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COLLEGE OF CIVIL ENGINEERING

FACULTY

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

Eugene Elwin Haskell, C.E., Dean of the College of Civil Engineering and Professor of Experimental Hydraulics.

Irving Porter Church, C.E., M.C.E., Emeritus Professor of Applied Mechanics and Hydraulics.

Henry Sylvester Jacoby, C.E., Professor of Bridge Engineering, in charge of the College Library.

Henry Neely Ogden, C.E., Professor of Sanitary Engineering.

Fred Asa Barnes, C.E., M.C.E., Professor of Railroad Engineering.

Ora Miner Leland, B.S. (C.E.), Professor of Geodesy and Astronomy.

Sidney Gonzales George, C.E., Professor of Mechanics of Engineering. (Absent on leave, first term.)

John Thomas Parson, Assistant Professor of Drawing.

Ernest William Schoder, B.S., Ph.D., Assistant Professor of Experimental Hydraulics.

Miles Albion Pond, Ph.B., Assistant Professor of Civil Engineering.

Francis Joseph Seery, S.B., Assistant Professor of Civil Engineering.

Ernest William Rettger, A.B., Ph.D., Assistant Professor of Applied Mechanics.

Charles Leopold Walker, C.E., Assistant Professor of Sanitary Engineering.

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Leonard Church Urquhart, C.E., Assistant Professor of Bridge Engineering, Secretary of the College Faculty.

Carl Crandall, C.E., Instructor in Civil Engineering.

Chauncey Ruthven McAnlis, B.S., C.E., Instructor in Civil Engineering.

John E. Perry, B.S., Instructor in Railroad Engineering.

Eric V. Howell, C.E., M.C.E., Instructor in Civil Engineering.

Louise Whittaker, College Librarian and Stenographer.

Helen R. Lynch, Secretary to the Dean.

Clinton D. Cass, College Mechanician.

GENERAL PLAN OF STUDIES

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

The facilities for instruction and for advanced investigations are thorough and efficient. Laboratory work is required in chemistry, mineralogy, geology, physics, and testing materials. In addition to the special library and laboratories of the College, all the other libraries, collections, and laboratories of the University are open to civil engineering students.

The work of the student comprises an extended course in mathematics mechanics and graphics, and their applications to engineering. The object aimed at is to give as thorough a preparation as possible for the general purposes of the profession in the following subjects: the survey, location, and construction of roads, railroads, canals, and water works; the construction of foundations under water and on land, and of superstructures and tunnels; the survey, improvement, and protection of coasts, and the regulation of rivers, harbors, and lakes; the astronomical determination of geographical coördinates for geodetic and other purposes; the application of mechanics, graphical statics, and descriptive geometry to the construction of the various kinds of arches, girders, roofs, trusses, suspension and cantilever bridges; the drainage of districts, sewerage of towns, and the irrigation and reclaiming of land; the design, construction, application, and tests of hydraulic and electric motors and steam engines; the preparation of drawings, plans, and specifications, and the proper inspection and tests of the materials used in construction. Instruction is given in engineering economy, finance, and jurisprudence. The latter subject deals in an elementary manner with the questions of easements and servitudes, and the ordinary principles of the laws of contracts and riparian rights.

The building occupied by the College of Civil Engineering is Lincoln Hall, a substantial brown stone structure, two hundred feet long and seventy feet wide, especially designed for its purpose. In addition to the laboratories and museums, the building contains the working library of the College, aggregating about four thousand volumes, reading rooms, class rooms, and draughting rooms. The astronomical and portions of the geodetic equipment are housed in the Fuertes Observatory* which contains all the instruments required for determining time, latitude, longitude, and azimuth. Several of the instruments are duplicates of those used by the United States Coast and Geodetic Survey. The large hydraulic laboratory with its buildings and equipment is located at the Fall Creek gorge, within a short distance of the College building.

*See p. 6.

LABORATORIES

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

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

2. **The Testing Laboratory** for materials of construction and for full sized members, joints, and structures. The equipment of this laboratory includes: a Riehlé 400,000 lb. testing machine with a capacity for beams and girders up to 19 inches in width and 18 feet in length, and for specimens in tension and compression up to 12 feet in length; an Olsen 100,000 lb. testing machine; an Olsen 50,000 lb. testing machine; an Olsen 10,000 lb. wire testing machine; a Thurston autographic torsion testing machine, a Riehlé torsion testing machine of 60,000 inch-pounds capacity, for testing rods and shafts up to one and a half inches in diameter and six feet in length; a Riehlé 5,000 lb. transverse load testing machine for flexural tests of bars of wood and metal up to four feet in length; an Amsler-Laffon compression testing machine; a standard Page impact machine for tests of road material; a Riehlé grinder for stone specimens; a standard Deval machine for abrasion tests of road material; and a standard rattler for paving brick.

The equipment also includes a set of torsion clinometers reading to single minutes for use with the Riehlé torsion machine; a Henning extensometer for tension tests of metals, and two self-indicating dial extensometers with fittings which adapt them for use in testing steel or iron tension or compression specimens, and also for testing full-sized concrete beams and columns and for tests of wire. The Martens mirror extensometer is also available. Knock-down forms are provided for the making of large concrete beams and columns.

3. **The Highway Laboratory.** The rock testing section, which includes a Deval machine, Page impact machine for the toughness test, impact machine for the cementation test, ball mill, core drill, diamond saw, grinding lap, Dorry machine, briquette molding machine, and a rattler for brick testing, is located in the basement of Lincoln Hall.

A special building of fireproof construction has been erected for the bituminous laboratory. The equipment, at present, includes an Engler viscosimeter, drying ovens, a New York State Board of Health oil tester, balances, a New York Testing Laboratory penetrometer, molds for the float test, bitumen extractors, and apparatus for distillations.

4. **The Hydraulic Laboratory.** In addition to the usual equipment for the ordinary laboratory experiments, the unique location and construction of this

laboratory render practicable investigations requiring a steady gravity water supply for long periods using relatively large flows of water. The water supply is obtained from Fall Creek with a water shed of 126 square miles. Beebe Lake, a pond of about 20 acres, has been formed by the construction of a concrete dam 26 feet high, with a spillway crest length of 130.5 feet. At one end of the dam there is an additional flood spillway 141.5 feet long. A rectangular canal 420 feet long and 16 feet wide is supplied from Beebe Lake through six headgates for controlling the amount of flow. The upper portion of the canal is 17.7 feet deep and the lower portion is 10 feet deep. In this canal are two sharp crested weirs 16 feet long over which discharges as large as 400 cubic feet a second may be passed.

The lower portion of the large 16-foot canal, 350 feet long between weirs, is used for measurements with floats and current meters. Models of dams may be built in the canal and the flow over them investigated with precision. An electrically operated car spans this canal and is used for rating current meters and Pitot tubes and for experiments that require means of towing floating or submerged objects through still or running water at various speeds. By means of a gear system the speed of the cable, which moves the car, may be varied through a range from ¼ to 12 feet a second.

Out-door work is usually suspended from December 1 to April 1 because of the freezing weather.

The laboratory building is built against the south cliff of Fall Creek gorge and extends vertically about 70 feet, from the pool below Triphammer Falls to the top of the gorge. A short branch canal six feet wide is housed by the upper portion of the laboratory building and may be supplied directly from Beebe Lake by means of a 48-inch cast iron pipe line with a short 30-inch branch at its lower end. A 30-inch valve controls the flow from the 48-inch pipe into the 6-foot canal. The 6-foot canal discharges either to waste into the pool below Triphammer Falls (a sheer drop of 60 feet) or into the upper end of a steel standpipe 6 feet in diameter and 60 feet high. A suitable mechanism causes an instantaneous diversion of discharges as large as 60 cubic feet a second from the waste flume into the standpipe or vice versa. The 6-foot standpipe is provided at the bottom with a 36-inch discharge valve operated by hydraulic pressure. There is a float gage indicating accurately the height of the water surface in the standpipe, when used as a measuring tank.

An independent 10-inch pipe line from the 30-inch pipe to the bottom of the laboratory supplies most of the pieces of apparatus used for class work and research. The 6-foot standpipe, also, may be used as a supply tank, water being supplied to it from either the 6-foot canal or the 10-inch pipe line.

In the laboratory building there is also a concrete flume 2 feet wide, 4 feet deep and 25 feet long. Flows up to 11 cubic feet a second can be passed through this and measured volumetrically. This flume is arranged conveniently for experiments on small weirs, low-head orifices, etc.

There are numerous flanged connections from 4 to 12 inches diameter for the attachment of apparatus.

The hydraulic machinery equipment at present includes only types of the turbine, Pelton-Doble wheel, multi-stage centrifugal pump and hydraulic ram, all arranged for testing.

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

5. **The Sanitary Laboratory.** This laboratory provides facilities for the physical, chemical, bacteriological, and biological analyses of water and sewage, and for the performance of such other tests as will acquaint the student with current practice as affecting the control and operation of the various types of water purification and sewage disposal plants.

The equipment includes microscopes and the necessary accessories for complete bacteriological and biological examinations of water; an autoclave, a hot-air sterilizer, a 37½° and two 20° C. incubators, a chemical balance, a United States Geological Survey turbidity rod and color standards; four experimental sand filters, fitted with loss of head gages, and providing for a total depth of sand and water of nine feet, for determining the rate and efficiency of operation of sand filters, as well as various types of sewage nozzles. The laboratory is well equipped with such glassware, reagents, accessories and apparatus as are needed for making the chemical analyses of water and sewage effluents.

6. **The Fuertes Astronomical Observatory,** which was removed to provide room for the Drill Hall, has been replaced by a new observatory situated north of Beebe Lake. It contains a transit room with four piers, a clock vault, a photographic darkroom, an office, a computing room, a class room, and a dome for a 12-inch equatorial telescope, in addition to a comparator room and two constant temperature rooms for geodetic laboratory work.

The equipment includes a Howard mean time astronomical clock, chronometers by Negus and Nardin, four chronographs, a Troughton and Simms transit, two Fauth prismatic transits with latitude levels, a Fauth zenith telescope, an altazimuth by Troughton and Simms, a 4½-inch equatorial telescope with driving clock and position micrometer, a 4-inch portable equatorial telescope, as well as sextants, surveyor's transits, clocks, collimators, micrometers, spherometer, level-trier, and various meteorological instruments.

7. **The Geodetic Laboratory** is housed in the new observatory building. Facilities are provided for work along the various lines relating to geodesy and advanced surveying, including geodetic astronomy.

For the investigation of measures of length and co-efficients of expansion a 4-meter comparator is available, being located in a specially constructed room in the basement of the observatory. The beam which carries the micrometer microscopes rests on piers independent of those which support the bed. The cradle bearing the bars under comparison can be moved laterally, so as to bring first one and then the other under the microscopes, by means of a crank outside of the case which protects the apparatus from sudden changes of temperature. A 4-foot comparator is used for the study of leveling rods. It is planned to remove the 100-meter field comparator from the site of the former observatory and to construct one of 50-meters at the new building, for the study of tapes under field conditions. Plumbing tubes of the Repsold type transfer the underground marks to the micrometer microscopes. Invar tapes standardized at the Bureau of

Standards are used for comparison. A 100-foot tape comparator is located on the fourth floor of Lincoln Hall.

The standards of length include: a steel meter bar of the International type which has been compared with the International Prototype Meter of the U. S. Bureau of Standards; a Rogers speculum metal decimeter and 4-inch scale, combined, accurately divided and compared; and a 4-meter bar for subsidiary measures.

