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VOLUME I NUMBER 6

SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS

ANNOUNCEMENT

1910-11

DECEMBER 15, 1910
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ITHACA, NEW YORK

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This announcement is intended to give detailed information to prospective students in the Sibley College of Mechanical Engineering and the Mechanic Arts of Cornell University.

For general information concerning the University and its various colleges, the requirements for admission, etc., the General Circular of Information should be consulted. This and the other Official Publications of Cornell University are listed on the last page of the cover of this pamphlet. Any one of the informational publications there mentioned will be sent gratis and post-free on application to The Registrar of Cornell University, Ithaca, N. Y.

FACULTY

Jacob Gould Schurman, A.M., D.Sc., LL.D., President.

Albert William Smith, B.M.E., M.M.E., Director of the College, Dean of the Faculty, and Professor of Power Engineering, in charge of the department.

Rolla Clinton Carpenter, M.S., C.E., M.M.E., LL.D., Professor of Experimental Engineering, in charge of Engineering Research.

Dexter Simpson Kimball, A.B., Professor of Machine Design and Construction, in charge of the department.

Henry Hutchinson Norris, M.E., Professor of Electrical Engineering in charge of the department.

George Robert McDermott, Professor of Structural Design. Absent on leave during 1910–11.

Herman Diederichs, M.E., Professor of Experimental Engineering, in charge of the Mechanical Laboratories.

William Nichols Barnard, M.E., Professor of Power Engineering, and Secretary of the College.

Vladimir Karapetoff, C.E., Professor of Electrical Engineering.

Clarence Floyd Hirshfeld, M.E., Professor of Power Engineering.

Howard Drysdale Hess, M.E., Professor of Machine Design.

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

George Stanley Macomber, M.E., Assistant Professor of Electrical Engineering.

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

Will Miller Sawdon, B.S. in M.E., Assistant Professor of Experimental Engineering.

Walter Stebbins Ford, M.E., Assistant Professor of Electrical Engineering.

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

Frank Arthur Burr, M. E., Assistant Professor of Power Engineering.

Leslie David Hayes, M.E., Assistant Professor of Machine Design.

——— ———, Assistant Professor of Mechanics of Engineering.

——— ———, Assistant Professor of Mechanics of Engineering.

Albert Edward Wells, Superintendent of Shops and Instructor in Machine Construction.

John Tainsh Williams, Instructor in Machine Design.

Charles Homer Tower, S.B., Instructor in Electrical Engineering.

William Edward Hogan, M.E., Instructor in Electrical Engineering.

Fred Hutton Kroger, B.S., M.S., Instructor in Electrical Engineering.

John F. H. Douglass, B.Sc., Instructor in Electrical Engineering.

Anson Munson Holcomb, B.S., Instructor in Electrical Engineering.

Henry Livingston Freeman, M.E., Instructor in Machine Design.

Clarence Walter Ham, M.E., Instructor in Machine Design.

Victor Raymond Gage, M.E., Instructor in Experimental Engineering.

Frank Girard Tappan, M.E., Instructor in Electrical Engineering.

John Floyd Stevens, M. E., Instructor in Electrical Engineering.

Tom Bruce Hyde, M.E., Instructor in Experimental Engineering.

Robertson Matthews, M.E., Instructor in Power Engineering.

Armin George Kessler, M.E., Instructor in Power Engineering.

Alexander Dawes Du Bois, B.S., Instructor in Electrical Engineering.
Frank Gibbs Anderson, M.E., Instructor in Electrical Engineering.
Daniel Robert Francis, E.E., B.A., Instructor in Machine Design.
Preston Littlepage Peach, M.E., Instructor in Machine Design.
Charles Everett Torrance, M.E., Instructor in Experimental Engineering.
Herbert McNair Douglass, M.E., Instructor in Machine Design.
W. Rodney Cornell, B.Sc., C.E., Instructor in Mechanics of Engineering.
Arthur Graham Bierma, M.E., Instructor in Experimental Engineering.
Guy Leroy Current, B.S. in E.E., Instructor in Experimental Engineering.
Leroy Alonzo Wilson, M.E., Instructor in Experimental Engineering.
William Roy Wigley, M.E., Instructor in Experimental Engineering.
Henry Mark Parmley, M.E., Instructor in Power Engineering.
Arden Benjamin Holcomb, A.B., Instructor in Electrical Engineering.
Fred Edgar Klinck, M.E., Instructor in Machine Design.
William Rayner Straus, M.E., Instructor in Machine Design.
Myron A. Lee, M.E., Instructor in Machine Design.
Charles Azariah Carpenter, M.E., Instructor in Machine Design.
Jerome Arthur Fried, M.E., Instructor in Machine Design.
Charles Dudley Corwin, M.E., Instructor in Machine Design.
Robert Long Daugherty, A.B., Instructor in Mechanics of Engineering.
——————— ———————, Instructor in Mechanics of Engineering.
Warren Howard Hook, M.E., Instructor in Experimental Engineering.
Joseph Franklin Putnam, M.E., Instructor in Experimental Engineering.
Stephen Remington Wing, M.E., Instructor in Experimental Engineering.
Paul Wheeler Thompson, M.E., Instructor in Power Engineering.
Tomlinson Carlile Ulbricht, M.E., Instructor in Power Engineering.
John George Pertsch, M.E., Instructor in Electrical Engineering.
——————— ———————, Instructor in Mechanics of Engineering.

Assistants

James Eugene Vanderhoef, Foreman in Foundry.
Clinton Byron Burke, Foreman of Wood Shop.
Walter Liston Head, Foreman of Forge Shop.
Raynor Egbert Seamon, Assistant in Wood Shop.
Frank A. Lynham, Assistant in Machine Shop.
Birdette Newton Howe, Assistant in Machine Shop.
Howard Stanley Bush, Assistant in Wood Shop.
Leroy Hooper, Foreman of Wood Shop.
Ward Brown Smith, Assistant in Machine Shop.
Charles Albert Brooks, Assistant in Forge Shop.
Hugh Gallagher, Assistant in Foundry.
George Washington Race, Mechanician in Sibley College.
Edgar Warren Gregory, Mechanician.
Margaret Isabelle Colquhoun, Clerk in Experimental Engineering.
Charles Alfred Culligan, Mechanician.
Fanny Elma Mix, Secretary to the Director.
Charles Bedell, Engineer.
Rowena L. Shephard, College Librarian.

PURPOSES OF INSTRUCTION

The College is organized not only to teach the fundamental principles that underlie all mechanical engineering, but also to give such practical training and such instruction in the economics of engineering as is possible in a technical school.

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, in Sibley College, an effort is made to bring the student into contact with teachers who are closely in touch with commercial engineering practice, to the end that he may thus become familiar with problems encountered in modern engineering and with commercial 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.

The success of an engineer has come more and more to depend upon his ability to meet men of education and culture on equal terms; and, since the work in the regular four-year course in this college is almost wholly technical, the student before entering the college should have a thorough general education, and if possible, the training of a liberal college course. Those who have not had this broader education should, if possible, spend one or two years in the College of Arts and Sciences. A Five-year Course for mechanical engineers, including the equivalent of one year in this latter college, is outlined on page 20; and a Six-year Course leading to the degrees of A.B. and M.E. is described on page 21. The entrance requirements for these courses are the same as for the College of Arts and Sciences and demand less mathematical preparation than is specified for the Four-year Engineering Course.

In addition to the prescribed courses in Sibley College 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.

ADMISSION AND CLASSIFICATION

The following four classes of students are admitted to the work of the Sibley College of Mechanical Engineering and the Mechanic Arts.

1. Persons that desire to begin as freshmen the regular undergraduate course leading to the degree of Mechanical Engineer.

2. Persons that have already attended some technical or similar institution and desire to enter with advanced standing the regular course in Sibley College leading to the degree of Mechanical Engineer.

3. Persons that desire to enter as special students not candidates for the degree of Mechanical Engineer.

4. Graduate students.

For the five years' course leading to the degree of Mechanical Engineer, see page 20.

For the combined course of six years leading to the degrees of Bachelor of Arts and Mechanical Engineer, see page 21.

1. REQUIREMENTS FOR ADMISSION TO THE FRESHMAN CLASS

All correspondence concerning admission to the freshman class should be addressed to the Registrar of Cornell University.

For admission to the four-year course the applicant must be at least sixteen years of age and must offer fifteen entrance units which must include English 3, History 1, Mathematics 4, and French or German 3. The four remaining units may be chosen by the student from group d, or they may be additional units from groups b and c. Not more than 2½ units, however, may be offered from group b. The term unit means the equivalent of five recitations a week for one year in a subject.

Subject	Units
Group a	
English	3
Geometry Plane	1
Geometry Solid	½
Algebra, Elementary A	1
Algebra, Elementary B	½
Algebra, Advanced	½
Trigonometry	½
Group b	
History—Ancient	½ or 1
" Modern	½ or 1
" American	½ or 1
" English	½ or 1
Group c	
German, Elementary	2
German, Advanced	1
French, Elementary	2
French, Advanced	1
Group d	
Spanish, Elementary	2
Spanish, Advanced	1
Latin Grammar and Caesar	2
Latin Composition and Cicero	1
Virgil	1
Greek Grammar and Xenophon	2
Greek Composition and Homer	1
Physics	1
Chemistry	1
Botany	1
Physiography	1
Zoology (Vert., Invert.)	1
*Biology (Zoology, Botany)	1
Drawing	½ or 1

*Biology may not be counted if either Botany (1 unit) or Zoology (1 unit) has been offered.

