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VOLUME 1 NUMBER 5

COLLEGE OF CIVIL ENGINEERING
COURSES OF INSTRUCTION
1910-11

DECEMBER 1, 1910
PUBLISHED BY CORNELL UNIVERSITY
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COLLEGE OF CIVIL ENGINEERING

FACULTY

Jacob Gould Schurman, A.M., D.Sc., LL.D., President.
Eugene Elwin Haskell, C.E., Director of the College of Civil Engineering and Professor of Experimental Hydraulics.
Charles Lee Crandall, C.E., M.C.E., Professor of Railroad Engineering.
Irving Porter Church, C.E., M.C.E., Professor of Applied Mechanics and Hydraulics, in charge of the College Library.
Henry Sylvester Jacoby, C.E., Professor of Bridge Engineering.
Henry Neely Ogden, C.E., Professor of Sanitary Engineering.
David Albert Molitor, B.S. in C.E., C.E., Professor of Topographic and Geodetic Engineering.
John Thomas Parson, Assistant Professor of Drawing, in charge of the Photographic and Drawing Collections.
Ernest William Schoder, B.S., Ph.D., Assistant Professor of Experimental Hydraulics, in charge of the Hydraulic Laboratory.
Fred Asa Barnes, C.E., M.C.E., Assistant Professor of Railroad Engineering.
Ora Miner Leland, B.S., C.E., Assistant Professor of Geodesy and Astronomy.
Miles Albion Pond, Ph.B., Assistant Professor of Civil Engineering, in charge of Descriptive Geometry.
Francis Joseph Seery, S.B., Assistant Professor of Civil Engineering.
Donald Derickson, C.E., Assistant Professor of Structural Engineering.
Samuel Latimer Boothroyd, B.S., M.S., Assistant Professor of Topographic and Geodetic Engineering.
Ernest William Rettger, A.B., Ph.D., Assistant Professor of Applied Mechanics.
Sidney Gonzales George, C.E., Assistant Professor of Applied Mechanics and Secretary of the College Faculty.
Charles Leopold Walker, C.E., Assistant Professor of Applied Mechanics.
Kenneth Bertrand Turner, C.E., M.C.E., Assistant Professor of Hydraulics.
Latta Vanderion Edwards, B.E., Instructor in Civil Engineering.
Paul Halladay Underwood, C.E., Instructor in Topographic and Geodetic Engineering.
Roland Parker Davis, S.B., M.C.E., Instructor in Bridge Engineering.
Leonard Alexander Lawrence, B.S., Instructor in Surveying.
John Clarence McCurdy, B.S., Instructor in Surveying.
Ralph McLane Bowman, C.E., Instructor in Bridge Engineering.
Edward Hooker Taylor, B.S. in C.E., Instructor in Civil Engineering.
William Harley Morris, C.E., Instructor in Civil Engineering.
Edward Vahan Baron, B.S., C.E., Instructor in Civil Engineering.
Earle Nelson Burrows, C.E., Instructor in Civil Engineering.
Thomas Jefferson Smull, C.E., M.E., Instructor in Civil Engineering.
Nathan Washington Dougherty, B.S. in C.E., Instructor in Civil Engineering.

Gertrude Marsh Sanford, College Librarian.
Eleanor E. Illston, Secretary to the Director.
Lena K. Haylett, College Stenographer.
Clinton D. Cass, College Mechanician.

COLLEGE OF CIVIL ENGINEERING

COURSES OF INSTRUCTION

1910–11

The registration of new students will take place from 9 A. M. to 4 P. M., Tuesday and Wednesday, September 27 and 28, 1910. Seniors, juniors, and sophomores in good standing, may register in the College between 9 A. M. and 4 P. M. on Wednesday and Thursday, September 28 and 29, 1910.

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 Courses of Instruction for that College for 1910–11. The required work in electrical engineering and steam machinery is given in Sibley College; for a description of these courses see Announcement of that College 1910–11.

A FOUR-YEAR COURSE LEADING TO THE DEGREE OF CIVIL ENGINEER

Freshman year	No. course	First term	Second term
Analytics	1	4	–
Differential Calculus	1	1	2
Integral Calculus	1	–	4
Physics	1	4	–
Physics	6	–	4
Chemistry	1	–	6
Descriptive Geometry and Drawing	1	5	2
Elementary Surveying	10	3	–

In addition to the above the required Drill must be taken.