The laboratory equipment also includes a Mendenhall half-second pendulum apparatus for the determination of the acceleration of gravity—the standard type used by the U. S. Coast and Geodetic Survey; a Kew magnetometer, a dip circle, and a declinometer, for observations of terrestrial magnetism; a dividing engine by the Société Genévoise; precision thermometers by Tonnelot and Boudin, standardized at the International Bureau in Paris; a small comparator for calibrating thermometers; and the usual auxiliary apparatus.

8. **The Photographic Laboratory** for reproducing the appearance of tested specimens, for the purposes of the lecture room, as an aid in topographic surveys and for the distribution of reprints of the collection of progress photographs of engineering structures owned by the College.

The equipment includes a revolving or panoramic camera constructed by the mechanician of the College from patterns generously supplied by the inventor, Mr. G. W. Parsons. This is especially useful in topographic work since the entire view of 360° at a station can be included on a film 6 inches wide and about 70 inches long.

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

The Museums of the College of Civil Engineering contain the following collections: 1. The Muret collection of models in descriptive geometry and stone cutting. 2. The DeLagrave general and special models in topography and geognosy. 3. The Schroeder models in descriptive geometry and stereotomy with over 50 brass and silk transformable models made in the College after the Olivier models. 4. The M. Grund collection of bridge and roof details, trusses, and masonry structures, such as right, oblique, and annular arches and domes, and several intricate models in stone cutting, supplemented by similar models by Schroeder and other makers. 5. A model railroad bridge of 25-foot span, one-fourth natural size, and a numerous collection of models of track details. 6. The Digeon collection of movable dams, artificial harbors, and working models in hydraulic engineering. 7. Working models of water wheels, turbines, and other water engines. 8. Several large collections of European and American progress photographs of engineering work showing the progress of construction, and many other photographs, blue-prints, models, and diagrams. 9. A collection of typical geodetic and surveying instruments of historical interest, including a secondary base-line apparatus made under the direction of the United States Coast and Geodetic Survey, a pair of base-bars constructed in this college, solar and magnetic compasses, levels, transits, theodolites, omnimeters, tacheometers, sextants, telemeters, altmeters, hypsometers, odometers, meteorological instruments, etc., with a large number of auxiliary and special instruments such as

planimeters, pantographs, elliptographs, calculating devices and computing machines.

REQUIREMENTS FOR ADMISSION

Candidates for admission should consult the General Circular of Information, which will be sent post-free on application to the Secretary of Cornell University, Ithaca, New York. All applications for admission to the freshman class should be addressed to the Registrar.

The subjects that may be offered for admission to the College of Civil Engineering are named in the following list and the figure in parenthesis following each subject indicates its value expressed in units and shows the maximum and minimum amount of credit allowed in the subject. A unit represents five prepared recitations a week for one year in a study.

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

Four-Year Course

For admission to the regular course, the applicant must offer fifteen units from the foregoing list of entrance subjects, as follows: English (3), history (1), elementary algebra (1), intermediate algebra (½), plane geometry (1), solid geometry (½), advanced algebra (½), plane trigonometry (½), either Greek, Latin, French, German, Spanish, or Italian (3†), and elective (4††). Applicants will be admitted, however, who offer fifteen entrance units as follows: English (3), history (1), elementary algebra (1), plane geometry (1), either Greek, Latin, French, German, Spanish, or Italian (3†), and elective (6††); but they will be required to make up their entrance deficiencies in the University in addition to the work prescribed in the regular four-year course. This will necessitate attendance for more than four years, since it may not be possible to take some courses in their required sequence.

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*If an applicant has counted Biology (1) he may not also offer Botany (½) or Zoology (½).

**Three hundred actual hours are required for one unit.

†It is recommended that the language requirement be satisfied by French or German.

††It is strongly recommended that at least three of these elective units be offered in language and history.

Six-Year Courses

For admission to the six-year course, leading to the degrees of Bachelor of Arts and Civil Engineer, the requirements are those of the College of Arts and Sciences, in which college the student is registered during the first four years.

There is also a six-year course leading to the degree of Civil Engineer at the end of five years and to the degree of Bachelor of Architecture at the end of six years. This course, arranged through the co-operation of the Faculties of Civil Engineering and of Architecture provides a progressively arranged series of studies that should give suitable training in Building Design and Construction. It follows the engineering course closely for the first four years, substituting however some fundamental architectural subjects for civil engineering work so that the full requirements for the C.E. degree cannot be met until the end of the fifth year. For details of this course, see Announcement of the College of Architecture.

ADMISSION FROM OTHER COLLEGES

A student, who having already attended some college or university, desires to enter one of these courses should file with the Registrar of Cornell University, on an official blank, to be obtained from him, a formal application for admission, along with an official certificate from the college or university already attended, of his honorable dismissal; his entrance examinations in detail; his terms of attendance and the amount of work that he has completed; and a detailed statement of the courses pursued. He should send also a catalog of the institution, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he has completed.

ADMISSION AS SPECIAL STUDENTS

College graduates over twenty-one years of age, who wish to pursue advanced work without being candidates for a degree, may be admitted without entrance examinations. See General Circular of Information.

PRIZES

For scholarships and prizes, see the General Circular of Information, and the pamphlet on Prizes, which may be obtained on application to the Secretary of the University.

A Fellowship, denominated the McGraw Fellowship, of an annual value of $400, is offered to graduates of the College of Civil Engineering and to graduates of Civil Engineering Colleges of equivalent rank. All Fellows are also exempt from tuition.

A Graduate Scholarship of an annual value of $200 is offered under similar conditions. Holders of graduate scholarships are also exempt from tuition.

Application blanks and detailed information may be obtained from the Dean of the Graduate School of Cornell University.

The Fuertes Medals, founded by Professor E. A. Fuertes and consisting of two gold medals, each of the value of one-half the amount of income provided by the endowment fund will be awarded under the following conditions:

One of these medals will be awarded annually by the University Faculty to that student of the College of Civil Engineering who may be found at the end of the first term of his senior year to have maintained the highest degree of scholarship in the subjects of his course, provided he has been in attendance in the University for at least two years; and the other medal will be awarded annually by the Faculty to that graduate of the College of Civil Engineering who may write a meritorious paper upon some engineering subject tending to advance the scientific or practical interests of the profession of the civil engineer. It is desired that papers be presented on or before April 15. If a paper is presented in printed form, it will not be received if it has been printed earlier than the next preceding April 15.

Neither medal shall be awarded unless it appears to the Faculty of the College of Civil Engineering that there is a candidate of sufficient merit to entitle him to such distinction. Candidates will be nominated to the University Faculty by the College of Civil Engineering annually.

The Fuertes Memorial Prizes in Public Speaking were founded by Charles H. Baker, a graduate of the College of Civil Engineering of the class of 1886. Three prizes, one of one hundred and twenty-five dollars, one of thirty-five dollars, and one of twenty dollars, are awarded annually to members of the junior and senior classes in the Colleges of Engineering and Architecture, for proficiency in public speaking. The conditions of the award are as follows:

1. The competition is open to seniors and juniors in the Colleges of Engineering and Architecture.

2. The competition will be held on the evening of the third Friday in April.

3. The candidates are required to read a summary of their arguments (not more than four hundred words in length) before a committee representing the Colleges of Engineering and Architecture. These summaries shall be read on the Monday of the week in which the final competition falls. Competitors, not to exceed eight in number, will then be selected for the final competition, the choice being based on the character of the summaries submitted.

4. The speeches delivered in the competition shall be on technical subjects and original in character. Any technical subject may be chosen by the competitor that may seem to him best suited to furnish an opportunity for persuasive argument. Questions relating to his profession that would naturally come before semi-technical or non-technical commissions, boards of directors, and conventions, are of peculiar fitness. In making the award, both the character of the argument and the manner of presentation will be considered. Each speech shall be limited to 15 minutes.

5. The delivery shall be without notes, but illustrative material such as diagrams, plans, models, or lantern slides may be used.

6. The prizes shall be awarded by a committee consisting of five members, one selected by each college concerned, one selected by the Department of Public Speaking and one selected by the President of the University from citizens of Ithaca prominent in mercantile or banking business or in public affairs.

7. A student who has already received the first prize shall not be eligible for subsequent competition.

The Charles Lee Crandall Prizes, founded in 1916 by Alumni of the College of Civil Engineering, consisting of a first prize of one hundred dollars, and a second

prize of about twenty-five dollars, or the balance of the yearly income from the fund, will be awarded each year by a committee appointed by the Dean of the College of Civil Engineering for the best paper written by a senior or junior in that college on a suitable subject, provided both the substance and the written form of the paper submitted show real merit. If, in any year, no papers of sufficient merit are presented for these prizes, the income from the fund for that year shall be added to the principal and the additional income used from time to time, to increase the amount of the prizes.

The fund was established to provide prizes to encourage original research, to stimulate interest in matters of public concern, and to inspire in the students an appreciation of the opportunities which the profession of civil engineering offers them to serve their fellow-men as intelligent and public-spirited citizens.

The William C. Seidell Book Fund of $1,000, was founded by Gerrit S. Miller. The income is used for the purchase of books for poor young men who are working their way through the College of Civil Engineering, and is paid by the Treasurer of the University upon the recommendation of the Dean of the College, preference being given to members of the freshman class.

THE IRVING PORTER CHURCH FUND

The Irving Porter Church Fund is a fund of twenty-five hundred dollars in Liberty Bonds presented in 1917 to Cornell University by former students of Professor Church; the income of the bonds is to be devoted to the purchase of additions to the library of the College of Civil Engineering.

COURSES LEADING TO THE DEGREE OF CIVIL ENGINEER

The registration of new students will take place from 9 a. m. to 4 p. m., Monday and Tuesday, September 29 and 30, 1919. Seniors, juniors, and sophomores in good standing, may register in the College between 9 a. m. and 4 p. m. on Tuesday and Wednesday, September 30 and October 1, 1919.

A student must register for at least 12 hours each term.

The required courses in mathematics, physics, chemistry, geology, and political economy are given in the College of Arts and Sciences; for a description of these courses see page 15 of this announcement. The required work in electrical engineering and steam machinery is given in Sibley College; for a description of these courses see page 17 of this announcement.

Four-Year Course

Freshman Year	No. course	First term	Second term
Analytics	5 (1)	5	–
Differential and Integral Calculus	5 (2)	–	5
Physics	2	5	–
Physics	7	–	3
Chemistry	1	–	6
Descriptive Geometry	1	2	2
Drawing	2	1	1
Elementary Surveying	10	3	–
Introductory Lectures	9	1	–
Military Drill	1	3	3

Sophomore Year

	No. course	First term	Second term
Practical Geology	31	3	3
Mechanics of Engineering	20	5	–
Mechanics of Engineering	21	–	5
Materials Laboratory	22	2 or 0	0 or 2
Physics	14	0 or 2	2 or 0
Drawing	4	2	2
Advanced Surveying	11	2	3
Materials of Construction	25	3 or 0	0 or 3
Technical Reports	24	0 or 3	3 or 0
Military Drill	1	3	3
Summer Survey (five weeks in June and July)	13	–	6

Junior Year

	No. course	First term	Second term
Elements of Economics	52	2	2
Railroads	60	4	1
Engineering Construction	67	–	3
Bridges	71A, 71B	4	3
Hydraulics	40	3	–
Municipal Sanitation	52	–	3
Engineering Problems	29	–	2
Survey Computations and Mapping	14	1	–
*Elective	—	3	3

Senior Year

	No. course	First term		Second term
Public Speaking	P.S. 1	3	or	3
Heat Engines and Auxiliaries	P. 11	3	or	3
Elements of Electrical Engineering	**E. 12	4		–
Water Supply	C.E. 30	3	or	3
Concrete Construction	C.E. 77	3	or	3
Specifications and Contracts	C.E. 90	2	or	2
Engineering Design	C.E. 91	3	or	3
Electives		6	and	6
Required hours in Senior year		17		16

For the Summer Term, see p. 14.