For details concerning entrance subjects and methods of admission see pages 4 to 21 of the General Circular of Information.

2. ADMISSION TO ADVANCED STANDING

All correspondence concerning admission to advanced standing should be addressed to the Registrar of Cornell University.

A student who, having already attended some technical or similar institution, desires advanced standing in the regular course in the Sibley College of Cornell University should file with the Registrar of Cornell University, on an official blank to be obtained from him, a formal application for admission to advanced standing in Sibley College along with an official certificate from the institution already attended, of (1) his honorable dismissal, (2) his entrance examinations in detail, (3) his terms of attendance and the amount of work that he has completed, and (4) a detailed statement of the courses pursued for which he desires credit at Cornell. He should send also 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.

3. ADMISSION AS SPECIAL STUDENTS

All correspondence concerning the admission of special students should be addressed to the Secretary of Sibley College.

Men at least twenty-one years of age may be admitted as special students in mechanical engineering not candidates for a degree, provided they have had considerable experience in some line of mechanical engineering work and give evidence of ability to do creditable work in the college; and provided they have neither been previously admitted to the University nor have been refused admission.

They will be required to have completed before admission the mathematical preparation of the regular students,—plane and solid geometry, elementary and advanced algebra and plane trigonometry,—and may be held for examination in these subjects. Special students must conform to all the regulations to which the regular students are subject. Upon fulfillment of all entrance requirements special students may become regular students and candidates for the degree. Special students will not, however, be permitted to make up deficiencies in entrance subjects by attending University instruction in those subjects.

4. ADMISSION AS GRADUATE STUDENTS

All correspondence relating to graduate work should be addressed to the Dean of the Graduate School.

In all departments in Sibley College, work is arranged to meet the special needs of graduate students. Graduate students register in the Graduate School and not in Sibley College. To be registered as a candidate for the degree of Master of Mechanical Engineering, the student must have satisfied the equivalent of the requirements of Sibley College for the M.E. degree. For further information regarding admission, registration, etc., see Announcement of the Graduate School.

GENERAL OUTLINE OF INSTRUCTION

The instruction in mathematics, in chemistry, in physics, and in general 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 Sibley College in the following departments:—1. Mechanics of Engineering; 2. Machine Design and Construction; 3. Experimental Engineering; 4. Power Engineering; 5. Electrical Engineering.

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

1. DEPARTMENT OF MECHANICS OF ENGINEERING

Instruction in this department begins with the course in the fundamentals of theoretical and applied mechanics, which is open to those who have had the necessary preliminary courses in analytical geometry and calculus. As the instruction in this subject is in direct preparation for nearly all of the engineering work that follows, the training is made most thorough. In brief, the course includes the mathematical and graphical treatment of statics as applied to material points and rigid bodies (centers of gravity, moments of inertia, forces, couples, framed structures, graphical statics, etc.); the kinetics of material points and rigid bodies, with applications to mechanisms (motions, velocities, accelerations, centrifugal and inertia forces, energy, power, resistance, etc.); and the mechanics of materials, (stresses, strains and resiliance of materials, the forces and moments produced by the loads acting on structural members, and the strength, deflection and curvature of these members).

Instruction is also given in this department in the elements of hydraulics, including hydrostatics and hydrokinetics, and in the theory of hydraulic machinery. The laboratory instruction in hydraulics is given in the Department of Experimental Engineering.

2. DEPARTMENT OF MACHINE DESIGN AND CONSTRUCTION

The courses in shopwork, drawing, and design are organized under one department to secure the close correlation of these subjects. Many of the exercises in the drawing room, pattern shop, foundry, and machine shop severally involve work on individual machine parts. In this way the student has presented to him all the necessary steps in the inception and production of finished machine parts.

Shopwork. The object of the instruction in this branch of the department is to not only 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, in the selection and arrangement of shop equipment, and in the organization and administration of industrial works. The student attends lectures on the general principles of engineering; he receives instruction in the foundry in moulding, core making, mixing of metals, operation of cupola, the use of moulding machines, etc., with consideration given to the methods and appliances for sweep-work, large work, and production in quantities; and he is given manual instruction in the forging and heat treatment of both iron and steel, supplemented with illustration of drop hammer work and methods used in manufacturing in large quantities.

Wood working is taught 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.

The principles of manufacturing are taught by lectures, supplemented by work of illustrative character in the machine shop, where carefully graded instruction is given in the use of measuring instruments, hand tools, and machine tools, including automatic and semi-automatic tools, 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 wage systems. The instruction is given to a great extent in connection with the construction of commercial machines.

Instruction is also given in the organization of industries, the finance of manufacturing, factory legislation, welfare work, rewarding labor, etc.

Machine Design. Instruction in this branch of the department begins with lettering, the use of drawing instruments, and descriptive geometry, followed by the elements of mechanical drawing according to the best modern practice in commercial drafting rooms.

Following this the student is taught empirical design and the principles of mechanism. The drawing room work in the latter course is closely related to the class room instruction in cams, gearing, and linkages, with application to the kinematic design of machines.

After the student has received instruction in mechanism and applied mechanics, he takes up the mathematical side of machine design, the instruction being given by lectures, recitations, and drawing room work. The student "lays out" mechanisms on the drawing board, analyzes the force, velocity, and energy transformations involved; proportions the members with consideration of strength, rigidity, and shop operations; and makes working drawings for the complete designs of machines.

In the senior year the student has the option of continuing the work of the preceding year, undertaking larger, broader, and more complex problems in the design of engineering structures and in the design, construction, and equipment of mills, factories, power houses, etc.

3. DEPARTMENT OF EXPERIMENTAL ENGINEERING

Instruction in this department begins 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 12) 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 settings; tests of boilers, steam engines, turbines, pumps, heaters, condensers, and injectors and other steam apparatus; test of air compressors and refrigerating machines; tests of external and internal combustion gas and oil engines; and tests of hydraulic machinery.

Research engineering is encouraged in this department and is in charge of a separate corps of specialists who devote their entire time to this work. Seniors and graduates 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.

4. DEPARTMENT OF POWER ENGINEERING

All students in Sibley College receive instruction in this department in their junior and senior years with the object of training them in the methods of solution of problems involved in the theory, design, and economics of heat engines and their auxiliary apparatus, considered both separately and in combination in power plants.

The work in this department begins with lectures and recitations on the elements of heat-power engineering, which includes the study of elementary thermodynamics of gases and vapors, theoretical and actual cycles, internal and external combustion engines, steam engines, fuels, boilers, producers, and accessories. This course is open to those who have had the necessary preparatory courses in sophomore mechanics and physics.

In their senior year all students in the college take the more advanced lecture, recitation, and computation courses devoted to problems involved in the selection and arrangement of power plant equipment with special attention to economic factors. In addition the student may specialize in this year in the design of steam engines or of internal combustion engines, by taking the lecture and drafting courses specially devoted to these subjects. He may also attend special lecture courses on steam turbines, steam boilers, and gas manufacture.

5. DEPARTMENT OF ELECTRICAL ENGINEERING

Instruction in electrical engineering is based on the required courses in physics and mechanics. The instruction begins with the elements of electrical engineering taught by experimental lectures, recitations, and laboratory exercises. Briefly, this introductory course covers a review of the fundamental laws of electric and magnetic circuits, electrical measurements, and the theory, structural features, and operating characteristics of electrical apparatus.

In the senior year the students who are specializing in mechanical engineering have a brief advanced laboratory course and receive instruction in the solution of such electrical problems as are encountered in general engineering practice.

Those who specialize in electrical engineering receive in the senior year more advanced instruction by lectures, computation exercises, and laboratory experiments. This subject is approached from three points of view: (a) experimental; (b) analytical; and (c) graphical. Each senior follows through a series of problems in which, starting with the data given, he makes application of the fundamental principles involved and predicts the performance of the mechanism or apparatus under various conditions of operation. In the laboratory a large variety of experiments show the characteristics of machines under operating conditions, and familiarize the students with the construction and operation of the various types of apparatus.

During the second term of the senior year a number of courses are offered by specialists in the different departments of the field of electrical engineering, these courses being planned simply to illustrate the manner in which the several industrial requirements are met. Electric railway engineering, telephone engineering, wireless telegraphy, power generation and transmission, and the design of electrical machinery are the topics treated this year. The students do not become engineers or designers in these various fields, but they learn enough of each to appreciate the kind of problems which predominate. In addition to these courses the electrical engineering students may elect work in other departments subject to the approval of their class adviser.

Non-Resident Lecturers. Supplementing the regular course of instruction, lectures are delivered from time to time by non-resident specialists in the profession.

BUILDINGS AND EQUIPMENT OF SIBLEY COLLEGE

The Sibley College of Mechanical Engineering and the Mechanic Arts receives 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 $130,000 for later constructions. 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 College, under an agreement with the late Hiram Sibley. There are five large buildings and several smaller ones. The college is supported by the general University endowment.

The main building is three hundred and seventy feet long, fifty feet in width, and three stories in height. It contains the reading room and reference library, drawing rooms, lecture rooms, offices and class rooms, and a large and well-lighted auditorium.

Franklin Hall is occupied on its first two floors and basement by the Department of Electrical Engineering, which in addition uses a portion of the basement of the main building for laboratories.

The Department of Experimental Engineering occupies a two story building one hundred and fifty feet long by forty feet wide, a gas engine laboratory forty by sixty feet, a boiler plant thirty by forty feet, an engine room forty by fifty feet, a refrigeration laboratory thirty by forty feet, and the east basement of the main building.