Sophomore year	No. course	First term	Second term
Geology	31	3	3
Mechanics of Engineering	20	5	5
Engineering Laboratory	22	–	4
Drawing	4	4	or 4
Advanced Surveying	11	–	3
Materials of Construction	25	3	or 3
Chemistry	6	5	–

In addition to the above the required Physical Training must be taken.

Junior year	No. course	First term	Second term
Political Economy	51	3	3
Railroad Engineering	60	4	4
Structural Design	71	4	4
Hydraulics	23	5	–
Hydraulic Laboratory	40	1	–
Municipal Engineering	52	–	4
Engineering Problems	29	–	2
Geodetic and Topographical Surveys	15	–	4

(Four and one-half weeks at close of year.)

Senior year	No. course	First term	Second term
Geodetic Surveying	13	5	–
Cartography	16	–	3
Water Supply	51	3	–
Reinforced Concrete Arch	72	–	2
Specifications and Contracts	90	–	2
Electrical Engineering (E.)	12	3	–
Steam Machinery (P.)	11	–	3
Thesis	92	–	3
Elective	–	6	3

For the thesis, work in engineering design or in investigation may be substituted; but such substitution must be approved by the professor in charge of the group in which the six hours mentioned in the next paragraph are taken.

At least six hours of elective must be chosen from one of the following groups, Engineering Design, course 91, being included. Engineering design shall not be elected in any group unless the elective subject corresponding and preparatory to that design shall be or has been previously elected. If Sanitary Engineering be elected, it is required that the entire group, as well as the thesis, be taken. Course 31 or 32 may be substituted for Engineering Design, course 91, in group a; and course 76 or 77 may be substituted for Engineering Design, course 91, in group d.

(a) Hydraulic Engineering

	No. course	First term	Second term
Hydraulic Construction	31	3	(or 3)
Water Power Engineering	32	(or 3)	3
Hydraulic Measurements	41	–	3
Experimental Hydraulic Motors and Pumps	42	3	–
Experimental Hydraulic Investigation	43	–	3
Engineering Design	91a	–	3

(b) Sanitary Engineering

	No. course	First term	Second term
Design of Sewerage Works	54	3	–
Engineering Design	91b	3	–
Purification and Control of Water Supplies	53	–	3

(c) Railroad Engineering

	No. course	First term	Second term
Maintenance of Way	61	3	–
Operation and Management	62	–	3
Testing Materials	30	3	–
Masonry and Foundations	74	3	–
Concrete Construction	77	3	(or 3)
Engineering Design	91c	–	3

(d) Bridge Engineering

	No. course	First term	Second term
Advanced Mechanics	26	3	–
Higher Structures	73	3	(or 3)
Concrete Construction	77	3	(or 3)
Steel Buildings	76	–	3
Masonry and Foundations	74	(or 3)	3
Engineering Design	91d	–	3

Free choice is given for the three or more hours remaining. The following subjects are suggested for work outside of the College:

Bacteriology, course 43. [Preparation, Microscopy, course 1, one hour.]

General Biology, course 1, three hours.

Sanitary Science, two hours.

Chemistry, Potable Water, course 75, two hours; Water Analysis, course 76, three hours; Assaying, course 18, three hours.

Contracts, six hours (in the College of Law).

Electrical Engineering. Elements of Electric Railway Practice, course 25, two hours.

Oratory. Public Speaking, course 1a, three hours; Public Speaking, course 1b, three hours; Public Speaking for Engineers, course 3, two hours; Argumentation and Debate, course 3, two or three hours.

Geology. Determination of Minerals by the Blow-Pipe Method, course 13, one hour.

Physics. Physical Experiments, course 14, one or more hours; Electrical Laboratory Practice, course 34, three hours.

Political Economy. Principles of Business Management, course 62, two hours; Municipal Government in the United States, course 74b, two hours; Money, Credit, and Banking, course 64, four hours.

Engineering Calculations, course E. X. 30, two hours, first and second terms.