In the scheduling of his work, each student in the College of Civil Engineering is subject to the following limitation: "No student shall anticipate the work of the curriculum of the College of Civil Engineering by more than one year."

A Six-Year Course Leading to the Degree of Bachelor of Arts at the End of Four Years and of Civil Engineer at the End of Six Years

Seniors in good standing in the College of Arts and Sciences, who have been in actual residence at least six terms, exclusive of summer sessions, and have a credit of at least 90 hours, may be registered both in the College of Arts and Sciences and in the College of Civil Engineering.

In accordance with this provision the following suggestion is given for a six-year course leading to the degrees of A.B. and C.E.

The following subjects are to be included in the course of study of at least 90 hours in the College of Arts and Sciences during the first three years of residence.

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*Of the electives in Junior year not more than three hours may be taken in approved non-technical subjects.

**Any one desiring to take a more extended course than E. 12 may substitute E. 14 and E. 15. These courses are described in the Announcement of Sibley College.

	No. course	First term	Second term
Analytic Geometry	5 (1)	5	–
Calculus	5 (2)	–	5
Physics	3, 7	6	3
Chemistry	1	6	(or 6)
Chemistry	6	5	(or 5)
Practical Geology	31	3	3
Descriptive Geometry	1	2	2
Drawing	2	1	1
Introductory Lectures	9	1	–
Elementary Surveying	10	3	–

The following subjects in Civil Engineering are to be taken during the fourth year, when the student is registered in both colleges.

	No. course	First term	Second term
Elements of Economics	52	2	2
Drawing	4	2	2
Advanced Surveying	11	2	3
Mechanics of Engineering	20, 21	5	5
Materials Laboratory	22	–	2
Materials of Construction	25	–	3
Physics	14	2	–
Summer Survey (five weeks in June and July)	13		6

The work for the fifth and sixth years is to include the subjects of the junior and senior years of the four-year course leading to the degree of Civil Engineer, except that course 52 in Elements of Economics should be replaced by electives.

Students desiring to take this course are recommended to confer with the deans of the faculties concerned.

GRADUATE STUDY AND ADVANCED DEGREES

The facilities for study and research offered by the various laboratories of this college are available for graduate students; they will also find among both the regular and the elective courses given in the College many that are suitable for graduate study.

The degrees of Master of Civil Engineering (M.C.E) and of Doctor of Philosophy (Ph.D.) are granted upon fulfillment of the conditions prescribed by the Faculty of the Graduate School. See Announcement of the Graduate School.

SUMMER TERM

Eight-week Term, beginning July 5, 1919

In pursuance of the policy of the University to provide instruction in the full work of a college year for students entering in December, 1918, the College of Civil Engineering will give instruction during the summer of 1919 in an eight-week term beginning July 5, 1919. Provision will be made during this eight-week term for certain instruction of students registered in the other colleges of the University, and in the Summer Session in accordance with the provisions made by the authorities in charge. Students registering in the Summer Session and desiring to take work in Descriptive Geometry, Mechanics, Reinforced Concrete, Bridge Stresses, Structural Design, Hydraulics, etc., will obtain information from the Announcement of the Summer Session by writing to Prof. R. M. Ogden, Goldwin Smith Hall, Cornell University, Ithaca, N. Y. Students registering in other colleges of the University should make arrangements through the assigning officers of their respective colleges.

COURSES OF INSTRUCTION

SUBJECTS GIVEN IN THE COLLEGE OF ARTS AND SCIENCES

Mathematics

Course 5 may not, without special permission, be taken simultaneously with any of the other courses.

1. **Solid Geometry.** Repeated in second term, credit three hours.

Open to all students, but designed especially for those who have entered with the minor requirements in mathematics and are preparing: (a) to teach mathematics in the secondary schools; (b) to take up engineering work later in the course; (c) to specialize in chemistry or physics.

2 (E). **Advanced Algebra.** First term, credit three hours. Open to engineering students who have satisfied the entrance requirements in Intermediate Algebra. The work here covered is the equivalent of that required in this subject for entrance to the four-year course.

3. **Plane Trigonometry.** Repeated in second term, credit three hours.

Open to all students, but designed especially for those mentioned under course 1.

5. **Analytical Geometry and Calculus.** Prerequisite courses, 1, 2, and 3 or their equivalent.

5 (1). Daily except Saturday, first term; credit five hours. Repeated in the second term.

5 (2). A continuation of the work of 5 (1). Daily except Saturday, second term; credit five hours. Repeated in the first term of the following year as 6 (2), daily, credit six hours.

Physics

Examinations for those who were unavoidably absent from either term examination in courses 2 to 7, and for those who have conditions to make up, will be held on Monday, September 29, 1919, at 9 a. m. in Rockefeller C. Similar examinations in connection with courses 8 to 14 will be held in Rockefeller C at 2 p m. on the same day. Students expecting to take any of these examinations should notify the department not later than September 22, 1919.

2. **Introductory Experimental Physics.** Repeated in second term, credit five hours. Three lectures, one 2-hour class-room period and one 2-hour laboratory period each week. Lectures T Th S, 9, 11, Rockefeller A. Professors MERRITT and GIBBS. Class-room and laboratory work. Hours to be arranged. Assistant Professor HOWE and assistants. Required of candidates for B.Chem., C.E., B.S., and D.V.M.

3. **Introductory Experimental Physics.** Primarily for students in mechanical and electrical engineering. Repeated in second term, credit six hours. Three lectures, one 2-hour class-room period, one 2-hour laboratory period and one problem hour each week. Lectures T Th S, 9, 11, Rockefeller A. Professors MERRITT and GIBBS. Class-room, laboratory, and problem work at hours to be arranged. Staff same as in Physics 2. This course presupposes a knowledge of trigonometry.

7. **General Physics.** Primarily for students in civil engineering. Classroom work. Repeated in second term, credit three hours. Prerequisite Physics 2. Mr. BAYLEY. Hours to be arranged.

14. **Physical Measurements.** Primarily for candidates for B.Chem., C.E., and M.E. Either term or throughout the year, credit one to four hours a term. Prerequisite analytic geometry and the calculus; and at least seven hours of Physics taken from preceding courses, or Physics 3 if Physics 8 and 9 be taken in parallel, or the equivalent. Assistant Professor BIDWELL and assistants. Six sections as assigned. Rockefeller 250–257.

Chemistry

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

1a. Lectures. M W F, 9 or 11. Professor BROWNE and Mr. GRIFFIN.

1b. Recitations (one hour a week to be arranged), and laboratory M F, 2–4.30; T Th, 2–4.30; W, 2–4.30, and S, 8–10.30. Dr. FOGLESONG and Assistants.

Entrance credit in chemistry does not carry with it University credit in course 1. If a student entering the University from a preparatory school desires credit in course 1 he must pass an examination set by the Department of Chemistry. This examination is held both in New York City and in Ithaca on the same day in September as the entrance examination. University credit in course 1 that is obtained by passing this examination does not carry with it entrance credit in chemistry.

Examinations for those who were unavoidably absent from the final examinations in course 1 will be held at 2 p. m. on the day before instruction begins in the fall.

6. **Qualitative and Quantitative Analysis.** Repeated in second term, credit five hours. Prerequisite course 1. Mr. RIDER and Assistants. Lectures, T Th, 12. 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.

Examinations for those who were unavoidably absent from the final examination in course 6 will be held at 2 p. m. on the day before instruction begins in the fall.

Military Science and Tactics

1. **Practical and Theoretical Training.** Throughout the year. Every able-bodied male student, a candidate for a baccalaureate degree, who is required to take five, six, seven, eight or more terms in residence, must take, in addition to the scholastic requirements for the degree, one, two, three, or four terms respectively in the Department of Military Science and Tactics. Three hours a week. Two hours on either Tuesday, Wednesday, or Thursday, 3:15–5:15 P. M. as student may elect; and Friday 4:45–5:45 P. M. New York State Drill Hall.

The requirements in Military Science and Tactics must be completed in the first term of residence; otherwise the student will not be permitted to register again in the University without the consent of the University Faculty.

The course of training is that prescribed by the War Department as basic for units of the Reserve Officers' Training Corps and includes physical drill, infantry drill, field artillery drill, machine gun drill, rifle shooting, personal hygiene, first-aid, camp sanitation, signaling, bayonet combat, map reading, military history, construction of intrenchments and obstacles and the fundamental principles of strategy and tactics to include the detachment and regiment.

2. **Elective Military Training.** Throughout the year. Credit two hours a term. Hours by assignment. New York State Drill Hall.

This is the advanced course, prescribed by the War Department for units of the Reserve Officers' Training Corps, and includes three hours each week in the performance of the duty of officer or non-commissioned officer with organizations undergoing the training given under Course 1, and two hours each week of theoretical instruction in preparation for such duties. Prerequisite Course 1 or its equivalent.

Course 2 may only be elected by permission of the Dean of The College of Civil Engineering, and the Professor of Military Science and Tactics. To enjoy the benefits offered by the Federal Government the student must agree to continue the course for four terms, and to attend two summer camps having a duration of about one month each.

Physical Training

1. Required of freshmen excused from drill. Throughout the year, three periods weekly. Class and squad work, and prescribed exercises.

2. Required of sophomores excused from drill. Throughout the year, three periods weekly. Class and squad work, and prescribed exercises.

For the required work in physical training see the Gymnasium Handbook.

Geology

31. **Practical Geology.** Throughout the year, credit three hours a term. Registration by special permission. Professor RIES. Lectures and laboratory work.

The practical application of geologic principles and the occurrence of such economic materials as are of importance to engineering students, the whole subject being treated with reference to their needs.

Political Science

52. **Elements of Economics.** Throughout the year, credit two hours a term. One lecture and two recitations a week. Mr. R. A. CAMPBELL.

A general introduction to economics. Section assignments will be arranged at the first lecture. Office at Goldwin Smith 252.