The machine shop and pattern shop occupy a two story building one hundred fifty feet by forty feet; and the foundry and forge shops, a one-story building one hundred and eighty by forty feet.

WORKSHOPS

The Shops are fully equipped throughout with standard hand and machine tools, selected with the view not only of giving manual instruction but also of illustrating modern manufacturing methods. The pattern shop has recently been completely re-equipped with new benches, lathes, and other power tools. The foundry contains five moulding machines of the various types and is equipped with a two-ton cupola, core ovens, crane, and over-head trolley, as well as with an ample supply of modern flasks and hand tools. The forge shop is equipped with twenty-eight standard forges and also contains a drop hammer, power shears and punch press. The machine shop is equipped with twenty-five standard lathes, two shaping machines, one large radial drill press, two standard drill presses, one horizontal and one vertical boring mill, two semi-automatic lathes, one automatic lathe, two grinding machines, and one key-seater, as well with as an ample supply of small hand tools. This shop has been equipped particularly for the purpose of illustrating modern manufacturing methods.

MECHANICAL LABORATORIES

The instruction in the Department of Experimental Engineering is given in several separate laboratories, each of which is thoroughly equipped with the machines, apparatus, and instruments necessary for instruction in research.

The Materials Testing Laboratory. This laboratory is equipped for tension and compression tests with an Olsen 300,000 pound machine, a Riehlé 100,000 pound machine, a 200,000 pound Emery hydraulic machine, together with several other machines varying in capacity from 10,000 to 100,000 pounds. For transverse tests there is a Riehlé machine of 200,000 pounds capacity and a Fairbanks machine of 10,000 pounds capacity. There is one Olsen torsion machine of 200,000 inch-pounds capacity, and two Thurston autographic torsion machines. The equipment includes measuring instruments, such as extensometers, a cathetometer, gas furnaces, tempering baths, and 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.

The Steam Laboratory. In this laboratory there is a 150 H.P. triple expansion Allis-Corliss engine so fitted up that it may be run as a simple, compound, or triple engine, condensing or non-condensing. There are also many smaller engines, including a McEwen, a Straight Line, a Russell, a Harris-Corliss, and two Payne engines, together with three surface condensers which may be connected up to these engines as desired. There is one 35 K.W. horizontal Curtis turbine and one 15 K.W. De Laval turbine. These turbines drive electric generators and may be run condensing or non-condensing.

There is a two-stage steam driven Ingersoll-Rand compressor, and three air-brake pumps of different types, together with meters, nozzles, and other instruments used in testing. The action of the air-brake may be studied in a complete brake equipment for a 25-car train. This part of the laboratory also contains several motor-driven fans, including one of the Sirocco type.

The equipment of apparatus and instruments used for engine testing comprises about 80 indicators of different types, about 75 steam gauges, a number of calorimeters for the 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 H.P. Babcock & Wilcox water-tube boiler of the marine type, and one 100 H.P. Babcock & Wilcox water-tube boiler of the standard type, both of which are fitted with internal superheaters. There is also one 80 H.P. Heine water-tube boiler and one 25 H.P. Roberts safety boiler connected with a Foster outside superheater. The auxiliary apparatus consists of one Cochrane open heater, one 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., completes the boiler equipment.

The Gas Engine Laboratory. The equipment consists of an 8 H.P. Westinghouse gas engine, an 8 H.P. Olds gasoline engine, an 8 H.P. Fairbanks gasoline engine, a 6 H.P. Hornsby-Akroyd oil engine, a 12 H.P. Priestman oil engine, and a 16 H.P. Acme gas engine run on producer gas from a 15 H.P. suction gas-producer. A 50 H.P. suction gas-producer is in course of erection. This engine equipment is chosen to give as great a variety as possible in fuel used, type of governing, etc. Hot air engines are represented by one Rider and one Ericsson engine. This laboratory is well equipped for work of investigation and testing, having a special testing floor. The supply of testing instruments includes several outside-spring indicators, optical indicators, and a manograph. For temperature measurements there are available high reading thermometers and pyrometer of the expansion and electrical types.

The Hydraulic Laboratory. In this laboratory are several small water wheels of the Pelton type, a small American turbine, several rotary and centrifugal pumps, and three hydraulic rams of different types and capacities. For the determination of the flow of water there are weir boxes and weir tanks, weir notches of different types, nozzles, hook gauges, a current meter, and several Venturi tubes.

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, together with the necessary hydrometers and thermometers.

The Refrigeration Laboratory. For the study of refrigeration in all its phases, the mechanical laboratory possesses a very complete York refrigerating plant having a capacity of 15 tons of ice, besides a Brunswick and a De La Vergne machine of small size.

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 laboratory equipment includes apparatus for the study of power transmission, such as Morin and Webber transmission dynamometers, a Reeves variable speed transmission, and a belt testing machine, by means of which not only the efficiency of transmission but also the amount of belt slip and the coefficient of friction may be determined.

THE ELECTRICAL EQUIPMENT

The Department of Electrical Engineering is fully equipped with modern apparatus for experimental lectures, laboratory practice, plant testing, standardizing of instruments, and investigation. This apparatus has been selected primarily to exemplify modern shop tests and to familiarize the student with the practical apparatus as well as with the theory of operation of electrical devices.

The Lecture Equipment. In addition to the usual complement of apparatus for demonstration, the lecture equipment includes an air-insulated, high-pressure transformer, with necessary regulators for subjecting insulators and insulating material to alternating pressures up to 60,000 volts. This can be supplemented by additional transformers for raising the pressure still higher. A 30,000 volt inductorium provides current for wireless telegraphy. Large cathode ray tubes, supplied from a special multiple plate, power driven, static machine, are used for the demonstration of alternating current phenomena. All the standard equipment, as well as many pieces of specially designed apparatus, are employed to illustrate the operation of the principal laws applied in electrical engineering. Exhibits of apparatus, such as street railway car controllers, rail sections, insulating and line material, etc., are provided in profusion. This list includes a complete outfit for exhibiting in actual operation the mutiple system of electric car control.

The Laboratories. The laboratory apparatus comprises a full complement of modern alternating and direct current machinery of all kinds. The alternating current equipment includes single and polyphase alternators and synchronous motors, induction motors, transformers, and all apparatus auxiliary thereto. A large variety of direct current dynamos and motors suitably mounted for testing, cover the field of direct current machinery. A De Laval steam turbine, geared to a double current generator, a direct connected marine set and circuit breakers, switches, water rheostats, and other auxiliaries are in use for plant test experients. The plant testing is done largely outside of the college building, and for this purpose a large variety of ammeters, voltmeters, wattmeters, and other instruments are maintained in adjustment at a high standard of accuracy. These nstruments have capacity great enough for testing the largest power plants

Special facilities are provided for the standardization of all electrical apparatus. Board of Trade and Reichsanstalt standards of resistance with large current carrying capacity, potentiometers and galvanometers, and reference standards of electro-motive forces are among the facilities provided for this purpose. A remarkable set of generators recently installed produces a pressure of 14,000 volts direct current by connecting in series and most carefully insulating twenty-four 550 volt dynamos. The pressure thus available gives opportunities for a wide field of investigation. In addition to the apparatus in the laboratories, the students may observe in operation a three-phase power transmission in the local power and lighting service. Large direct-connected generators, rotaries, constant current regulators and induction motors, as well as the lighting and railway system are convenient for inspection. The University has recently installed a modern hydro-electric plant containing large three-phase alternators direct driven by Doble impulse water wheels. The power station also contains smaller units for direct current supply with all necessary auxiliary apparatus.

ENGINEERING LIBRARY

In addition to the well equipped engineering library located in the main building the student has access to the General Library of the University and to the special libraries of the other colleges of the University.

SCHOLARSHIPS AND PRIZES

A special pamphlet on scholarships and prizes is published by the University. It may be had on application to the Registrar.

A detailed description of the scholarships that are open to members of the entering freshman class is given in the General Circular of Information.

Particular attention is directed to the following which are open only to students in the Sibley College of Mechanical Engineering and the Mechanic Arts.

Sibley Prizes in Mechanic Arts. Under the gift of the late Hon. Hiram Sibley, made in 1884, the sum of one hundred dollars will be annually awarded to those students in the Sibley College who shall, in the opinion of the Faculty of that institution, show the greatest merit in Sibley College work.

The Frank William Padgham Scholarship, covering tuition and fees in Sibley College, will be assigned to the best competing candidate in the scholarship examination in the studies required for entrance to the regular course in Mechanical Engineering, who shall have had his preparatory education in the public schools of Syracuse, N. Y. The holder shall pursue the regular course in Mechanical Engineering in Sibley College, and will be excused from the payment of tuition and the regular Sibley College fee.

This special undergraduate scholarship cannot be held in connection with a New York State Scholarship.

COURSES OF STUDY

The following courses of study are offered:

1. The regular course in the Sibley College of Mechanical Engineering and the Mechanic Arts, leading to the degree of Mechanical Engineer and covering a period of four years.

2. A five years' course, in which the student is during his first two years of residence registered in the College of Arts and Sciences. The five years' course leads to the degree of Mechanical Engineer.

3. A six years' course, in which the student is during his first three years of residence registered in the College of Arts and Sciences. The six years' course leads to the degree of Bachelor of Arts at the end of the fourth year and to the degree of Mechanical Engineer at the end of the sixth year.

These courses are separately described on pages 16, 20, and 21.

1. THE FOUR YEAR COURSE LEADING TO THE DEGREE OF MECHANICAL ENGINEER

In the regular four-year course leading to the degree of Mechanical Engineer, instruction is the same for all students during the first three years. In the fourth year, some opportunity is offered for specializing in the different branches of mechanical and electrical engineering.