A Five-Year Course Leading to the Degree of Civil Engineer

First Year—In College of Arts and Sciences

	No. course	First term	Second term
Solid Geometry, Trigonometry	6a, 7a	6	–
Advanced Algebra	4b	–	5
Chemistry	1, 6	6	5
Other Art Subjects. (See lists, etc., below)		5	6

In addition to the above, the required Drill must be taken.

Second Year—In College of Arts and Sciences

	No. course	First term	Second term
Analytic Geometry	1	4	–
Calculus	1	1	6
Physics	1, 6	4	4
Other Art Subjects. (See lists, etc., below)		3	6
Descriptive Geometry and Drawing	1	5	2

In addition to the above, the required Physical Training must be taken.

List of Courses open to Freshmen without Special Permission of the Administrative Board in Charge of Freshmen and Sophomores

Greek, 1, 3, 5, 6; Latin, 1, 3, 4; Germanic Languages, 1, 2, 3, 4, 5, 6, 7, 8; Romance Languages, 1, 2, 3, 12, 30, 32, 40, 42; English, 1; Music, 1; History 1, 21; Bibliography, 1, 1a; Mathematics, 1, 2a, 2b, 3, 4 6, 7; Physics, 1, 5, 6, 10; Chemistry, 1, 6, 7; General Biology, 1; Botany, 1, 2; Entomology, etc., 2, 4, 5; Vertebrate Zoology and Neurology, 2, 5; Geology, 1, 2a, 2b, 2c.

This list is subject to the following restriction:

"He may not register or receive credit, during those years for any courses in mathematics, physics, or chemistry, or for any courses outside the College of Arts and Sciences, other than those there specified; nor may he register during his freshman or sophomore year, for any course in the College of Arts and Sciences, which is specified for a later year of the outline which he is following."

THIRD YEAR—IN THE COLLLEGE OF CIVIL ENGINEERING

	No. course	First term	Second term
Geology	31	3	3
Physical Experiments	14	2	–
Mechanics of Engineering	20	5	5
Engineering Laboratory	22	–	4
Surveying	10, 11	3	3
Materials of Construction	25	–	3
Drawing	4	4	or 4

FOURTH YEAR—IN COLLEGE OF CIVIL ENGINEERING

	No. course	First term	Second term
Political Economy	51	3	3
Railroad Engineering	60	4	4
Structural Design	71	4	4
Hydraulics	23	5	–
Hydraulic Laboratory	40	1	–
Municipal Engineering	52	–	4
Engineering problems	29	–	2
Geodetic and Topographic Surveys	15	–	4
(Four and one-half weeks at close of year.)			

FIFTH YEAR—IN THE COLLEGE OF CIVIL ENGINEERING

	No. course	First term	Second term
Geodetic Surveying	13	5	–
Cartography	16	–	3
Water Supply	51	3	–
Reinforced Concrete Arch	72	–	2
Specifications and Contracts	90	–	2
Electrical Engineering (E.)	12	3	–
Steam Machinery (P.)	11	–	3
Thesis	92	–	3
Elective		6	3

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

	No. course	First term	Second term
Analytic Geometry	1	4	–
Calculus	1	1	6
Physics	1, 6	4	4
Physics	10	1	1
Chemistry	1	6	(or 6)
Chemistry	6	5	(or 5)
Geology	31	3	3
Descriptive Geometry and Drawing	1	5	2

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

	No. course	First term	Second term
History and Political Science	51	3	3
Drawing	4	4	(or 4)
Elementary Surveying	10	3	–
Advanced Surveying	11	–	3
Mechanics of Engineering	20	5	5
Engineering Laboratory	22	–	4
Materials of Construction	25	–	3

The satisfactory completion of the above courses will lead to the degree of A.B. The work for the fifth and sixth years is to include the subjects of the junior and senior years of the regular four-year course leading to the degree of C.E., except that course 51 in Political Economy is replaced by an elective.

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 find also 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 fulfilment of the condition prescribed by the Faculty of the Graduate School.

COURSES OF INSTRUCTION

1. **Drawing and Descriptive Geometry.** Freshmen. Credit, five hours first term, and two hours second term.