Public Speaking

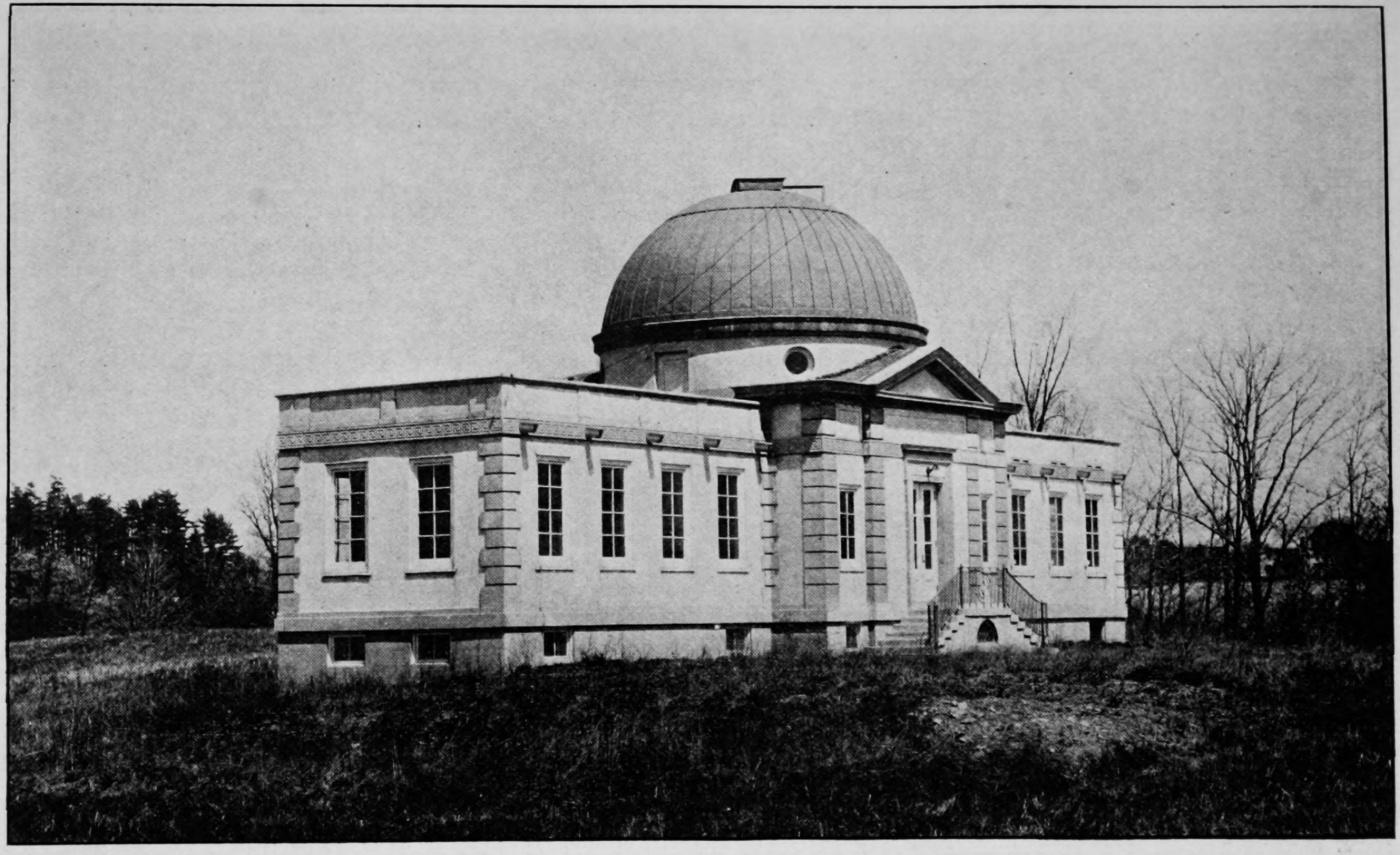
1. **Public Speaking.** Throughout the year, credit three hours a term. Goldwin Smith 24. Professor WINANS.

Designed to give the student the fundamentals of speech preparation and to help him to acquire a simple, direct manner of speaking. Original speeches and interpretation of selections.

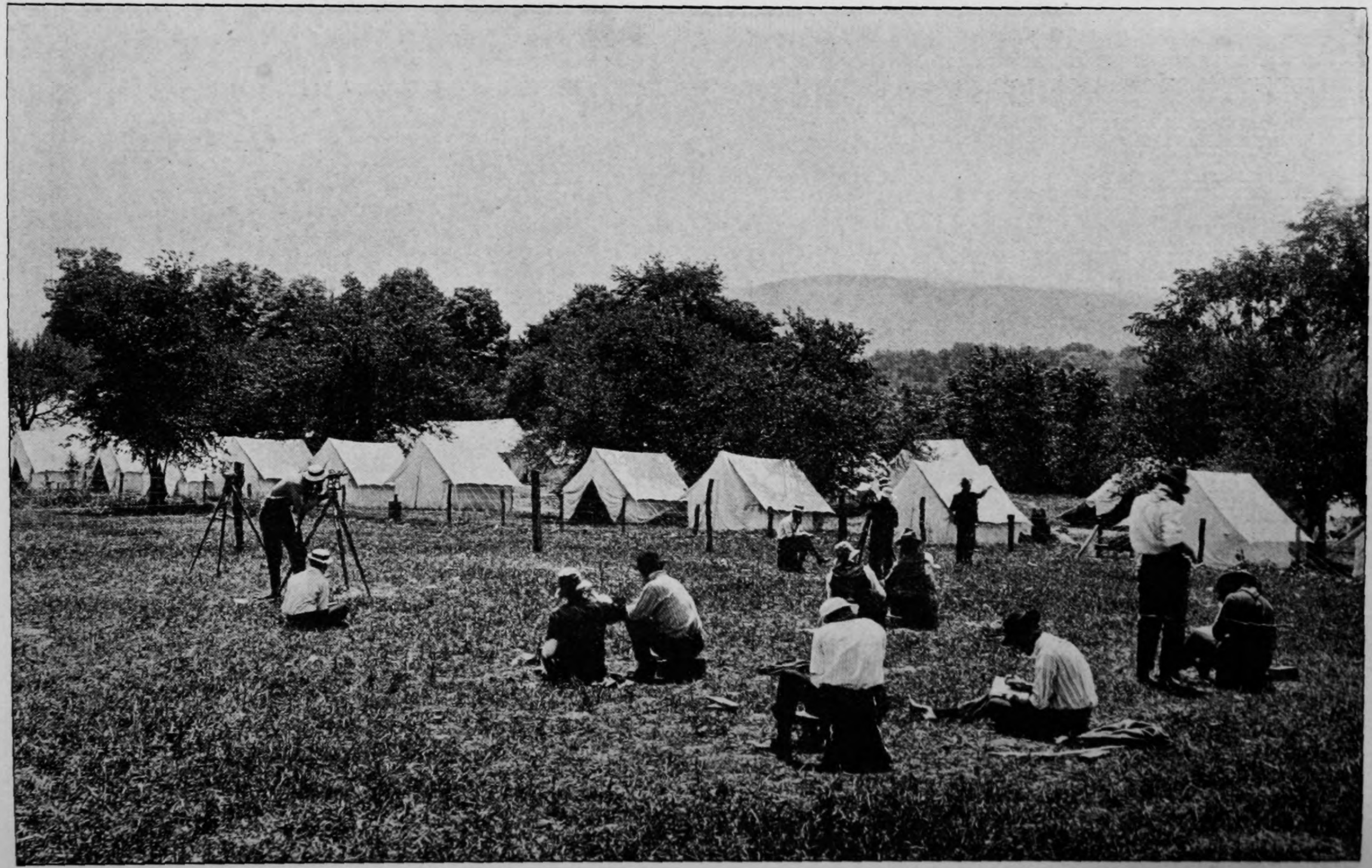
SUBJECTS GIVEN IN SIBLEY COLLEGE

P. 11. **Heat Engines and Auxiliaries (for Civil Engineers).** Required of all seniors in civil engineering. Either term, credit three hours. Not open to Sibley students. Prerequisite Physics 7 and 10, (or the equivalent), Chemistry 1, C.E. 20 and 21. One lecture and two recitations a week.

A study of the air compressor, and the uses of compressed air; of the internal combustion engine; and of steam power apparatus. Emphasis is placed upon



THE FUERTES ASTRONOMICAL OBSERVATORY
NORTH OF BEEBE LAKE



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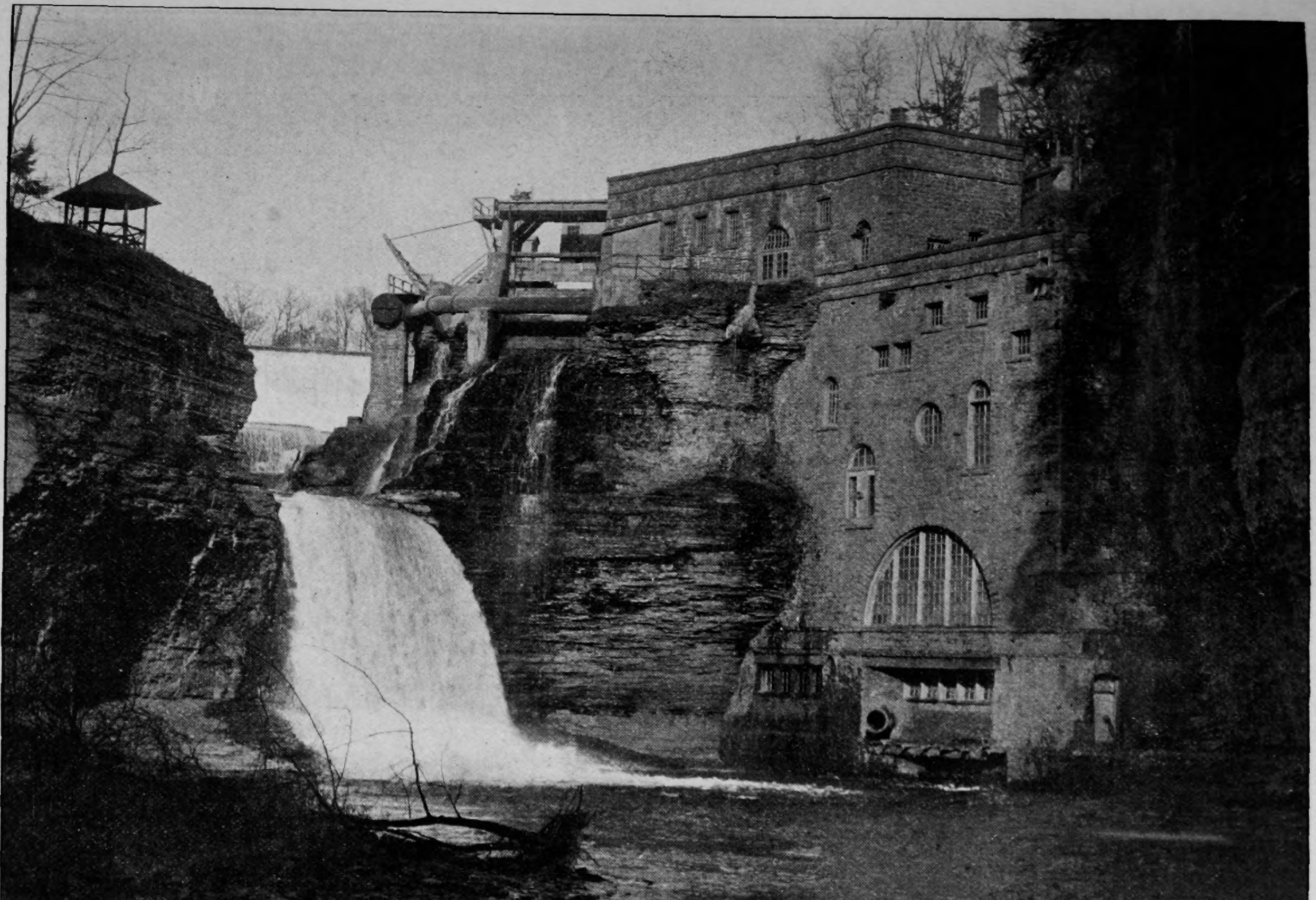