The sequence of subjects in the four-year course and the time devoted to each course, are tabulated below. The detailed descriptions of the courses are given on pages 23 to 35.

Schedule of Four Year Course

In referring to courses the following abbreviations are used:—Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Machine Design, D; Shop, S. For description of courses given in Sibley College see pages 23–35; for description of courses given by other colleges, see pages 22 to 23.

About three hours of actual work in shops, laboratories, computing work, and drawing count as one hour credit in the schedule.

FRESHMAN YEAR

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytic Geometry	22	1a	4	0
Differential Calculus	22	1b	1	2
Integral Calculus............	22	1c	0	4
Chemistry	22	1	0 or 6	6 or 0
Physics Lectures	22	1	4 or 0	0 or 4
Physics Recitations	22	5	2 or 0	0 or 2
Drawing and Desc. Geom	24	D1	3	3
Foundry	24	S3	2 or 0	0 or 2
Forge	24	S4	0 or 1	1 or 0
Engineering Principles	24	S2	0 or 1	1 or 0
Military Drill		1	1	1

Sophomore Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering ..	23	M5, 6	5	5
Physics Recitations	22	8, 9	2	2
Physics Laboratory	22	14	2	2
Chemistry	23	6	0 or 5	5 or 0
Kinematics	25	D6	0	2
Drawing	25	D5, 7	3	3
Materials	27	X6	2 or 0	0 or 2
Pattern Making	24	S7	3 or 0	0 or 3

In addition to the above, three hours a week of either Military Drill or Physical Culture must be taken in the sophomore year.

Junior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Heat-Power Engineering	29	P10	3	3
Electrical Machinery, Lectures, Recitations and Laboratory	31	E10	4	4
Mechanical Laboratory	27	X10	3*	0
Mechanical Laboratory	28	X11	0	3
Machine Design				
(a) Lectures and recitations	26	D16	3	2
(b) Drawing	25	D10	2	2
Machine Work..............	24	S10	2	2
Principles of Manufacturing ..	24	S11	2	0
Hydraulics.................	23	M12	2 or 0	0 or 2

*Replaces former sophomore course X7 and not regularly given for juniors in 1910-11. Juniors who have not had course X7 should take X10 in the second term with the seniors.

Senior Year

In the senior year the student must complete one of the following groups:

Group A. Steam Power Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	30	P20	3	3
Mechanical Laboratory	28, 27	X20, 10	3	3
Electrical Laboratory........	34	E29	3 or 0	0 or 3
*Electrical Engineering Problems	35	E31	0 or 2	2 or 0
*Industrial Organization	24	S20	2	0
Economics	23	52	2	2
Steam Machinery Design	30	P21	3	3
Designing and Drawing	30	P22	3	3
Steam Turbines	31	P25	0	2

*By petitioning the Faculty on or before Oct. 31 a thesis, or investigation, may be offered as a substitute for these subjects. A bound copy of this thesis, in the original typewriting (not a carbon copy) and in standard form, must be delivered to the Director's office before May 15th. This copy will become the property of the University.

Group B. General Mechanical Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	30	P20	3	3
Mechanical Laboratory	28, 27	X20, 10	3	3
Electrical Laboratory........	34	E29	3 or 0	0 or 3
*Electrical Engineering Problems	35	E31	0 or 2	2 or 0
*Industrial Organization	24	S20	2	0
Economics	23	52	2	2
General Engineering Design ..	26	D22	3	3
Design and Drawing	26	D23	3	3
Steam Turbines	31	P25	0	2

Group C. Gas Power Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	30	P20	3	3
Mechanical Laboratory	28, 27	X20, 10	3	3
Electrical Laboratory........	34	E29	3 or 0	0 or 3
*Electrical Engineering Problems	35	E31	0 or 2	2 or 0
*Industrial Organization	24	S20	2	0
Economics	33	52	2	2
Gas Machinery Design	31	P26	3	3
Designing and Drawing	31	P27	3	3
Gas Manufacture............	31	-P28	0	2

Group D. Electrical Engineering

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	30	P20	3	3
Mechanical Laboratory	28, 27	X20	3	0
Electrical Laboratory........	34	E28	4	4
Electrical Engineering	32	E20	2	2
Electrical Engineering	32	E21	4	4
*Industrial Organization	24	S20	0	2
Economics	23	52	2	2
*Elective— E22, 23, 24, 26, or 27, 32–35			0 or 2	2 or 0

*By petitioning the Faculty on or before Oct. 31 a thesis, or investigation, may be offered as a substitute for these subjects. A bound copy of this thesis, in the original typewriting (not a carbon copy) and in standard form, must be delivered to the Director's office before May 15th. This copy will become the property of the University.

Suggested Technical Electives

These electives may be taken only with the approval of the Class Adviser and of the departments concerned. For detailed information see announcements of the departments giving the courses.

FOR SENIORS ONLY

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
*Steam Boiler Design	30	P23	2	0
Steam Turbines	30	P25	0	2
Gas Manuf. and Distribution	31	P28	0	2
Gas Power Machinery	31	P29	2	0
Advanced Design	31	P39	1–3	1–3
Engineering Research	28	X22	1–3	1–3
Power Plant Testing	29	X23	1–3	1–3
Motor Car Construction	29	X24	0	1
Heating and Ventilating	29	X25	0	2
Mechanical Refrigeration	29	X26	0	2
Engineering Calculations	34	E30	2	2
Research in Elect. Eng	35	E33	1–3	1–3
*Structural Engineering	26	D24	2	0
*Ship Design	27	D26	0	3
*Structure and Strength of Ship	27	D27	0	3
*Resistance, Propulsion, etc	27	D28	0	2
*Aerial Engineering	26	D25	2	0
Advanced Designing	27	D39	1–3	1–3
Research in Elect. Eng	35	E33	1–3	1–3
Railway Cons. and Maintenance		C.E.63	0	2
Concrete Construction		C.E.77	3	3
Alternating Currents		Phys.33	2	0
Electrical Lab. Practice		Phys.34	3 or 0	0 or 3

*Not given in the year 1910–11.

FOR E.E. SENIORS ONLY

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Design of Elect. Machinery	32	E22a	0	2
Design of Elect. Machinery	33	E22b	0	2
Gen. and Dist. of Elect. Energy	33	E23a	0	2
Gen. and Dist. of Elect. Energy	33	E23b	0	2
Telephone Engineering	33	E24	3	0
Advanced Electric Railways	33	E26a	0	2
Advanced Electric Railways	34	E26b	0	2
Wireless Teleg. and Teleph	34	E27	0	2
Current Electrical Topics	35	E34	1	1

Students having the necessary preparation and having the approval of their Class Adviser may take subjects in the following list (as well as any other subjects in the University) in any year, except when the year is indicated by a figure immediately following the subject.

Course	No. Course	Hours 1st Term	Hours 2d Term
Surveying	C.E.12	0	2
Spec. and Contracts (3 or 4)	C.E.90	0	2
Elem.of Elect. Ry. Pract.(3 or 4)	E25	2	0
Illuminating Eng. (3 or 4)	E32	0	2
Assaying	Chem.18	3	0
Adv. Quant. Anal.	Chem.14	1–3	1–3
Adv. Quant. Anal	Chem.15	2	0
Qual. and Quant. Gas Anal.	Chem.19	1	0
Tech. Gas Anal.	Chem.20	2	0
Photometry	Phys.15	1–3	1–3
Photom. and Illum.	Phys.43	2	0
Photography	Phys.18	2 or 0	0 or 2
Bldg. Stone and Clay Prod.	Geol.30	0	2 or 3
Practical Geology	Geol.31	3	3
General Econ. Geol.	Geol.32	2 or 3	2 or 3
Mining of Mineral Deposits	Geol.34	2	2

2. A FIVE-YEAR COURSE LEADING TO THE DEGREE OF MECHANICAL ENGINEER

Requirements for Admission

The requirements for admission to the five-year course are those of the College of Arts and Sciences, in which college the student will be registered for the first two years. For these requirements see page 6 of the Circular of Information for Prospective Students. Before transferring to Sibley College at the beginning of his third year of residence, the student must have satisfied all the entrance requirements for the regular four years' course in Sibley College.

Outline of Course

The following outline gives the subjects which must be taken in the first two years in order that the student may enter the third year properly prepared.

In referring to courses of instruction the following abbreviations are used: Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Machine Design, D; Shop Work, S. For description of courses given in Sibley College see page 23; for description of courses given by other colleges, see the announcements of those colleges.

First Year (in the College of Arts and Sciences)

Course	No. Course	Hours 1st Term	Hours 2d Term
Solid Geometry	6a	3	0
Trigonometry	7a	3	0
Advanced Algebra	5a	0	5
Chemistry	1	0	6
Descriptive Geometry	D2	3	0
Engineering Principles	S2	0	0
Elective in Arts		9	6

SECOND YEAR (in the College of Arts and Sciences)

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytical Geometry	22	1a	4	0
Differential Calculus	22	1b	1	2
Integral Calculus	22	1c	0	4
Chemistry	23	6	5	0
Physics Lecture	22	1	0	4
Physics Recitation	22	5	0	2
Drawing	25	D3	0	3
Foundry	24	S3	2	0
Elective in Arts			6	3

THIRD YEAR (in Sibley College)

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	23	M5, 6	5	5
Physics Recitations	22	8, 9	2	2
Physics Laboratory	22	14	2	2
Kinematics	25	D6	0	2
Drawing	25	D5, 7	3	3
Materials	27	X6	2	0
Forge Work	24	S4	1	0
Pattern Making	24	S7	0	3
Elective in Arts			4	2

FOURTH AND FIFTH YEARS

The fourth and fifth years are identical with the third and fourth years of the regular four-year course (see page 17, 18).

