Professor CHAMBERLAIN and Messrs. WOOD and ROY.

441. **Electrical Power-Plant Design.** Required of seniors in Electrical Engineering. First term only. Credit three hours. Prerequisite courses 411, 412 and 431, 432. One lecture, one recitation, and one computing period a week. Selection and arrangement of the proper electrical equipment for direct and alternating current power-plants. Some attention is also devoted to operating features, and to questions of public policy and finance. Professor LINCOLN and Assistant Professor M. G. NORTHROP.

442. **Electrical Design.** Elective for seniors in Electrical Engineering. Second term only. Credit four hours. Must be accompanied by 422 and 424. Three recitations and one computing period a week. A study of the fundamental principles underlying the design of direct- and alternating-current machinery. Professor LINCOLN and Assistant Professor M. G. NORTHROP.

444. **The Economics of Public Utilities.** Elective for seniors in Electrical Engineering. Second term only. Credit two hours. Two recitations a week. A study of the Origin and Development of Public Utilities, Franchises, Regulation and Legislation, Valuation, Rates and Rate Structures, Public Ownership and Public Relations. Professor LINCOLN.

451. **Medium and High-Frequency Phenomena.** Required of seniors in Electrical Engineering. First term. Credit three hours. Two lectures and one laboratory or computing period a week. Prerequisites, courses 411, 412, 431, and 432 and concurrent with 421 and 423. Consideration of the theory of alternating currents as applied to telegraph, telephone, and radio communication. Special emphasis is placed upon the theory and the application of thermionic devices to electrical engineering. Professor BALLARD and Assistant Professor MCLEAN and Mr. MOEDER.

452. **Electrical Communication Engineering.** Elective. Open to seniors in Electrical Engineering. Second term. Credit four hours. Two lectures, one laboratory period and one report a week. Prerequisites, courses 411, 412, 431, 432, 421, 423, and 451. Consideration of problems, apparatus and measurements, particularly applicable to electrical communication engineering. Professor BALLARD and Assistant Professor MCLEAN and Mr. MOEDER.

455–8. **Advanced Signal Corps Course.** Elective. Open to Electrical Engineering students who elect course 452. One lecture a week during junior and senior years. Credit four hours for the course. Prerequisite, two preceding years basic military instruction. A study of military adaptations of commercial communication systems, and problems in command and leadership of Signal Corps troops. Leads to reserve commission in Signal Corps, U. S. Army. Lieutenant DON MCNEAL.

461. **Elements of Electric Railway Practice.** Elective for seniors. First term only. Credit two hours. Prerequisite courses 411, 412, and 431, 432. One recitation and one computing period a week. Apparatus and construction involved in a modern railway system, including cars and car equipment, overhead and track construction, and other topics of similar character. Some attention is devoted to the relation of electric railways to the public and to finance. Professor CHAMBERLAIN.

462. **Industrial Application and Control of Electricity.** Elective. Second term. Credit two hours. Open to seniors and graduate students. A study of electric motor drive; selection of motors; study and selection of motor control; power requirements for various kinds of machinery; electric hoists, welding, heating. Professor CHAMBERLAIN.

464. **Electrical Transmission and Distribution.** Elective for E.E. seniors. Second term only. Credit three hours. Two recitations and one computing period a week. This course is designed to give an understanding of the fundamentals of electric transmission and distribution. Prerequisites 411, 412, 431, 432, 421, 423. Must be accompanied by 422 and 424. Professor LINCOLN and Assistant Professor M. G. NORTHROP.

466. **Illumination.** Elective. Second term. Credit two hours. Open to juniors and seniors in the College of Engineering. Prerequisite courses: Physics 28a, 29a. A study of the production, measurement, and utilization of light with emphasis on the latter. Recitation, discussion and problem work. Oral reports on illumination topics of current interest are a feature of the course and supplement the text book material. (Given in alternate years.) Assistant Professor STRONG.

471, 472. **Current Topics in Electrical Engineering.** Elective. Open to seniors and graduate students in Electrical Engineering. First or second term, or both. Credit two hours a term. Two one-hour seminar periods a week devoted to the presentation and discussion of noteworthy articles in current electrical literature. The purpose of the course is two-fold: (1) To familiarize the student with the latest development in the various branches of electrical engineering; and (2) to afford some practice in abstracting, presenting, and critically discussing engineering topics of timely interest. Assistant Professor M. G. NORTHROP.

481, 482. **Engineering Mathematics.** Elective. Open to seniors and graduate students only. Throughout the year. Credit two hours. Two recitations a week and home work. General methods by which engineering problems are expressed in mathematical form. The course consists of problems taken from mechanical, civil, or electrical engineering, involving analytical geometry and the elements of differential and integral calculus. The topic will be selected to suit the class. Professor KARAPETOFF and Dr. MALTI.

483, 484. **Special Electrical Engineering Problems.** Open to seniors. First or second term or both. Credit one or more hours. A course to meet the need of students who are not particularly interested in the other electives. Theoretical and experimental investigations on electrical apparatus. Each student selects his own subject, which, however, must meet with the approval of the Director of the School of Electrical Engineering. Professors and instructors as required.

485. **Applied Mathematics.** Required of juniors in Electrical Engineering. Second term only. Credit three hours a term. Two lecture-recitations and one report a week. Selected applications of elementary calculus and analytic geometry to practical problems in electrical engineering, such as resistance of non-cylindrical conductors, most economical size of conductors for transmission lines and electrical machinery, leaky direct-current lines, average and effective values of currents, and the like. The simplest forms of linear differential equations, in application to transient electrical phenomena, will also be briefly treated. The main aim of the course is to provide experience in using the mathematics with which the student is already familiar, in application to problems in engineering. The emphasis will be laid upon formulating problems and establishing equations,

rather than upon the purely mathematical details of solution. Professor KARAPETOFF and instructors.

491. **Non-resident and Special Lecturers.** Required. Credit one hour each year. Open to juniors and seniors. These lectures are primarily intended to include the technical addresses given during the academic year before the regular meeting of the local section of the A.I.E.E., and such other special lectures as may be designated. Notice of the lectures will be posted on the bulletin board of the School of Electrical Engineering. Credit of one hour may be obtained by attending at least fifteen of the lectures offered during the academic year. For credit a notebook giving a résumé of each lecture attended (not more than about one page for each lecture) must be handed in at the Director's office during Block Week at the end of the second term. The honor system applies to attendance at these lectures.

Seminary in Electrical Engineering. For graduate students. Seniors may attend by special permission but no credit will be given. Conducted by Professor KARAPETOFF.

492. **A.I.E.E., Student Branch.** Members of the junior and senior classes in Electrical Engineering may obtain one hour elective credit by joining and taking an active part in the activities of the Student Branch of the A.I.E.E. Application for membership should be made at the Director's Office.