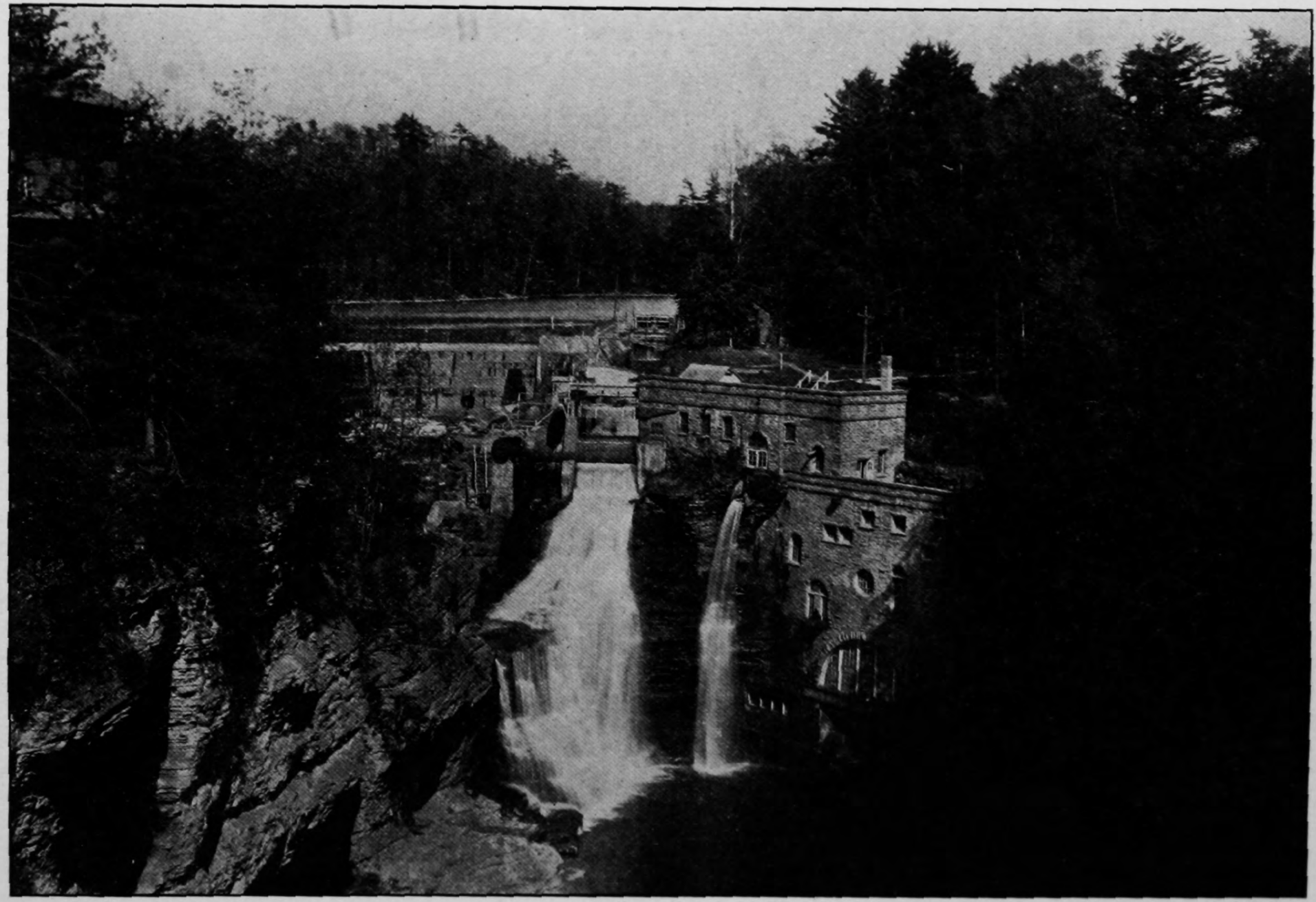

HYDRAULIC LABORATORY

the practical operating characteristics of the machines, and the theory underlying their operation is developed incidentally, although thoroughly. In connection with steam power apparatus, reciprocating engines and turbines are considered as well as boilers and auxiliaries. Some attention is given to central station operating conditions, and to the factors governing the cost of power. The chief interest of the course is, however, in smaller power units, such as the civil engineer is likely to meet with in his field of practice.

This course is recommended for all students who wish to obtain a general knowledge of steam machinery without great technical detail. Professor ELLENWOOD, Mr. CLARK and Mr. PERKINS.

E. 12. **Essentials of Electrical Engineering for Civil Engineers.** Required of all seniors in civil engineering. First term only, credit four hours. Two lectures or recitations and one laboratory experiment with report 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 PERTSCH and Mr. ———.

[P 12. **Small Power Plants.** Three recitations a week, one term. This elective course, open to those who have completed P 11, or its equivalent, involves discussion of the selection, operation, and maintenance of small steam engines, turbines and internal combustion motors, particular attention being paid to ignition and carburation. It is also aimed to discuss recent improvements in small engines, turbines, and boilers. The student is expected to do considerable reading of assigned technical articles in library books or magazines. Professor ELLENWOOD.] Not given in 1919–1920.

SUBJECTS GIVEN IN THE COLLEGE OF CIVIL ENGINEERING

Descriptive Geometry and Drawing

1. **Descriptive Geometry.** Freshmen. Credit two hours first term, and two hours second term. A study of the representation of lines, planes, surfaces, and solids, and their inter-relations. Warped surfaces. A textbook is used and recitations are held upon the problems there stated or explained. The drawing periods serve to allow the students to make drawings of original problems which are illustrations and applications of the problems in the book. Tangencies, intersections, shades and shadows, perspective. The intersections include various forms of the intersections of planes with surfaces and solids, of surfaces with solids, and of solids with solids. The work in shades and shadows includes shade lines on solids and the shadows of solids on planes and other solids. Original problems are assigned for work in the drawing room. Lectures and problems. Two two-hour periods are assigned to each section. Assistant Professor POND and Mr. ———.

2. **Drawing and Lettering.** Freshmen. Credit two hours. One drawing period a week throughout the year. The work is sub-divided and is taken up in the following order: freehand lettering, which includes instruction and practice in a one-stroke freehand letter for working drawings. It is intended that the

student shall acquire proficiency in the use of a letter applicable for shop and other drawings where a finished letter is not required but where rapidity and clearness are essential. Geometrical problems, which include the drawing of the problem in pencil and ink; also a study of simple forms of projection in plan, elevation, and section. Cross sections, which include practice in using drawing instruments in making the conventional signs of section through different materials. Tracing details, which includes the use of tracing cloth in making tracings from blue prints of standard drawings, and from pencil drawings; also making blue prints from tracings. Six sections. Assistant Professor PARSON and Mr. ———.

4. **Drawing and Lettering.** Sophomores. Throughout the year, two drawing periods a week. Prerequisite course 1. The work is subdivided and is taken up in the following order: lettering, which includes a study of, and practice in, different styles of letters, as Roman, Gothic, and stump, together with their combination into appropriate titles. Isometric drawing, which includes the principles involved in isometric projection, with practice in drawing from models and from dimensions. Line shading, which includes the shading of flat and curved surfaces by lines variously spaced and by lines of different thickness. Detail and dimension drawing, which includes the tracing of typical dimension drawings and in making detail drawings from sketches, models, and from other drawings on different scales. Topographic signs, which include practice in the different kinds of standard topographic signs for mapping. Tinting and shading, which includes instruction in, and practice with, water colors, in the rendering of flat and curved surfaces, together with the use of crayon. Each student is required to make a number of plates and to become reasonably proficient in handling the brush and in using crayon. Assistant Professor PARSON.

9. **Introductory Lectures.** Freshmen. Credit one hour. Two lectures a week with required readings. This course of lectures is designed to introduce the first-year men to the various fields of engineering and to demonstrate to them some of the simpler and more general methods of engineering construction. It is the purpose of the lecturers, in which number are included all the members of the faculty, to awaken the interest of the freshmen in their chosen profession, through the aid of vivid description, of stimulating biography, and of personal experience. The course is under the direct supervision of Dean HASKELL.

Topographic and Geodetic Engineering

10. **Elementary Surveying.** Freshmen. First term, credit three hours. Use of steel tape, level and transit. Fundamental surveying methods Measurement of lines, angles, and differences of elevation. Land surveying; areas and plotting. Recitations, field work, computations, and mapping. Text-books: Breed and Hosmer's Elementary Surveying, and Leland and Boothroyd's Area of Land. One recitation and two field or computation periods a week. Assistant Professors UNDERWOOD, and LAWRENCE, and Messrs. PERRY and ———.

11. **Advanced Surveying.** Sophomores. Throughout the year: first term, credit two hours; second term, credit three hours. Prerequisite course 10. City, topographic, hydrographic, mine, and geodetic surveying and field astronomy. Surveys of the United States Public Lands. Precise measurements. Transit and stadia; plane table; sextant. Soundings; stream measurement.

Subterranean surveys. City planning. Earth volumes. Triangulation; base lines; precise leveling. Field determinations of azimuth, time, and latitude. Recitations and field and office work. Textbooks: Breed and Hosmer's Higher Surveying and Campbell's Practical Astronomy. Assistant Professors UNDERWOOD and LAWRENCE, and Messrs. PERRY and ———.

11a. **Advanced Surveying.** For students in Forestry and Landscape Art. Second term, credit two hours. Prerequisite course 10. Topographic hydrographic, mine, and geodetic surveying and field astronomy. United States Public Land Surveys. Precise measurements. Transit and stadia; plane table; sextant. Stream measurement. Topographic reconnaissance. Road location; circular curves. Triangulation for the control of local surveys; base lines. Field determinations of time, latitude, and azimuth. Recitations. Textbook: Breed and Hosmer's Higher Surveying. Assistant Professors UNDERWOOD and LAWRENCE.

12. **Elementary Surveying.** Primarily for students in Sibley College. Second term, credit two hours. A short elective course intended for those students outside of the College of Civil Engineering who desire work in surveying but who are unable to devote more than two hours to the entire subject. A knowledge of plane trigonometry is required. Use of surveying instruments. Tape measurements. Leveling. Problems with transit and tape. Stadia. Recitations, first half term; field work, computations, and plotting, second half. Textbook: Breed and Hosmer's Elementary Surveying. Two periods a week. Two sections. Assistant Professor UNDERWOOD and Mr. PERRY.

13. **Summer Survey; Topographic, Hydrographic, and Geodetic Survey; Camp.** Sophomores. Five weeks in June and July; credit six hours. Date of beginning to be announced in second term. Prerequisite course 11. Open also to students in Forestry and Landscape Art who have had course 11a, for whom the work is modified to meet their special needs. Practical experience in surveying under field conditions. An extensive topographic survey with the transit and stadia and the plane table, and a hydrographic survey of a portion of Cayuga Lake, are executed, and field maps are made. Triangulation and precise leveling control the topographic and hydrographic work. A base line is measured with invar tapes. Astronomic observations for azimuth, latitude, and time are made and results computed. Each student takes part in all branches of the work. Field and office work six days a week. Professor LELAND, Assistant Professors UNDERWOOD and LAWRENCE, and others.

14. **Survey Computations.** Juniors. Prerequisite course 13. First term, credit one hour. Reduction of the observations made at the Camp during the previous summer, in course 13, embracing base-line measurement, triangulation, and leveling. The work results in a set of permanent records which include the descriptions of stations and benchmarks with their elevations, and the geographic positions, azimuths, and distances of the triangulation stations. Four sections. Professor LELAND and Assistant Professors UNDERWOOD and LAWRENCE.