3. A SIX-YEAR COURSE LEADING TO THE DEGREES OF A.B. AND M.E.

A student in the College of Arts and Sciences who has satisfied at least six terms of residence, no one of them under the provisions of paragraphs (2) or (3) page (i of Announcement of Courses of Instruction the College of Arts and Sciences) and who has a credit of at least ninety hours, may, with the permission of the faculties concerned be registered both in the College of Arts and Sciences and also in any other college of Cornell University.

This provision enables a student who so desires, to obtain the degree of A.B. from the College of Arts and Sciences at the end of four years, and the degree of M.E. from Sibley College at the end of six years. Advice and assistance in arranging such a course may be had by applying to the Director of Sibley College and the Dean of the College of Arts and Sciences.

COURSES OF INSTRUCTION

The following courses required of students in Sibley College are given in the college of Arts and Sciences.

1. **Analytic Geometry and Calculus.** Twenty-four sections, daily except S, first term; daily, second term.

- 1a. Analytic Geometry. Credit four hours first term.
- 1b. Differential Calculus. Credit one hour first term, two hours second term.
- 1c. Integral Calculus. Credit four hours second term.

1. **Introductory Experimental Physics.** Repeated in second term, credit four hours. Professors NICHOLS, MERRITT, and SHEARER. M T W Th, First term 9 or 12, second term 12, Rockefeller A.

Entrance Physics is not accepted as an equivalent for this course.

5. **Introductory Physics.** Class room work. Repeated in second term, credit two hours. Messrs. GIBBS, HOWE, MURDOCK, FORMAN, and ZELLER. M W, or T Th, Rockefeller, to be assigned.

8. **General Physics.** Theory. First term, credit two hours. Prerequisite courses 1 and 5 and Mathematics 1. Messrs. FISHER, GALAJIKIAN, MOLBY, RICHTMYER, RODGERS, TAYLOR, GOLDBERG, HARRINGTON, and WING. Two days as assigned, Rockefeller, as assigned.

Text-book work in statics, dynamics, properties of matter, and heat, including thermometry, expansion, calorimetry, radiation and conduction. Two hours of course 14 must be taken in connection with course 8.

9. **General Physics.** Theory. Second term, credit two hours. Prerequisite courses 8 and the first term of 14. Instructing staff as in course 8. Two days as assigned, Rockefeller as assigned.

Text-book work. A continuation of course 8. Magnetism and electricity properties of vapors, and an introduction to the kinetic theory of gases and thermodynamics. Two hours of course 14 must be taken with course 9.

14. **Physical Experiments.** Throughout the year, credit two hours a term. Prerequisite courses 1 and 5. Assistant Professor BLAKER, and Messrs. RICHTMYER, FISHER, DORSEY, GALAJIKIAN, MOLBY, RODGERS, TAYLOR, GOLDBERG, HARRINGTON, and WING. Rockefeller 250–257 as assigned.

Physical measurements, properties of matter, mechanics, heat, light, sound, magnetism, and electricity; the adjustment and use of instruments of precision. Results and errors are carefully discussed. Two hours of course 14 must be taken with course 8 and two hours with course 9.

1. **Introductory Inorganic Chemistry.** Lectures, recitations, and laboratory. Repeated in second term, credit six hours.

1a. Lectures. First term, T Th S, 11, Professor DENNIS and Mr. SUTHERLAND; M W F, 11, Professor BROWNE and Mr. SUTHERLAND. Second term, M W F, 11. Morse 1.

1b. Recitations (one hour a week), and laboratory (two 2 ½ hour periods a week) to be arranged. Professors DENNIS and BROWNE, Mr. WELSH, and Messrs. HOLMES, HOULEHAN, GAUB, FINK, HOLLINGSHEAD, and NUNEZ.

6. **Qualitative and Quantitative Analysis.** Repeated in second term, credit five hours. Prerequisite course 1. Dr. LUNDELL, Mr. LEMON, and Messrs. MILLER, RIEGGER, DILLON, WALKER, RHODES, and UHLRICH. Lectures, T Th, 12, Morse L. R. 1.

Laboratory sections: M W F, 2–5; T Th S, 8–11; T Th S, 9–12.

Qualitative work: the properties and reactions of the common elements and acids and their detection in various liquid and solid mixtures.

Quantitative work: the preparation and use of volumetric solutions and work in elementary gravimetric analysis.

52. **Elements of Economics.** A special course for engineering students. Seniors. Throughout the year, credit two hours a term. Production and distribution of wealth, emphasizing particularly the financial or practical view instead of the theoretical. Lectures, text book readings, and class discussions. Assistant Professor BAUER.

ELECTIVES

Sibley students who have the time available may take any course in any college in the University provided they have the approval of their Class Adviser, and of the department concerned.

SUBJECTS GIVEN IN SIBLEY COLLEGE

The courses in each department in Sibley College are numbered in accordance with the following plan:

Numbers	1 to 4	inclusive	denote	freshman	subjects.
"	5 to 9	"	"	sophomore	"
"	10 to 19	"	"	junior	"
"	20 to 39	"	"	senior	"
"	40 to 45	"	"	graduate	"

About three hours in shops, laboratories, computation work and drawing count as one credit hour in the schedule.

Department of Mechanics of Engineering

M. 5 and 6. **Mechanics of Engineering.** Sophomores. M. 5 in first term, M. 6 in second term. Credit five hours a term. Prerequisites, mathematics 1. Theoretical and applied mechanics with mathematical and graphical treatment; statics of a material point and of rigid bodies,—centers of gravity, moments of inertia, resolution and composition of forces and couples, framed structures, graphical statics; kinetics of a material point and of rigid bodies, with application to mechanisms,—motions, velocities, initial velocities, acceleration, centrifugal and inertia forces, impact, energy, work, power, friction, and graphics of machines; and mechanics of materials,—stresses, strains, resilience, forces and moments produced by loads acting on structural members (beams, cantilevers, continuous girders, columns, cylinders, plates, etc.), and strength, rigidity, and flexure of members, etc. Professor WOOD, Assistant Professors ———, ———, Messrs. ———.

M. 12. **Hydraulics.** Juniors. Either term, credit two hours. Prerequisites M. 5 and 6. Hydrostatics,—pressures in tanks, centers of pressure and floatation; hydrokinetics,—flow through orifices and pipes and over

weirs, losses of head, Kutter's Formula, impulse and reaction; and theory of hydraulic machinery, including motors and pumps.
Professor WOOD and Assistant Professor ———.

Department of Machine Design and Construction

Machine Construction

S. 2. **Engineering Principles.** Freshmen. Either term as assigned, one hour credit. First half of the term, discussion of the general principles that underlie the transmission of energy from natural sources. Professor SMITH. Second half of the term, a discussion of the applications of energy. Mr. WELLS.

S. 3. **Foundry Work.** Freshmen. Either term, two hours credit. Six hours of work per week. Moulding, core making, mixing and casting of metals, use of molding machines. Demonstration of large work and production in quantities. Daily 8–11, 11–12, 2–5, as assigned. Messrs. VANDERHOEF and GALLAGHER.

S. 4. **Forge Work.** Freshmen. Either term, one hour credit. Three hours of work per week. Forging, welding, tool dressing, tempering, etc., together with demonstrations in the production of drop forgings. Daily 8–11, 11–2, 2–5, as assigned. Messrs. HEAD and BROOKS.

S. 7. **Pattern Making.** Sophomores. Either term, three hours credit. Nine hours of work per week. Prerequisite, S. 3. Use of hand and machine tools, for wood working followed by graded instruction in pattern making, construction of core boxes, etc. Daily 8–11, 11–2, 2–5, as assigned. Messrs. HOOPER, SEAMAN, BUSH, and ———.

S. 10. **Machine Work.** Juniors. Throughout the year, credit two hours a term. Six hours of work per week. Prerequisites S. 3, 4 and 7. Use of measuring tools, 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 as discussed in course S. 11. Must be accompanied by S. 11. Daily 8–11, 11–2, 2–5, as assigned. Messrs. WELLS, LYNHAM, HOWE and SMITH.

S. 11. **Principles of Manufacturing.** Juniors. First term only, two hours credit. This course must be taken in connection with course S. 10. Lectures on theory of measuring instruments, shop tools and equipment; shop processes; manufacturing methods; theory of costs and time keeping systems; factory management. Mr. WELLS.

S. 20. **Industrial Organization.** Seniors and Graduates. Either term, two hours credit. Requires S. 10 and S. 11. Lectures giving a more extended discussion of the finance of manufacturing, supplemented by an inquiry into the reasons for certain modern tendencies such as factory legislation and factory welfare work; methods of rewarding labor, bonus and profit sharing schemes, etc., etc. Professor KIMBALL.

Machine Design

D. 1. **Drawing and Descriptive Geometry.** Freshmen. Throughout the year, credit three hours a term. Nine hours of work a week. Lettering, (proficiency in at least one style of simple lettering); descriptive geometry (lectures and drawing)—including lines, planes, solids, tangents, intersections, sections, developments, with solutions in all quadrants; isometric projection; mechanical drawing; working drawings,—including conventions, standards, etc., following the best practice of commercial drafting rooms. Messrs. WILLIAMS, FRANCIS, DOUGLASS, FRIED, LEE, ———, ———, and ———.