Drawing and Lettering. Six hours a week during first term. The work is sub-divided and is taken up in the following order. Geometrical Problems, which includes the drawing of the problem in pencil and ink; also a study of simple forms of projection in plan, elevation and section; thirty actual hours. Cross Sections, which includes practice in using drawing instruments in making the conventional signs of sections through different materials; nine actual hours. 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; twenty-one actual hours. 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; thirty hours' actual time.

Descriptive Geometry. A study of the representation of lines, planes, surfaces, and solids, and their inter-relations. Warped Surfaces. Tangencies. A text-book is used and recitations are held upon the problems there stated or explained. A drawing period serves to allow the student to make drawings of original problems which are illustrations and applications of the problems in the book. Recitations, two hours a week. Original problems, two and one-half actual hours a week. Two hours' credit in second term. 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. Recitations, one hour a week. Original problems, two and one-half actual hours a week. Assistant Professor POND and Instructors TAYLOR and MORRIS. First term. Six sections in drawing, four sections in recitations, and eight sections in problems. Second term. Six sections in recitations, and six sections in problems.

4. **Drawing and Lettering.** Sophomores. Credit, four hours first term, for one-half of the class; and for the other half a credit of one hour first term and three hours second term. Preparation required: course 1. The work is sub-divided 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; seventy-five actual hours. Isometric Drawing, which includes the principles involved in isometric projection, with practice in drawing from models and from dimension drawings; twelve actual hours. Line Shading, which includes the shading of flat and curved surfaces by lines variously spaced and by lines of different thickness; eighteen actual

hours. 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; forty-eight actual hours. Topographic Signs, which includes practice in the different kinds of standard topographic signs for mapping; twelve actual hours. 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 with handling the brush and with the use of crayon; fifteen actual hours. Assistant Professor PARSON and ————. Three sections for each half of the class.

Topographic and Geodetic Engineering

10. **Elementary Surveying.** Freshmen. First term, credit, three hours. The recitations cover the principles, uses and adjustments of the level and transit, and the application of steel tapes to ordinary measurements; also the theory and practice of topographic surveying with transit and stadia. The field work covers the application of the tape, level and transit to the various fundamental operations finally leading to a topographic survey of the Campus with transit and stadia, including computations, plotting notes and drawing a field sheet with contours. Text-book, Johnson's Surveying. One recitation and six hours field work a week. Professor MOLITOR, Assistant Professor BOOTHROYD, and Instructors LAWRENCE and MCCURDY. Eight sections in recitations, and six sections in field work.

11. **Advanced Surveying.** Sophomores. Second term, credit three hours. Pre-requisite, course 10. The recitations cover the applications of the fundamental surveying operations to land, railroad, city and hydrographic surveying, including the use of the sextant and plane table; also the subjects of precise leveling and triangulation, including base lines, angle measuring and determination of azimuth by single altitudes of the sun. The field work reviews the adjustments of transit and level, and covers land and city surveying, more accurate tape measurements, base line measurements with standardized tapes according to the most approved methods, angle reading for the triangulation, use of sextant and plane table in connection with hydrographic and topographic work, precise leveling and determination of azimuth from the sun. Computations and plotting notes. Text-book, Johnson's Surveying. Three recitations a week before the Easter recess and nine hours a week field work after the Easter recess. Professor MOLITOR, Assistant Professor BOOTHROYD, and Instructors LAWRENCE and MCCURDY. Eight sections in recitations and three sections in field work.

12. **Elementary Surveying** for students in Sibley College. Second term, credit two hours. This course is in every respect like course 10 except in amount of field work. Two recitations per week before the Easter recess and six hours a week field work after the Easter recess. Instructors LAWRENCE and MCCURDY. Six sections in recitations, and three sections in field work.

13. **Geodetic Surveying.** Seniors. Credit, five hours. Preparation required: course 15 or its equivalent. The course is divided into three parts, namely, astronomy, geodetic surveying, and the adjustment of observations by the method of least squares. The work in astronomy is devoted to the elements of practical astronomy with reference to the needs of engineers in the determination of azimuth and the auxiliary determinations of time and latitude. One afternoon a week is given to practice in computation including the reduction of the astronomic observations made at the junior camp of the preceding summer. In geodetic surveying, the methods of triangulation, base measurement, and precise leveling are studied, especially from the standpoint of economics. Methods of computation and reduction are considered. The application of the method of least squares to engineering problems is studied with special reference to the adjustment of triangulation and leveling. Campbell's Practical Astronomy and Crandall's Least Squares and Geodesy are used as text-books. Four recitations and one three-hour computing period a week. Assistant Professors LELAND and BOOTHROYD and Instructor UNDERWOOD. Recitations and computations, six sections.