14A. **Mapping.** Elective. Upperclassmen. Required of students in Forestry. Second term, credit two hours. The construction of a final topographic map of the area covered by the field work of course 13 during the preceding summer. The field sheets are combined for this purpose, reduced in scale from

1:4800 to 1:12000, and reproduced, using the triangulation system as a base for the work. Lectures and drawing. Professor LELAND.

14B. **Problems in the Adjustment of Observations.** Elective. Upperclassmen. Prerequisite course 13. Second term, credit one hour. A series of examples in the adjustment of typical surveying work such as leveling, direct measurement of lines and angles, and simple triangulation figures, using the method of least squares. Lectures and problems. Textbook: Leland's Notes on the Adjustment of Observations. Professor LELAND.

15. **Least Squares; Adjustment of Observations.** Elective. Prerequisite, calculus and physics. First term, credit two hours. Lectures and recitations. The course is designed for students who have experimental investigations in view. Applications are made to problems in physics, astronomy, mechanics, hydraulics, surveying, etc., with some attention given to the derivation of empirical formulæ. Two hours a week, as may be arranged. Assistant Professor UNDERWOOD.

16. **Advanced Topographic Surveying.** Elective. Upperclassmen. Prerequisite course 13. First term, credit two hours. Economics of surveying methods. Surveys for special purposes, such as extensive construction work; storage and distribution of water for irrigation; earthwork on a large scale; lines of communication; topographic reconnaissance, etc. Photographic surveying. Lectures. Two hours a week. Professor LELAND.

17. **Geodesy and Geodetic Laboratory.** Elective. Upperclassmen. Prerequisite course 11. First term, credit three hours. A course for the consideration of special problems in geodetic work. Precise leveling. Deflection of the plumb line. Figure of the earth. Use and investigation of geodetic instruments and apparatus; circles, levels, micrometer microscopes, standards of length, thermometers, pendulums, magnetic apparatus, etc. Subject to arrangement to meet the special needs of students. Lectures, reading, discussions, and laboratory work. Three periods a week. Professor LELAND.

18. **Geodetic Astronomy.** Elective. Upperclassmen. Prerequisite course 11. Second term, credit three hours. A study of the more precise methods of determining time, latitude, longitude, and azimuth, together with practice at the observatory in making and reducing the observations, including the determination of instrumental constants. Lectures, recitations, and observations. Three periods a week as may be arranged. Professor LELAND and Assistant Professor UNDERWOOD.

Mechanics of Engineering

20. **Mechanics of Engineering.** For sophomores in Civil Engineering. First term, credit five hours. Repeated in one section, second term. Prerequisite, Mathematics Course 5.

Statics of a material point and of rigid bodies by graphic and by algebraic methods of analysis. Chains and cords. Centers of gravity. Moment of inertia of plane figures. Mechanics of Materials including stress and strain, tension, shearing, compression, torsion, flexure; Elastic curves; Safe loads; Columns; Flexure of beams by semigraphic treatment. Review problems showing application of principles of Mechanics in Engineering Design.

Textbooks: Church's Mechanics of Engineering, and Notes and Examples in Mechanics, supplemented by other printed notes and problems. Four recita-

tions and one computing period a week. The computing period will be in charge of an instructor and will be devoted to the solution of mechanics problems, the use of the slide rule, planimeter, etc. The solution of each problem is to be written up in good form and will be criticized by the instructor. If found unsatisfactory, either as to form or matter, it will be returned for revision. Emphasis will be placed particularly upon correct numerical work and consistent use of proper units. Each student is required to provide himself with a slide rule of approved type. Professor GEORGE and Assistant Professor RETTGER.

21. **Mechanics of Engineering.** Second term. Continuation of Mechanics 20. Prerequisite Mechanics 20. Credit five hours. Dynamics (kinetics) of a material point. Impact. Virtual velocities. Centrifugal and centripetal forces. Pendulums. Moment of inertia of rigid bodies. Dynamics (kinetics) of rigid bodies. Work. Power. Energy. Friction. Dynamometers. Work and energy. Four recitations and one computing period a week. Professor GEORGE and Assistant Professor RETTGER.

26. **Advanced Mechanics.** Seniors and graduates. Either term, credit three hours. Prerequisite courses 20 and 21. Linear arches. Curved beams. Special cases of flexure. Problems in the mathematical theory of elasticity. Thick hollow cylinders and spheres. Plates. Castigliano's theorem of least work. Internal work and its derivatives. Recitations. Three hours a week. Professor GEORGE and Assistant Professor RETTGER.

29. **Engineering Problems.** Juniors. Second term, credit two hours. Prerequisite courses 20, 21 and 40. The object of this course is to provide a review course involving additional practice in using the principles and methods of applied mechanics. A series of problems, such as occur in ordinary engineering practice, and covering a wide range of topics, is given out for solution. Computations and reports; five hours a week. Professor GEORGE and Assistant Professor RETTGER.

24. **Technical Writing.** Sophomores. Either term, credit three hours. This course is intended to aid the student in finding the application of his high school training in English to writing technical reports. One lecture, one recitation, and one exercise for the discussion of written work, each week. Textbook: Sypherd's Handbook of English for Engineers. Professor OGDEN.

Materials of Construction

22. **Materials Laboratory.** Sophomores. Either term, (about one-half of the class each term), credit two hours. Must be preceded by, or taken with, courses 20 and 21 and must be taken with course 25. Experimental determination of the properties of materials by mechanical tests. Study of testing machines: their theory, construction, and manipulation. Calibration of testing machines and apparatus. Commercial tests of iron and steel. Tensile, compressive, torsional, shearing, and flexure tests of metals and various woods with stress-strain observations. Tests of cement for fineness, specific gravity, normal consistency, time of setting, soundness, and tensile and compressive strength for neat and mortar mixtures. Tests of concrete aggregate, and of road material and paving brick. The course is planned to coördinate with course 25 and aims to supplement directly the study of the properties of materials by the actual handling of

the materials and observations of their behavior under stress. Laboratory work two and one-half hours a week. Assistant Professor WALKER and Mr. ———.

25. **Materials of Construction.** Sophomores. Either term (one-half of the class each term), credit three hours. Must be preceded by, or taken with, courses 20 and 21, and must be taken with course 22.. Textbook: Mill's Materials of Construction. The materials studied are: lime, cement, stone, brick, sand, timber, ores, cast iron, wrought iron, steel, and some of the minor metals and alloys. The chemical and physical properties, uses, methods of manufacture, methods of testing, and unit stresses of each material are considered, particular emphasis being laid on the points of importance to engineers. The work is planned to coördinate with the course in Materials Laboratory and supplements that work where necessary. Three recitations a week. Assistant Professor WALKER.

27. **Testing Materials.** Elective. Seniors and graduates. Second term, credit three hours. Prerequisite courses 22 and 25 or their equivalents. Special investigations of an advanced nature of the properties of structural units and the materials of construction.

Tests may be made upon full-sized sections in iron and steel, upon wooden columns, beams, and trusses; standard tests of paving brick and macadamizing materials; standard tests of cement and concrete aggregates; special investigations of the properties of concrete, plain and reinforced, upon full-sized beams and columns; tests upon the bonding strength of steel and concrete; tests upon riveted steel joints; tests upon wire cables, etc. Mills' Materials of Construction and the publications of the American Society of Civil Engineers, and of the American Society for Testing Materials, are used as reference works. The aim of the course is to provide not only a knowledge of materials by observation of their behavior under stress, but also a knowledge of the technique of testing materials; a training in precise methods of observation and interpretation of results; and an appreciation of the relation of theoretical investigation to engineering practice. Advanced students are encouraged to make use of the laboratory facilities for special research. Seven and one-half hours a week as arranged. Assistant Professors WALKER and URQUHART.

Hydraulic Engineering

30. **Water Supply.** Seniors. Either term, credit three hours. Prerequisite course 40. Three recitations a week from assigned texts and the working of assigned problems.

About half of the term is devoted to the methods of making the preliminary investigations for a hydraulic development involving the use of a stream or the ground water, general hydrology, water resources of a basin, methods of systematic stream gaging, stream characteristics, working up data, use of mass curves in storage studies, percolating waters, probable dependable draft, flow into wells, etc. The second half of the term is devoted to a review of the methods of developing public water supplies from the several sources, typical structures, a study of the working conditions and fundamental data for designing conduits, distributing reservoirs, and a network of street mains, particular attention being given to the requirements for fire protection and the economics of pumped supplies. In the problems, applications of the text are made to particular localities, the topographic maps of cities and drainage basins forming the bases of the problems.

Students contemplating extensive election of hydraulic courses should arrange to take this course the first term. Courses 31, 32 and 33 are elaborations of details in this course. Assistant Professor SEERY.

31. **Hydraulic Construction.** Seniors and graduates. First term, credit three hours. Repeated second term. Should be taken after or concurrently with Water Supply, 30. One recitation from assigned texts and two long computing periods a week for working problems. The course is largely devoted to a study of water storage and the engineering investigations and design of structures associated with stream regulation for public water supplies, water power, irrigation or navigation. Extensive problems are worked involving the preliminary investigation of a project, exploration of dam sites, surveys of reservoir sites, the economics of storage, manipulation of storage and pondage, the preparation of an estimate of quantities, costs, plan of progress in construction, etc., for a particular project. The stability of weir dams by graphics, and the analytic design of high masonry dams by Wegmann's method together with a study of all the factors affecting the stability and form of section of a dam, and the methods of construction are fully covered by text and in problems. Earthen dams and embankments, timber weirs, movable dams and flashboards are also considered. Course 31 may be substituted for Engineering Design, Course 91. Assistant Professor SEERY.

32. **Water Power Engineering.** Seniors and graduates. First term, credit three hours. Prerequisite, C.E. 40, and must be taken after or concurrently with Course 30. Recitations from assigned text and the working of lengthy problems. The course is devoted to a general study of the problems of water power development, the factors affecting the economics of a project, the engineering and commercial feasibility of developing power and the value of a mill site. A detailed study of the characteristics of modern turbine types, the selection of mechanical equipment suited to the conditions of installation and operation, the effects of load factors, pondage, storage and steam auxiliary on the capacity and cost; together with an analysis of the power capacity of a low head mill site, the speed regulation of a plant under medium head fed by a long penstock, and a thorough study of the phenomena of unsteady flow and surging, with and without surge tanks, are covered by the text and incorporated into numerical problems taken from existing plants. Course 32 may be substituted for Engineering Design, Course 91. Assistant Professor SEERY.

33. **Pumps and Pumping.** Seniors and graduates. Second term, credit three hours. Prerequisite Course 40; should be preceded by or taken concurrently with course 30.

Recitations from assigned texts and working of problems. The course deals with types and characteristics of pumps with particular reference to adaptation of the mechanical equipment of a pumping station to the working conditions as indicated by the load curve of pumping stations for public water supplies, irrigation and drainage projects, special fire protection systems, etc. A thorough study of centrifugal pumps and their characteristic curves, the interpretation of tests, methods of making tests, and the forecasting of the results, and costs of operation of pumps for the several purposes above mentioned, will be made by text and exemplified by numerical problems to be worked by the student. Assistant Professor SEERY.