D. 2. **Descriptive Geometry.** First year students in the Five-year Course only. First term, credit three hours. Nine hours of drawing a week. The same work in descriptive geometry as that give in connection with course D. 1. Messrs. WILLIAMS, FRANCIS, and DOUGLASS.

D. 3. **Drawing.** First term, for those taking the special course in chemistry in the College of Arts and Sciences. Second term, for second-year students in the five-year course. Credit three hours. Nine hours of drawing a week. Mechanical drawing; working drawings, including conventions, standards, etc. following the best practice of commercial drafting rooms. Drawing same as that given in connection with course D. 1. Messrs. WILLIAMS, and DOUGLASS.

D. 5. **Machine Drawing.** Sophomores. First term, credit three hours. Nine hours of drawing a week. Requires course D. 1. Application of the work of course D. 1 to machine drawing in connection with empirical designing; proportioning of machine details as fixed by common practice rather than by mathematical theory; making and using standard data sheets; making of assembly drawings. Assistant Professor HAYES, Messrs. PEACH, STRAUSS, and KLINCK.

D. 6. **Kinematics.** Sophomores. Second term, credit two hours. Requires course D. 1 (or D. 2 and 3) and must be taken with course D. 7. Two recitations a week on the theory of mechanisms, instant centers, cams gears, linkages, velocity and acceleration diagrams, etc. Assistant Professor HAYES, Messrs. PEACH, STRAUSS, and KLINCK.

D. 7. **Kinematic Drawing.** Sophomores. Second term, credit three hours. Nine hours of drawing a week. Requires course D. 1 (or D. 2 and 3) and must be taken with course D. 6. Drawing board application of the work in course D. 6. Solution of mechanisms by means of instant centers, the designing of cams, gears, linkages, etc., drawing of velocity and acceleration diagrams, etc. Assistant Professor HAYES, Messrs. PEACH, STRAUSS, and KLINCK.

D. 10. **Drawing and Design.** Juniors. Throughout the year, credit two hours each term. Six hours of drawing a week. Requires courses D. 5, D. 6, D. 7 and C.E. 20 (or M. 5 and 6), and must be taken with course D. 16. Drawing room problems in elementary machine design illustrating the work as given in D. 16. The student for the first time undertakes the design of a complete machine, laying out the general outlines, proportioning the details theoretically, and modifying his results by practical consideration. All computations necessary for the complete design must be carefully and systematically made. Working drawings of the most important details and a finished assembly drawing are completed. Professor KIMBALL, Assistant Professor ALBERT, Messrs. FREEMAN, CORWIN, ———, and ———.

D. 16. **Machine Design.** Juniors. First term, two lectures and one recitation a week; second term, one lecture and one recitation a week. Three hours credit first term and two hours second term. Requires courses D. 6, D. 7, C.E. 20 (or M. 5 and 6) and must be taken with D. 10. Selection of mechanism for specified work and study of practical considerations involved. Analysis of energy and force problems in machines. Determination of driving devices as based on work to be done. Proportioning of detail parts as dictated by stress and practical considerations. Applications of the laws of mechanics and kinematics to the design of machines and a discussion of empirical design and modifications due to practical considerations. Professor KIMBALL, Assistant Professor ALBERT, Messrs. FREEMAN, CORWIN, and ———.

D. 22. **General Engineering Design.** Required of seniors in group B. Throughout the year, three hours credit each term. Lectures. Requires D. 10, D. 16 and P. 10, and must be taken with D. 23. For students who do not wish to specialize in any particular branch of engineering but wish to get a general knowledge of mechanical engineering design and construction. The work of the first term consists of a discussion of the problems met with in the design, construction and equipment of mills, factories, etc., including foundations, walls, floors, trusses, roofs and mill and construction work in general; powering of factories, motor driving of machine tools, etc. In the second term this work is applied to the outline design of a complete power house, including the location of plant, track and wharf facilities; selecting and locating of boilers and engines; coal storage, coal and ash handling equipment; selection and arrangement of condensers, pumps, steam piping arrangement, etc. Professor HESS and Mr. CARPENTER.

D. 23. **Drawing and Design.** Nine hours of work a week throughout the year, credit three hours a term. Requires courses D. 10 and 16 and P. 10 and can only be taken in connection with D. 22 Design and drawing of various classes of work illustrating the principles discussed in D. 22. Graphical analysis of stresses in trusses and other structures. In the second term, drawings are made for the complete outline design of a power house as outlined under course 22. Professor HESS and Mr. CARPENTER.

*D. 24. **Structural Engineering.** Seniors. First term, credit two hours. Requires course D. 10 and D. 16. Fundamental principles underlying the design and construction of framed structures, involving the use of wood, steel, brick, stone, concrete, reinforced concrete, etc., singly and in combination. Application to the design of buildings suitable for engineering shops and factories. Foundations for the walls and in way of machinery, taking into account the character, stable and otherwise, of soil-bottom and nature of the loads. Framing and construction of the side and division walls, floors and roofs, of the various materials which may be employed. Modern methods of lighting and ventilation. Paints and other protective coatings for metallic and wooden structures, and to the relative costs of construction, upkeep, and repairs. Professor McDERMOTT.

*Not given in 1910–11.

*D. 25. **Aerial Engineering.** Seniors. First term, credit two hours. Prerequisite courses M. 5 and M. 6. Physics of the atmosphere; physical properties and technique of the gases used in aerostatics and derigibles. Areodynamics; theory of aerodynamic support and resistance of bodies in motion, with special reference to the results of modern experimental research. Construction of air-craft, suitable machinery and propellers. Professor McDermott.

D. 26. **Ship Design.** Seniors. Second term, three hours credit. Requires course C.E. 20 or M. 5 and 6. Lectures and computations. The conception and derivation of the elements of form; hydrostatic principles involved in the design of vessels; and the most modern methods of computing the geometrical quantities, displacements, centers of buoyancy, metacenters, moment to trim, initial stability. Register tonnage and freeboard will also be explained. Professor McDermott.

*D. 27. **The Structure and Strength of Ships.** Seniors. Second term, three hours credit. Requires courses D. 10, D. 16, and C.E. 20 or M. 5 and 6. Lectures on the structural elements, their functions and inter-relations, of the different types of vessels belonging to the mercantile and naval marine. The materials used in shipbuilding and their preservation. The rules and regulations of the chief registration bureaus. In application of the subject-matter of the lectures, a scantling section of a typical vessel will be drawn out, and strength calculation made. Professor McDermott.

*D. 28. **Resistance, Propulsion, and Powering of Ships.** Seniors. Second term, credit two hours. Requires courses D. 10, D. 16, and C.E. 20 or M. 5 and 6. Lectures discussing the fundamental hdyro-dynamic principles involved in the study of the resistance of vessels, and of the different propelling agents, chiefly the screw propeller. The mechanical space, and weight efficiencies of the different types of propelling machinery,—steam reciprocating and turbine, singly and in combination, electric, hydraulic, and of the internal combustion motors—are fully gone into and viewed from the propulsive and commercial efficiency standpoints. Methods of approximating required horse-power, and the determination of the most suitable dimensions of propeller are carefully reviewed, problems being worked out, illustrative of the methods discussed. Professor McDermott.

D. 39. **Advanced Designing.** For graduates or seniors who have had the equivalent of D. 22 and D. 23 or of D. 26, 27 and 28. Advanced work in original design as arranged for with Professors Kimball, McDermott, and Hess.

Department of Experimental Engineering

X. 6. **Manufacture of Engineering Materials.** Required of sophomores. Credit two hours, either term as assigned. Requires Chemistry 1. Two lectures a week. Metallurgy of iron and steel, copper, etc.; the manufacture of brasses, bronzes, and of other engineering materials. Professor Diederichs.

X. 10. **Mechanical Laboratory:—Properties of Engineering Materials.** Seniors in 1910–11. Second term, credit three hours. Requires X. 6, M. 5 and 6. One laboratory period a week. Mechanical strength of ma-

*Not given in 1910–11.

terials,—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 keep a standard note-book, which will be called for at stated intervals for inspection. Professor DIEDERICHS, Assistant Professor UPTON, Messrs. WIGLEY, ——— and ———.

(NOTE.—After the year 1910–11 this course will be given to juniors in the first term).

X. 11. **Mechanical Laboratory:—Introductory Experimental Engineering.** Juniors. Second term, credit three hours. Requires M. 5 and 6, or C.E. 20, Chem. 6, Phys. 1 and 5. One laboratory period a week as assigned, one written report per week. Calibration of indicator springs, steam gauges, thermometers and dynamometers; practice and tests of various computing machines; viscosity and friction tests of lubricants on various testing machines; tests of heating values of coals; steam quality tests, with various forms of calorimeters; measurement of water; efficiency test of steam engines and pumps, steam heaters and condensers. Reports are required and these must include all the data and results of the various tests, together with the conclusions. The preparation of the report is considered an important part of the laboratory course. Text book: Carpenter's Experimental Engineering. Professor DIEDERICHS, Assistant Professor UPTON, Messrs. PUTNAM, HOOK, WIGLEY and WING.

X. 20. **Mechanical Laboratory:—General Experimental Engineering.** Seniors. First term, credit three hours. Requires X. 10, 11, P. 10. One laboratory period a week. Efficiency tests of Corliss compound engine, steam injector, centrifugal blowing fan, Ericsson hot air engine, Rider hot air engine, gas engine with city gas, gas engine with gasoline and oil engine; tests on hydraulic machinery; pyrometers of various types; and valve setting on automatic and Corliss engines.