14. **Least Squares; Adjustment of Observations.** Elective. Preparation required: 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 formulae. Two hours a week, as may be arranged. Assistant Professor LELAND.

15. **Topographic and Geodetic Survey.** Juniors. End of second term, credit, four hours. Preparation required: courses 10, 11, and 60. This work is intended to give the student some practical experience in the methods of conducting extensive surveying operations in the field. All of the various problems connected with a complete topographic and geodetic survey are taken up in detail and each student is given ample opportunity to participate in the work, serving at different times, in every capacity from chief of party down to helper and rodman. A system of triangulation is planned proceeding from a base line with determinations of azimuth and geodetic positions and the topography is filled in with transit and stadia and partly with plane table and stadia. Precise levels are run from U. S. bench marks to the proximity.

16. **Cartography.** Seniors. Second term, credit, three hours. Preparation required: courses 13 and 15. One-third of the time is devoted to the computations resulting from the field work of the previous summer surveys, course 15, embracing base-line measurement, triangulation, and trigonometric and precise leveling. The work results in a set of permanent records, with the geographic positions, azimuths, distances and elevations of the various triangulation stations. The remainder of the course consists of the construction of a final topographic map of a portion of the area covered in the preceding summer survey. Several of the field sheets are combined for this purpose, and reduced in scale from 1:4800 to 1:12000, using the

triangulation system as a basis for the work. Computing, three hours, and drawing, six hours per week. Assistant Professor LELAND and Instructor UNDERWOOD. Eight sections.

17. **Geodesy and Geodetic Astronomy.** Elective. Seniors and graduates. Preparation required: course 13. Second term, credit, three hours. A special course for the consideration of the more advanced portions of the subject, as the investigation of the figure of the earth and allied problems. Lectures, reading, and discussions. Three hours a week. Assistant Professor LELAND.

18. **Geodetic and Astronomic Laboratory.** Elective. Seniors and graduates. Second term, credit, three hours. Special work at Fuertes Observatory in the investigation and use of geodetic and astronomic instruments and apparatus. Circles, levels, micrometer microscopes, standards of length, thermometers, and pendulums. Astronomic observations of various kinds. Nine hours a week, as may be arranged. Assistant Professor LELAND.

19. **Photographic Surveying.** Elective. Preparation required: course 11. Second term, credit, two hours. Methods of making topographic surveys with the camera, and of plotting the data. Lectures and recitations, followed, perhaps, by a survey of small extent to illustrate the principles involved. Hours subject to special arrangement. Assistant Professor LELAND.

Applied Mechanics and Hydraulics

20. **Mechanics of Engineering.** For sophomores in Civil Engineering and students specializing in chemistry. Throughout the year, credit, five hours for each term. Preparation required: Mathematics, course 1. A study of the principles, and applications to engineering, of the mechanics of solids; as relating to the mutual actions, motions, pressures, strength, stiffness, and resilience of the members of structures and machines. Original problems form a prominent feature. Statics of a material point and of rigid bodies. Centers of gravity. Chains and cords. Dynamics, (kinetics) of a material point. Impact. Virtual velocities. Centrifugal and centripetal forces. Pendulums. Moments of inertia of plane figures and of rigid bodies. Dynamics (kinetics) of rigid bodies. Work. Power. Energy. Fly-wheels. Friction. Graphical statics of mechanism. Dynamometers. General theorem of work and energy applied to machines. Stresses and strains. Tension. Shearing. Compression. Torsion. Flexure. Elastic curves. Safe loads. Columns. Text-books: Church's Mchanics of Engineering, and Notes and Examples in Mechanics, supplemented by other printed notes and problems. Lectures and recitations, daily except S, throughout the year. Professor CHURCH, Assistant Professors GEORGE, RETTGER, and SEERY. Eight sections.