Theoretical and Experimental Hydraulics

40. **Hydraulics.** Juniors. First term, credit three hours. Prerequisite courses 20 and 21. Two recitations and one computing period a week; six of the recitation hours are utilized for experimental demonstrations. Hydrostatic pressure. Manometers. Strength of pipes. Stability of dams. Immersion and flotation. Flow of liquids through orifices, nozzles, Venturi meters, and pipes and over weirs. Time required to empty tanks and reservoirs. Simple, compound, branching and looping pipes. Elementary power calculations in common pumping and fire protection problems. Flow of water in open channels. Pressure on stationary solids due to deviated flow. Assistant Professor SCHODER.

41. **Advanced Hydraulics.** Elective for juniors and seniors. Second term, credit three hours. Prerequisite course 40. One recitation and two long periods a week. One period is devoted to problems and the other to laboratory work and preparation of reports. The recitations and problems take up topics in stability of flotation; overflow dams, free and submerged; backwater and variable flow in open channels; standing waves; water hammer and surges; flow of air in pipes; impulse wheels and turbines; centrifugal pumps; hydraulic rams; logarithmic plotting. The laboratory experiments include gage testing, orifices, nozzles, pipes, current meter rating, Pitot tube, Venturi meter. Assistant Professor SCHODER.

42. **Hydraulic Measurements.** Elective for seniors and graduates. First term, credit three hours. Prerequisite courses 40 and 41. Three periods a week in laboratory or computing room. In addition to more thorough experimental investigations on some of the laboratory topics mentioned under course 41, e. g. weirs, Pitot tubes, pipes and current meters, the work includes fire hose and nozzles, ordinary water meters, floats in open channels, actual measurement of river discharge (on a week-end trip) and such occasional tests as opportunity offers in the laboratory or the immediate neighborhood of Ithaca. Assistant Professor SCHODER.

43. **Experimental Hydraulic Motors and Pumps.** Elective for seniors and graduates. Second term, credit three hours. Prerequisite course 41. Three periods a week. The determination of efficiency, capacity, and characteristics of hydraulic machinery by tests. Assistant Professor SCHODER.

44. **Experimental Hydraulic Investigation.** Elective for seniors and graduates. Either term, credit three hours (or more in special cases). Prerequisite courses 40 and 41, or equivalent. The subject and scope of the investigation should be selected by conference at the beginning of the term if not previously arranged. It is often permissible and desirable for two students to work together on the same investigation. Written reports are required but the text need not be typewritten in thesis style. These reports are kept by the department. In most cases it is necessary to arrange a definite schedule for work in the laboratory to avoid interferences. Work involving a large proportion of the equipment in amount or time, or involving unusual cost, is subject to the approval of the Dean of the College of Civil Engineering. Assistant Professor SCHODER.

Municipal and Sanitary Engineering

50. **Sanitary Biology.** Juniors. Second term, credit five hours. Prerequisite Chemistry, course 6. Textbook: Buchanan's Household Bacteriology. Notes on Algæ and Protozoa.

The course includes a study of the principles of microscopy, bacteriology, and algology with special reference to sanitary engineering. Bacteriological and biological examinations of water supplies are made; and the identification and control of the various plant forms which render water supplies objectionable, or which indicate dangerous pollution, are taken up. Three recitations and two laboratory periods a week. Assistant Professor WALKER.

52. **Municipal Sanitation.** Juniors. Second term, credit three hours. Prerequisite course 40. Sewer design and construction, and sewage disposal. Recitations, three times a week with occasional lectures. Problems illustrating the matter taken up in the recitations, such as problems on sewage flow, both domestic and storm water, hydraulic problems, construction problems dealing with masonry foundations and reservoir walls and with various details of disposal plants. Textbooks: Ogden's Sewer Design, Ogden's Sewer Construction, and notes on Sewage Disposal. Four sections. Professor OGDEN.

53. **Purification and Control of Water Supplies.** Seniors and graduates. Second term, credit three hours. Prerequisite course 40. Examination of water, physical, chemical, and bacteriological; normal quality of surface and subterranean waters, with effects of storage; communicable diseases and water supplies; epidemics of typhoid fever and cholera with studies of etiology, etc.; purification of water, sedimentation, and coagulation; slow sand filtration, theory, construction, and operation, with examples; rapid sand filtration, theory, construction, and operation, with examples; miscellaneous purification processes, aeration, softening, iron removal, sterilization, distillation, and purification by chemicals. Professor OGDEN.

54. **Sewerage Works.** Seniors and graduates. First term, credit three hours. Prerequisite course 52. Three hours a week for 15 weeks, divided between lectures and recitations. Textbook: Kinnicutt, Winslow, and Pratt's Sewage Disposal. The work is upon the construction and operation of sewers and sewage-disposal works, illustrated by lantern slides and by reference to recent descriptions of sewage-disposal plants in the current literature. There are, generally speaking, three recitations or one week's work on each of the following topics; disposal by dilution (salt and fresh water); chemical precipitation; broad irrigation, with special reference to institutions; natural and artificial filtration beds; sedimentation and septic tanks; Imhoff tanks; contact beds, sprinkling filters, and activated sludge. It is intended to differentiate this course from the junior work by making the latter chiefly a discussion of principles involved, while the senior course is a detailed investigation of the methods of construction with the reasons involved. Professor OGDEN.

55. **Sanitary Laboratory.** Seniors. Second term, credit three hours. Prerequisite courses 50, 52, and Chemistry 6. This course offers a practical demonstration of some of the topics considered in courses 52, 53, and 54. Studies of the qualities of water in streams, sewers, and in the city sewage settling tank are made by means of the usual tests for suspended solids, for dissolved oxygen

and for oxygen consumed. Examinations of samples of sand are made for percentage of voids, for turbidity, for frictional resistance to water flow, and for efficiency as filters. Comparative tests of precipitants on various naturally and artificially polluted waters are carried out and losses of head in columns of sand are found. Measurements of velocities and grades in the city sewers and a study of their interrelation with sizes of pipes and depths of flow are made. Nine hours a week. Professor OGDEN.

56. **Municipal Engineering.** Elective. Graduates. A discussion and study of questions other than water and sewerage dealing with the health of cities. Lectures, reports, and readings. Three hours. Professor OGDEN.

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

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

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

Railroad and Highway Engineering

60. **Railroad Surveying and Drawing.** Juniors. Throughout the year, credit four hours first term and one hour second term. Sections of 20 to 25 men each. Prerequisite course 13.

First Term. Railroad Surveying. The work consists of (1) field problems, (2) location work, (3) recitations.

Field Problems.—In the field problems the section is divided into parties of three so that each student obtains more individual instruction, more practice in handling instruments, and a more intimate knowledge of the problems.

Each party's work involves the laying out and checking of simple and transition curves, the use of the aneroid barometer, study and inspection of the details of switches, turnouts, and other yard work, and occasional recitations and office problems. The greater portion of the time is spent on simple and transition curve problems. Two periods, of two and one-half hours each, a week for the first ten weeks.

Location work.—Each section is required to make complete preliminary and location surveys for a line two or three miles long. In this work the section is divided into level, transit, topography, and cross section parties as the different phases of the work are encountered; finally structure and right of way surveys are made. The assignments of the men are changed every period so that each student receives practice in the various kinds of field work and in the office work of computing and plotting involved in a survey of this character. One six-hour period a week for ten weeks.

Recitations.—Three recitations a week are given for the remaining five weeks of the term. The first two weeks are spent on earthwork computations; the remaining three weeks are devoted to a review of the theory and applications of simple and transition curves, switches and turnouts, barometric leveling, vertical curves, etc.

Textbooks, Crandall and Barnes' Railroad Surveying, and Crandall's Earthwork Tables.

Second Term. Railroad Drawing.

Each man makes a map and profile of the line surveyed by his section during the first term. The student is also required to compute part of the earthwork, to make a mass diagram of the line, and use the same in determining the best distribution of the material. Each student also makes a plan and estimate of cost for one of the structures. One three-hour period a week throughout the term.

Professor BARNES, Assistant Professor CONWELL, and Messrs. PERRY, CRANDALL, and MCANLIS.

61. **Railroad Maintenance of Way.** Elective. Seniors and graduates. First term, credit three hours. Prerequisite course 60. The subjects treated are: track materials, with especial reference to the section, method of manufacture and composition of steel rails; to the economics of tie preservation and the use of metal ties; and to the effect of quality of ballast upon maintenance. Machine and other methods of grading for second track; drainage; track laying both by machine and hand methods, ballasting and bringing new track to line and grade. Turnouts and switches; derailing switches; side tracks and yard tracks; sorting and terminal yards. Track maintenance; track tools; work trains. Action of car wheels on curves; widening of gage. Double tracking; separation of grades; and improvement in grades and alinement. Lectures and recitations three hours a week. Professor BARNES.

62. **Railroad Operation and Management.** Elective. Seniors and graduates. Second term, credit three hours. Prerequisite course 60. The course is based on Morris' Railroad Administration and Latimer's Railway Signaling, both of which are used as textbooks. Under organization the following subjects are treated: the general principles underlying organization and the effect of each on efficiency; principal departments of railway service with a brief outline of the work of each; departmental and divisional systems of organization, with examples on various roads and discussion of adaptability of each. The duties of officers and the work of the different departments are taken up in considerable detail. The most important laws affecting railroads are given in discussing the work of the legal department. Freight traffic, freight houses, classification yards, car service rules, accounting, etc., are among the topics considered under operation. Signaling and interlocking and train rules are also considered. Lectures and recitations three hours a week. Professor BARNES.

63. **Railroad Location.** Elective. Juniors and Seniors. Credit three hours, second term.

A detailed study is made of the economic principles governing the location of new railroads, both steam and electric, and the revision or relocation of existing lines to make them most efficient as transportation machines. Some of the topics treated are: estimation of revenue, expenses and rates; steam and electric

locomotive performance and train operation; gradients, distance and curvature; line and grade revisions, grade crossing elimination and additional facilities; location surveys and estimates. Lectures and recitations with problems involving investigations of projects, revisions and comparisons of alternate locations, three hours a week. Professor BARNES.

65. **Highway Engineering.** Elective. Seniors and graduates. Either term credit three hours. Prerequisite first term of course 60. Work consists of recitations and lectures on the economics of location and the prevailing methods of construction and maintenance of earth roads, sand-clay and top-soil roads, and water-bound macadam, etc.; a study of the interpretations of tests of bituminous materials and their characteristics; treatment of macadam surfaces with non-bituminous and bituminous dust preventives and binders; economics of selection of type and methods of construction and maintenance following types of city pavements: bituminous concrete, sheet asphalt, wood block, concrete, brick, stone blocks, etc. As each type of pavement is taken up in class the equipment and organization best adapted to its successful construction are discussed.

Problems are assigned in road location, street intersections, etc., and in making detailed estimates of cost of different kinds of road and pavement construction. Assistant Professor CONWELL and MR. PERRY.

66. **Highway Laboratory.** Elective. Juniors and seniors. Either term, credit three hours. Students are required to make all the standard tests of materials used in highway construction. Special emphasis is placed upon tests of bituminous materials, study of analyses, characteristics of different materials, and heat treatments and their effect. The classes are required to study specifications of various materials.

Special tests and investigations will be made to investigate the strength of various combinations of materials and also the effects of modifications in design. One lecture and two laboratory periods a week. Assistant Professor CONWELL and MR. PERRY.