Reports are required to be full and complete, to include data and results of each test under consideration, and all information necessary to completely understand the machine tested and the methods used. Carpenter's Experimental Engineering is used as a text-book. Professor DIEDERICHS, Messrs. GAGE, BIERMA, TORRANCE, WILSON, CURRENT.

[X. 21. **Mechanical Laboratory:—Advanced Experimental Engineering.** Required of seniors. Second term, credit three hours. One laboratory period per week alternating with one computing period. Written report required on each experiment. Detailed study of methods of testing and methods of computation in the following subjects: Boiler testing and flue gas analysis; triple expansion Corliss engine with heat analysis; De Laval and Curtiss turbines with heat analysis; two-stage air compressor; refrigerating machine; belt testing; flow of water over weirs and through nozzles.

Concerning the requirements governing reports see last paragraph under X. 20 above.]

(NOTE.—This course will not be given in the year 1910–11. Course X10 will be substituted for it in the second term for seniors.)

X. 22. **Engineering Research.** Elective. Either term, credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates who have shown proficiency in research engineering. Commercial tests and special problems. Professor CARPENTER, Assistant Professor SAWDON and Mr. HYDE.

X. 23. **Power Plant Testing.** Elective. Either term, credit one hour for forty hours of actual work. Open to a limited number of seniors who have shown proficiency in research engineering. Testing of complete power plants as occasion offers. Registration arranged for when opportunities occur. Notices of opportunities will be posted on the department bulletin board. Professor CARPENTER, Assistant Professor SAWDON and Mr. HYDE.

X. 24. **Motor Car Construction.** Elective. Seniors and graduates. Second term, credit one hour. Two lectures a week, illustrated by lantern slides showing the structure and development of the motor car. Professor CARPENTER.

X. 25. **Heating and Ventilating.** Elective. Seniors and graduates. Second term, credit two hours. Lectures and recitations covering the methods of design and of construction of various forms of ventilating and heating apparatus. Carpenter's Heating and Ventilating used as a text-book. Professor CARPENTER.

X. 26. **Mechanical Refrigeration.** Elective. Seniors and graduates. Second term, credit two hours. Lectures on design, operation, and testing of refrigerating systems. Professor DIEDERICHS.

Department of Power Engineering

P. 10. **Elementary Heat-Power Engineering.** Required of all juniors. Throughout the year, three hours credit each term. Prerequisites, Physics 8, 9, and 14, Chemistry 6, C.E. 20 or M. 5 and 6, and D. 5, 6, and 7. Two recitations and one lecture a week throughout the year. Thermodynamics of gases and vapors, theoretical cycles and general theory of heat engines; application to gas and steam engines; practical modifications in real engines; engine efficiencies and performance; the indicator card as a measure of work and basis for design; economic features,—reduction of losses by jacketing, superheating, compounding; valves and valve gears; types of engines; governors; fly wheels; balancing; fuels and combustion. Assistant Professor BURR, and Messrs. PARMLEY and ULLBRICHT.

P. 11. **Heat Engines and Auxiliaries, For Civil Engineers.** Required of all C.E. seniors. Second term only, three hours credit. Not open to Sibley students. Pre-requisites, Physics, 6 and 10, (or the equivalent), Chemistry 1, C.E. 20. Three lectures a week.

(a) Elementary consideration of behavior of gases; gas engines.

(b) Theory of vaporization; theory of combustion; study of boilers; types of boilers; advantages and disadvantages of various types.

(c) Action of vapors in cylinders; steam engines; parts and operation; types, advantages and disadvantages, application; steam consumption and efficiencies.

(d) Advantages of condensing; types of condensers; condenser pumps; condenser auxiliaries, as cooling towers, pond, etc.

(e) Pumps; feed pumps, city water works' pumps, etc.

(f) Contractors plants; portable and traction engines, hoisting engines, locomotives and similar machinery.

This course is recommended for all students that wish to obtain a general knowledge of steam machinery without great technical detail. Assistant Professor BURR.

P. 20a. **Power Plant Design.** Required of all seniors. First term, three hours credit. Requires course P. 10. Two lectures and one recitation a week. A continuation of course P. 10.

Multiple expansion engines.

Principles governing transfer of heat; heating surfaces of boilers; principles of combustion; boiler furnaces and grates; types of boilers; types of stokers; natural and forced draft; feed water heaters; economizers; superheaters.

Theory of condensation; types of condensers; condenser pumps; cooling towers and similar devices.

Water treating apparatus, filters, separators, and similar auxiliary apparatus.

Steam turbines, refrigerating machinery, and air compressors; elementary theory, types, and efficiencies. Professor SMITH and Mr. MATTHEWS.

P. 20b. **Power Plant Design.** Required of all seniors. Second term, three hours credit. Requires P. 20a.. Two lectures and one computing period a week. Consideration of selection of elements and their combination in power plants, with the object of producing the maximum profit from operation. Professor A. W. SMITH and Mr. MATTHEWS.

P. 21. **Steam Engine Design.** Required of seniors in group A and not open to others. Throughout the year, three hours credit a term. Requires courses D. 10, D. 16, and P. 10 and must be accompanied by course P. 22. Three lectures a week. Discussion of the types, arrangements, and general proportions of steam engines; the theoretical and practical considerations entering into the design of valve gears, and engine details; governor design; balancing; the determination of fly-wheel weights; the selection of the machinery for a steam power plant and its arrangement. Professor BARNARD and Mr. THOMPSON.

P. 22. **Designing and Drawing.** Required of seniors in group A and not open to others. Throughout the year, three hours credit a term. Requires courses D. 10, D. 16, and P. 10 and must be accompanied by P. 21. Three drawing periods a week. A drafting course paralleling the lecture course P. 21, and also including a small amount of turbine design. Professor BARNARD and Mr. THOMPSON.

*P. 23. **Steam Boiler Design.** Seniors. First term, one hour credit. Requires courses D. 10, D.16, and P. 10. 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. Professor BARNARD and Mr. THOMPSON.

P. 25. **Steam Turbines.** Senior elective. Required of groups A and B. Second term, two hours credit. Requires course P. 10. Two lectures a

*Not given in 1910-11.

week. Classification of turbines and description of leading features of the various types. Mechanical and thermal consideration 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. Professor BARNARD and Mr. THOMPSON.

P. 26. **Gas Machinery Design.** Required of seniors in group C and not open to others. Throughout the year, three hours credit a term. Requires courses D. 10, D. 16, and P. 10. Must be accompanied by courses P. 27 and P. 28. Three lectures a week throughout the year. The rational and empirical design of Internal Combustion Engines and Gas Producers. Professor HIRSHFELD and Mr. KESSLER.

P. 27. **Design and Drawing.** Required of seniors in group C and not open to others. Throughout the year, three hours credit each term. Requires courses D. 10, D. 16, and P. 10. Must be accompanied by courses P. 26 and P. 28. Three drawing periods a week. The practical application of principles discussed in P. 26. Professors HIRSHFELD and Mr. KESSLER.

P. 28. **Gas Manufacture and Distribution (General).** Seniors. Required of seniors in group C. Second term, two hours credit. Requires courses D. 10, D. 16, and P. 10. Two lectures a week. The theoretical and practical principles governing the production and handling of all industrial gases. Professor HIRSHFELD and Mr. KESSLER.

P. 29. **Gas Power Machinery (General).** Seniors. First term, two hours credit. Requires courses D. 10, D. 16, and P. 10. Two lectures a week. General theory and salient points in the design and operation of internal combustion engines and gas producers. Description of existing commercial types, study of relative advantages, and consideration of questions of economy. Professor HIRSHFELD and Mr. KESSLER.

P. 39. **Advanced Designing.** Elective for seniors and graduates. Work and credit as arranged.

Department of Electrical Engineering

E. 10. **Elementary Electrical Engineering.** Required of all juniors. Throughout the year, four hours credit a term. Requires Physics 8, 9, and 14, C.E. 20 or M. 5 and 6. One lecture a week in each term; three recitations a week in first term, and one in the second term; and one laboratory period a week in the second term.

First term. Illustrated lectures and recitations, giving a brief review of the entire field of electrical engineering, including the fundamental laws of electric and magnetic circuits, the measurement of electrical quantities, the elementary theory, structural features, and operating characteristics of generators, controlling devices, transformers, transmission line, motors, etc.

Second term. Laboratory work and experimental lectures on the effects of resistance, inductance and capacity in series and parallel circuits, and the principal characteristics of electrical machinery operation. Part of the lectures during this term are devoted to such subjects as commutation, regulation of electrical machinery, etc. Professor NORRIS, Assistant Professor MACOMBER, and Messrs. KROGER, TAPPAN, HOLCOMB, and ANDERSON.

E. 12. **Electrical Engineering for Civil Engineers.** Required of all seniors in civil engineering. First term only, three hours credit. One experimental lecture, one recitation and one laboratory experiment each week. The purpose of the course is four-fold: (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; (4) to enable the student to read intelligently electrical engineering literature. Assistant Professor MACOMBER and Mr. HOLCOMB.

E. 13. **Electrical Engineering for Chemists.** Required of senior chemists. Second term only, three hours credit. One recitation and one laboratory experiment with report each week. The purpose of this course is three-fold: (1) to review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with the phraseology of current electrical engineering literature; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice. Assistant Professor MACOMBER, Messrs. KROGER, TAPPAN, HOLCOMB, and ANDERSON.