22. **Engineering Laboratory.** Sophomores. Second term, credit, four hours. Must be preceded by, or taken with, course 20. Use of engineers' computing devices, viz: The common slide rule, the Fuller spiral slide rule, Thacher calculating instrument, and Goodchild chart. Use of the planimeter, adjustments and use of the cathetometer. Experiments involving

the parallelogram of forces (funicular polygons.) Determination of specific gravity with the Jolly balance. Centers of gravity of plates and prismoids (models). Efficiency of the inclined plane and of the compound crane. Systems of levers. Harmonic motion of masses, etc. Experiments in testing materials. Use of the 50,000 lb. and the 100,000 lb. Olsen machines, in tensile tests of bars of iron and steel. The Thurston and Riehlé torsion machines; determination of their constants; and tests of specimens for the determination of shearing stresses and of the modulus of elasticity for shearing. Flexure of wooden and steel bars; deflections and modulus of elasticity. Elongation of steel wires with observations by cathetometer or dial extensometer. Breaking tests of wooden columns. Moments of inerta of beam sections by graphic and analytical methods; and also by the use of the mechanical integrator. Use of the Kew magnetometer. Determination of specific gravity, fineness, normal consistency, soundness (normal and accelerated tests), time of set, and strength (both in tension and compression), of cements, neat and with sand. Determinations of voids in sands and broken stone. Laboratory work, five hours a week. Computations and reports five hours a week. Professor CHURCH, Assistant Professor MILLS, and Instructors TAYLOR, MORRIS, and ———. Six sections.

23. **Hydraulics.** Juniors. First term, credit, five hours. (With topics in hydrostatics and pneumatics.) Preparation required: course 20. Fluids at rest. Hydrostatic pressure. Manometers. Strength of pipes. Pressure of water against walls and dams. Earth pressure. Immersion and flotation. Compressed air motors. Air compressors. Gas engines. Barometric leveling. Steady flow of liquids through pipes and orifices, and over weirs. Fluid friction. Losses of head. Time of emptying vessels. Steady flow of water in open channels. Kutter's formula and diagrams based thereon. Steady flow of gases through pipes and orifices. Overshot, breast, and undershot water wheels. Theorems for flow in a revolving pipe. Impulse wheels (Pelton, Girard, etc.). Turbines and reaction wheels. Backwater. Theory of turbine testing. Other hydraulic motors and machinery. As part of the work of instruction, experimental demonstrations are given in the Hydraulic Laboratory, at intervals of two or three weeks, to illustrate the principal phenomena of hydrostatics and hydraulics. Text-books: Church's Mechanics of Engineering, and Hydraulic Motors. Lectures and recitations, daily except S. Professors CHURCH and OGDEN, Assistant Professors SCHODER and TURNER. Six sections.

25. **Materials of Construction.** Sophomores. Either term (one-half of the class each term), credit three hours. Must be preceded by, or taken with, course 20. Text-book, Johnson'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 stress being laid on those points of importance to engineers. The work is planned to coordinate with the course in economic geology and supplements that work where necessary. One lecture and two recitations a week. Assistant Professors MILLS and GEORGE. Four sections each term.

26. **Advanced Mechanics.** Elective. Seniors and graduates. First term, credit, three hours. Preparation required: course 20. 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. Applications. Recitations. Three hours a week. Professor CHURCH. T Th S, 10.

29. **Engineering Problems.** Juniors. Second term, credit, two hours. Preparations required: courses 20 and 23. The object of this course is to provide additional practice in using the principles and methods of Applied Mechanics, both of solids and fluids. 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; six hours a week. Professor CHURCH, Assistant Professors SEERY, GEORGE and TURNER. Four sections.

30. **Testing Materials.** Elective. Seniors and graduates. First term, credit three hours. Preparation required: 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. Johnson's 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 not only to provide 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 work. Seven and one half hours a week as arranged. Professor CHURCH and Assistant Professor MILLS.