67. **Engineering Construction.** Juniors. Second term. Credit three hours. Prerequisites 40 and first term of 71.

A course in the fundamentals of construction with special reference to field methods, plant layouts and costs. The course includes: estimates and analyses of costs with reference to planning, preparatory and construction periods; earth and rock excavation, tunneling, foundations, masonry, haulage, timbering, falsework, etc.

The above are applied to the various types of engineering construction to which they are best adapted. Frequent problems are given to bring out these applications and lantern slides are used to illustrate current practice. Attention is also given to the economic selection of structures, etc.

Lectures, recitations, and problems, three hours a week..

Professor BARNES, Assistant Professor CONWELL and Messrs. PERRY, CRANDALL, and MCANLIS.

Bridge Engineering

71A. **Structural Design and Bridge Stresses.** Juniors. Either term. Credit four hours. Prerequisite courses 20 and 21.

Structural Design. The recitations cover the graphic analysis of simple beams and roof trusses in chapters I and II of Merriman and Jacoby's Roofs and

Bridges Part II. The computations and drawings include complete detail designs and working drawings of wooden joints to resist large tensile stresses, and of a wooden roof truss for given specifications. The object of the course is to show how to apply the principles of mechanics to the design of every detail of the simple structures named, and to study the forms and strength of joints and fastenings used in heavy framing. The computations required are to be arranged in systematic order in the form of reports. Reference book: Jacoby's Structural Details. Computation and drawing, two and one-half hours a week.

Bridge Stresses. Stresses due to dead, live, and wind loads, initial tension, and impact. Panel loads and locomotive axle loads. Determination of the position of live loading for greatest stresses. Maximum and minimum stresses. Analytic and graphic methods are used. The principal types of simple trusses employed in modern construction are considered, in several cases both with and without counterbracing. Historical notes on truss bridges. The solution of many numerical examples taken from practice forms a prominent part of the class work. Each student is required to compute all the stresses in the main trusses and lateral bracing for a through Pratt truss railroad bridge which is to be designed subsequently. Textbooks: Merriman and Jacoby's Roofs and Bridges, Parts I and II. First term. Two recitations and one computation period a week. Professor JACOBY, Assistant Professors BURROWS and URQUHART.

71B. **Structural Design.** Juniors. Either term. Credit three hours. An elementary course in Steel Design. Complete design, detail drawings, bill of material and estimate of weight of a steel roof truss and of a through railroad plate girder. Textbook: Merriman and Jacoby's Roofs and Bridges, Part III. Three computation and drawing periods a week. Professor JACOBY and Assistant Professor BURROWS.

72. **Reinforced Concrete Arch.** Seniors and graduates. Elective. First term, credit three hours. This course may be substituted for engineering design, course 91f. Prerequisite courses 20 and 21, and the first part of course 71. The design of an arch of reinforced concrete including its abutments and centering. The general form and proportions are determined by two preliminary investigations. The final investigations of the arch ring are made in accordance with the elastic theory, the live loading for maximum unit-stresses in the arch ring, as well as the direction and magnitude of abutment thrusts, being determined by means of influence lines. The design is supplemented by several illustrated lectures on the different types of concrete arch bridges of recent construction, their principal details, methods of erection, and influence on design. Textbook: Hool's Reinforced Concrete Construction, Vol. III. Lectures, computation, and drawing, nine hours a week. Assistant Professor BURROWS.

73. **Higher Structures.** Elective. Seniors and graduates. Either term, credit three hours. Prerequisite courses 20, 21 and 71. Determination of the loading and stresses in continuous girders and trusses, swing bridges, and metallic arches. The arches include arch ribs and trussed arches with three and two hinges respectively. Both analytic and graphic methods are used. The latter include displacement diagrams to find the deflections of trusses and the reactions of statically indeterminate structures, and the use of influence lines to find their loading and stresses. These studies are accompanied by historical notes on arches, drawbridges, and cantilever bridges. Textbook: Merriman and Jacoby's

Roofs and Bridges, Part IV. Recitations, three hours a week. Professor JACOBY.

74. **Masonry and Foundations.** Seniors and graduates. Either term, credit three hours. Prerequisite courses 20 and 21. Piles and pile driving, including timber, concrete, tubular and sheet piles; cofferdams; box and open caissons; pneumatic caissons for bridges and buildings, caisson sinking, and physiological effects of compressed air; pier foundations in open wells; freezing process; hydraulic caissons; ordinary bridge piers; cylinder and pivot piers; bridge abutments; spread footings for building foundations; underpinning buildings; subterranean explorations; unit loads. Textbook: Jacoby and Davis's Foundations of Bridges and Buildings. Recitations, collateral reading in engineering periodicals, and illustrated reports. Three hours a week. Professor JACOBY.

75. **Bridge Design.** Elective. Seniors and graduates. Credit three hours. Prerequisite Course 71, second term. Computations and drawing for the complete design of a riveted railroad bridge of six or seven panels, the stresses for which were computed in connection with the previous study of bridge stresses. The computations to determine the sections of all members and of pins, pin plates, splices, and other details as well as of connecting rivets are to be written up in the form of systematically arranged reports. The drawings consist of general detail plans showing the location of all rivets as well as the composition and relation of all members and connections. The final report is to give a full list of shapes and plates, and a classified analysis of weight for the span. Textbook: Merriman and Jacoby's Roofs and Bridges, Part III. Second term. Computation and drawing, twelve hours a week. Professor JACOBY, Assistant Professor BURROWS.

76. **Steel Buildings.** Elective. Seniors and graduates. First term, credit three hours. Prerequisite courses 20, 21 and 71. This course may be substituted for Engineering Design course 91. This course comprises the design of the steel framework for a building of the prevailing type used in power house or shop construction. Dead, snow, and wind stress diagrams are drawn for the roof trusses. Provision is made for an electric crane moving the full length of the building and the stresses in the framework due to the movement of the crane determined. The effect of the wind and the eccentric load due to the crane girder are considered in the design of the columns. Reports and drawings. Three two-hour periods a week. Assistant Professor URQUHART.

77. **Concrete Construction.** Either term, credit three hours. Prerequisite Courses 20 and 21. Concrete materials, properties of plain concrete, its making and deposition. Elementary theory of reinforced concrete as applied to columns, rectangular beams and slabs, T-beams and beams reinforced for compression. Direct stress combined with flexure. Laboratory work includes the making and testing of columns, beams, and bond specimens. Two recitations and one laboratory or computing period a week. Assistant Professor URQUHART.

78. **Concrete Design.** Elective. Seniors and graduates. Second term, credit three hours. Prerequisite Course 77. This course may be substituted for Engineering Design, Course 91. Applications of the theory of reinforced concrete to the design of the various types of retaining walls. Selective problems in the design of reinforced concrete structures such as buildings, sewers, etc. Reports and drawings. Seven and one-half hours a week. Assistant Professor URQUHART.

79. **Concrete Highway Bridge Design.** Elective. Seniors and graduates. Second term, credit three hours. Prerequisite Course 77. This course may be substituted for Engineering Design, Course 91. Application of the theory of reinforced concrete to the design of short-span bridges and their piers and abutments, of the type used on state highways, in viaduct construction, and in grade elimination. Reports and drawings. Seven and one-half hours a week. Assistant Professor URQUHART.

Specifications, Designs, Etc.

89. **Cost Keeping and Management.** Elective. Seniors and graduates only. First term, credit two hours. An elementary course on the principles which govern the organization and management of laborers on construction; systems of payment, measurement of efficiency and cost keeping, with illustrative examples. Professor BARNES.

90. **Specifications and Contracts.** Seniors. Either term, credit two hours. Development of contract principles; agency, tort, and independent contractor; contracts of association, and of sale and transportation. Preparation of engineering contracts. Relation to commercial contracts. Practical suggestions for general condition clauses, as extras, contractor's risks, payments, arbitration, etc. Specifications and methods of studying them; skeletons of important examples of contracts and specifications. Practice in analyzing and in writing specifications. Acquisition, ownership, and conveyance of land; rights and liabilities in streams, surface and underground waters; property rights defined by boundaries; and determination of boundaries of land. Tucker's Contracts in Engineering is used as a text, and Wait's Law of Operations in Engineering Construction as a reference book. Lectures and recitations, two hours a week. Professor BARNES, and Messrs. CRANDALL and PERRY.

91. **Engineering Design.** Seniors. Credit three hours. The student is required to make complete designs in one of the following subdivisions, subject to approval; hours to be arranged.

(c) **Hydraulic Engineering.** Second term. General prerequisite 40 (or former 23) and 29. For best results hydraulic design should be preceded by course 30, but the two may be taken concurrently. Course 31 or 32 may be substituted for Engineering Design. One or both of these courses should be elected by the student specializing in hydraulics unless he has a good reason for electing independent design instead. The purpose of the course is not to duplicate in large part work regularly given in Courses 31, 32 and 41 or in the courses in structural engineering. Assistant Professor SCHODER.

(d) **Sanitary Engineering.** First term. This course must be preceded by or taken at the same time as course 54, and may not otherwise be elected. The following problems assigned in 1909–10 indicate the scope of the work:

1. Computations, design, and detail drawings for the wooden forms needed for brick or concrete sewers of various diameters and forms of cross sections.

2. Computations, design, and detail drawings for a pile foundation to support sewers from 3 to 10 feet in diameter.

3. Design and detail drawings for patterns of cast iron manhole covers.

4. Computations, designs, and detail drawings for flap valve as outlet of settling tank; the design involving a lifting device.

5. Design and detail drawings of a sewage screen, involving a device for raising screen for cleaning.

6. Computations, designs, and detail drawings for an inverted siphon for sewage flow. The problem involves a flushing gate and overflow as well as manholes.

7. Design of disposal plant for a small community as an asylum or school. Professor OGDEN.

(e) **Railroad and Highway Engineering.** Second term. The problems are those encountered in the location and construction of railroads and highways, and include the following subjects: economic location of railroads and highways; selection, design, and detailed estimates of cost of different types of highway surfaces for various traffic conditions; culverts; bridges; retaining walls; tunnel and subway design; small depot buildings; freight houses; water supply and coaling plants; icing stations; turntables and engine-houses; gravel washing plants; track layouts with details of signals and interlocking; yard and terminal design, etc. Bills of material and estimates of cost are usually required.

The field is so broad that the interest of the student is given consideration in assigning problems. Professor BARNES, Assistant Professor CONWELL, and Messrs. PERRY and CRANDALL.

(f) **Bridge Engineering.** Second term. Course 71 is required as general preparation for engineering design in bridges and buildings. Course 73 is required in preparation for designs relating to draw, cantilever, suspension, and metallic arch bridges. Course 77 is similarly required for designs of bridges and buildings in reinforced concrete. Courses 72, 75, 76, 78 and 79, may be substituted for engineering design. Professor JACOBY and Assistant Professor URQUHART.

92. **Thesis.** Elective. Seniors. Credit three hours. The thesis is intended to demonstrate the ability of the student for independent investigation, or his ability to apply the fundamental principles acquired in this course to the study of some special problem related to civil engineering. The latest date for filing the subject with the Dean of the College is October 15 for the first term, and January 15 for the second term. The plan of work is to be submitted to the professor having charge of the subject, to whom also regular reports are to be made, showing the progress of the investigation. The latest date for presenting the complete thesis is June 1. A pamphlet containing instructions in regard to theses in Civil Engineering is available and should be consulted by students registered for this course.

Special and Graduate Courses

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