E. 20. **Theory of Electrical Machinery.** Required of seniors in electrical engineering. Throughout the year, two hours credit a term. Requires course E. 10. Two lectures a week. First term work covers chiefly the laws of the electric and the magnetic circuit; representation of alternating currents by vectors and by complex quantities; the nature and effects of inductance, capacity and iron loss. Second term is devoted to the theory of transmission lines, transformers, generators, motors, and rotary converters. The lectures are as far as possible correlated with the work in course E. 21. Professor KARAPETOFF.

E. 21. **Characteristics of Electrical Machinery.** Required of seniors in electrical engineering. Throughout the year, four hours credit a term. Requires course E. 10. Two recitations and two computing periods a week. Problems on the work covered by course E. 20; in particular, performance characteristics of transmission lines, transformers, induction motors, alternators, synchronous motors and converters, and direct-current generators and motors. Text-books used: Karapetoff's Elective Circuit; Norris & Dennison, Electrical Characteristics of Circuits and Machines. Professor KARAPETOFF and Messrs. DOUGLASS and PERTSCH.

E. 22a. **Design of Electrical Machinery.** Elective for seniors in electrical engineering. Second term only, two hours credit. Requires first term of E. 20 and E. 21. Two recitations a week. Principles of commercial design of electrical machinery.

(1) General data: deduction of principal formulae used in designing direct and alternating current machinery and transformers; empirical electrical and mechanical data.

(2) Commercial requirements; cost of manufacturing; requirements of service; guarantees.

(3) Deduction of design data from tests on existing machines.

(4) Elementary design with given principal dimensions.

(5) Selection of principal dimensions for a complete line of similar machines.

(6) Mechanical design and preparation of shop drawings.

Hobart's Continuous Current Dynamo Design is used for recitations. Professor KARAPETOFF and Mr. DOUGLASS.

E. 22b. **Design of Electrical Machinery.** Elective for seniors taking E. 22a. Second term only, two hours credit. Two computation periods a week. The work in the computing room comprises two problems: a complete mechanical design of an electric machine with given principal dimensions, and an electric design of a commercial line of similar machines such as transformers, generators, motors or rotary converters. The work in this course parallels that in E. 22a. Professor KARAPETOFF and Mr. DOUGLASS.

E. 23a. **Generation and Distribution of Electrical Energy.** Elective for seniors in electrical engineering. Second term only, two hours credit. Requires first term of E. 20 and E. 21. Two lectures a week. Selection of apparatus for generating stations and distributing systems. The design of generating units, transforming apparatus, and auxiliaries is not taken up in detail, since the intention is to show the proper combinations of the apparatus to correctly represent standard theory and practice. The design of the transmission line and of the distributing system is, however, studied in detail, the application of the theory being brought out in lectures and established by practical problems. Assistant Professor FORD and Mr. HOLCOMB.

E. 23b. **Generation and Distribution of Electrical Energy.** Elective for seniors taking E. 23a. Second term only, two hours credit. Two computing periods a week. The work in this course parallels that in E. 23a. Assistant Professor FORD and Mr. HOLCOMB.

E. 24. **Telephone Engineering.** Elective for seniors in electrical engineering. First term only, three hours credit. Requires E. 10. Two lectures and one recitation a week. General principles of electrical engineering as applied to modern telegraph, telephone and other systems of transmission of intelligence. Particular attention is paid to telephony and to problems encountered in telephone engineering. Assistant Professor MACOMBER.

E. 25. **Elements of Electric Railway Practice.** Elective for juniors or seniors. First term only, two hours credit. Requires C.E. 20 (or M. 5 and 6) and Physics 9 and 14. Two lectures a week. Apparatus and construction involved in a modern railway system, including car equipment, trucks, motors, controllers, bodies, and accessories, overhead construction, third rail, conduit, and other systems and other topics of similar character. The underlying idea is to show the application of the general laws of electricity to this particular branch. Some attention is devoted to the relation of electric railways to the public and to finance. Professor NORRIS.

E. 26a. **Advanced Electric Railway Practice.** Elective for seniors in electrical engineering. Second term, two hours credit. Pre-requisites, first term of E. 20 and E. 21 and E. 25. Two lectures. Fundamental theory of train movement, comprising what may be termed the characteristic curves of railway operation. Professor NORRIS.

E. 26b. **Advanced Electric Railway Practice.** Elective for seniors taking course E. 26a. Second term, credit two hours. Two computing or inspection periods a week. Practice is given in plotting time-speed curves, motor heating curves, railway load curves, drop in transmission lines, etc. Inspections of local equipment are made, including the power house and sub-station of the local railway, track and overhead construction of cars, administration of car barn, etc. The work in this course parallels that in E. 26a. Professor NORRIS.

E. 27. **Wireless Telegraphy and Telephony.** Elective for seniors in electrical engineering. Second term only, two hours credit. Requires first term of E. 20, E. 21, and E. 28. Two lectures a week. Fundamental principles involved in wireless telegraphy and telephony, and study of the development of the application of these principles up to the present status of the art. The lectures are supplemented by numerous experiments to fully illustrate the practical application of the theory. Mr. KROGER.

E. 28. **Electrical Laboratory.** Required of seniors in electrical engineering. Throughout the year, four hours credit a term. Requires X. 11, E. 10. Two laboratory periods, one recitation and one report a week. The work during the first term includes the following simple experiments selected from the most important branches of electrical engineering: tests of ammeters, voltmeters, and integrating wattmeters; arc-lamps and series arc lighting; electrical relations in transmission lines; characteristics of direct-current generators and motors; commercial tests of transformers; load tests on alternators and induction motors; assembling switchboards, wiring controllers; telephone work, etc. During the second term more advanced experiments are conducted, such as performance tests of transmission lines, transformers, alternators and induction motors; commercial tests on magnetic qualities of steel and iron; tests of special alternating-current instruments; winding D.C. and A.C. armatures; separation of losses in generators and motors, electrical relations in polyphase systems; operation of rotary converters, electric railway experiments; determination of A.C. wave-form; regulation of storage batteries. Text-book, Karapetoff's Experimental Electrical Engineering. Assistant Professor FORD, Messrs. HOLCOMB, DUBOIS, HOGAN, ANDERSON, and STEVENS.

E. 29. **Electrical Laboratory.** Required of all seinors, excepting electrical engineers. Requires X. 11, E. 10, P. 10. One laboratory period, one recitation and one report a week. The course is arranged for the needs of mechanical engineers, particular attention being paid to the operating features of electrical machinery. The experiments are selected from those given during the first term in course E. 28. Text-book, Karapetoff's Experimental Electrical Engineering. Assistant Professor FORD, and Messrs. HOLCOMB, HOGAN, DUBOIS, and STEVENS.

E. 30. **Engineering Calculations.** Elective. Open to seniors and graduate students only. Throughout the year, two hours credit a term. General methods by which engineering problems are expressed in mathematical form, studied to establish a better understanding of the unity between the instruction in pure mathematics and in the various engineering courses. It is aimed to better prepare the student for engineering research and for the study of advanced engineering literature. The fundamental physical and mathematical assumptions are critically reviewed, and the limitations in the results pointed out. Methods are indicated for obtaining approximate solutions, establishing empirical formulae, and solving problems by the use of tables, charts and mechanical devices. The course consists of problems taken from mechanical, civil and electrical engineering, involving analytic geometry and the elements of differential and integral calculus. Perry's Calculus for Engineers is used as the text-book. Professor KARAPETOFF.

E. 31. **Electrical Engineering Problems.** Seniors in mechanical engineering only. First or second term, two hours credit. Requires E. 10. A series of problems with recitations on electric circuits, machines, and applications. Electrical problems which are met by mechanical engineers in practice. Mr. TOWER.

E. 32. **Electrical Illumination Engineering.** General elective for juniors and seniors. Second term only, two hours credit. Students intending to take this course are advised to take Physics 15 and 43 during the first term. A brief review of the theory of illumination, a study of the theory, structure and operation of the various types of electrical illuminating devices, and also the general engineering features of electric lighting systems as a whole, including a discussion of their design and management. Assistant Professor MACOMBER.

E. 33. **Research in Electrical Engineering.** (Corresponds to X. 22 in mechanical engineering). First or second term, or both. One to three hours. Requires E. 10, 11. Tests of electrical apparatus both alone and in power plants. The number of students who can be accommodated will depend upon the available opportunity for testing. Professor NORRIS, Assistant Professor FORD, and Messrs. HOLCOMB, HOGAN, DUBOIS, and STEVENS.

E. 34. **Current Electrical Topics.** Elective for seniors in electrical engineering only. Throughout the year, one hour credit. A one-hour conference each week. The electrical periodicals are systematically examined and the important articles are abstracted and discussed. Professor NORRIS.

E. 40. **Advanced Electrical Engineering.** Open to graduate students only. Two to six hours credit each term. The graduate seminar, which forms the basis of this course, meets weekly. Special reports are prepared for these meetings, and thesis work is discussed. Abstracts are made of important engineering publications. Professors NORRIS and KARAPETOFF.

OFFICIAL PUBLICATIONS OF CORNELL UNIVERSITY

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These publications include the annual Register, for which a charge of twenty-five cents a copy is made, and the following publications, any one of which will be sent gratis and post-free on request:

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Courses of Instruction in the College of Arts and Sciences,
Announcement of Sibley College of Mechanical Engineering and the Mechanic Arts,
Announcement of the College of Civil Engineering,
Announcement of the College of Law,
Announcement of the College of Architecture,
Announcement of the Medical College,
Announcement of the New York State College of Agriculture,
Announcement of the Winter Courses in the College of Agriculture,
Announcement of the New York State Veterinary College,
Announcement of the Graduate School,
Announcement of the Summer Session,
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