Hydraulic Engineering

31. **Hydraulic Constructions.** Elective. Seniors and graduates. Credit, three hours. Lectures, recitations, and reports. Preparation required: courses 20 and 23; must also be preceded by or taken with course 51. Textbooks: Wilson's Irrigation Engineering, with parts of Turneaure and Russell's Water Supplies and Thomas and Watt's River Improvement. Problems are assigned and must be completed before credit will be allowed. The work is divided into four parts, as follows:

Design and Construction of Dams, which includes the derivation of Wegman's formula for the profile of a high masonry dam and the working of a problem involving all the factors affecting the form of the cross section. The design and construction of earthen, timber, and metallic dams, are also

considered. Water Storage, which includes the investigations of a reservoir site, surveys, borings, and cost of storage; the design of spillways and flood channels; and the effect on the stream discharge for various capacities of storage. Irrigation Engineering, which includes the problems peculiar to the irrigation of land with the necessary storage and distribution and with some attention to the agricultural problems involved. River Engineering, which includes a general study of river hydraulics with special reference to regulation, and bank protection. Either term. Assistant Professor SEERY. First term, T Th S, 11; second term, M W F, 11.

32. **Water Power Engineering.** Elective. Seniors and graduates. Either term, credit, three hours. Preparation required: courses 23 and 40. Text-book: Mead's Water Power Engineering. The development of power on a stream, including the economic and commercial features affecting the value of a mill site; river hydraulics; the selection of turbines and a study of their characteristics; speed regulation; design of penstocks; the conveyance of water in canals, flumes, and pressure conduits; arrangement of machinery, etc., effect of pondage, storage and load factor, on capacity and equipment. The mechanical equipment is taken up and a problem illustrating the subject in a concrete example is worked by each student. Problems are assigned and must be completed before credit will be allowed. Assistant Professor SEERY. First term, M W F, 11; second term, T Th S, 11.

Experimental Hydraulics

40. **Hydraulic Laboratory.** Juniors. First term, credit, one hour. Must be preceded by, or taken with, course 23. The course is intended to familiarize the student with the simpler hydraulic phenomena and with the observations and calculations involved. Written reports are required. The work includes: Logarithmic plotting and its applications; experiments on the flow of water over a weir, through several types of orifices, through a pipe, through a Venturi meter, and through a nozzle; and a test of a water motor. Text-book: Schoder and Turner's Hydraulic Laboratory Manual. One three-hour period a week. Assistant Professors SCHODER, TURNER, and WALKER. Six sections.

41. **Hydraulic Measurements.** Elective. Seniors and graduates. Second term, credit, three hours. Preparation required: courses 23 and 40. The experimental portion of this course is intended to test the accuracy of measuring devices and methods as well as the exactness of hydraulic formulae. The work includes: Construction of pipe-flow diagrams; the Pitot tube; water-meters; nozzles; weirs; current-meters and floats in open channels; lectures on measurement of flowing water in large streams. Three afternoons a week. Professor HASKELL, Assistant Professors SCHODER and TURNER. M W F, 2–5.

42. **Experimental Hydraulic Motors and Pumps.** Elective. Seniors and graduates. Second term, credit, three hours. The determination of efficiency, capacity, and characteristics of hydraulic machinery. Assistant Professor SCHODER.

43. **Experimental Hydraulic Investigation.** Elective. Seniors and graduates. Second term, credit, three hours. This course is intended for those

students who desire to carry on experimental investigations in hydraulics under more immediate direction and supervision than prevails in case of thesis work. Written reports are required, but need not be typewritten nor bound in thesis style. These reports are kept by the department. It is often possible and desirable for two students to work together on the same investigation. The field and scope of the investigation should be selected during the first two weeks of the term. For the experimental portion of the work the equivalent of three three-hour periods a week, is required. Assistant Professor SCHODER. T Th S, 8–11.

44. **Advanced Experimental Hydraulics.** The facilities of the hydraulic laboratory are available for thesis work and for experimental investigations by graduate students. Subject to special arrangements in each case. Professor HASKELL and Assistant Professor SCHODER.

Municipal and Sanitary Engineering

51. **Water Supply.** Seniors. First term, credit, three hours. Preparation required: course 23. Text-book, Turneaure and Russell's Public Water Supplies, except Chaps. 8–10 and 19–23. Problems are assigned and must be completed before credit is allowed. These problems cover the various features of water works development as follows: Estimate of future population and consumption; hydrology of a drainage basin; rainfall and probable run-off; use of a mass diagram in determining necessary volume of storage; location of a conduit on a topographic map with calculation of size of conduit; determination of size of a distributing reservoir; design for adequate fire pressure in a distribution system; pumping and economic sizes for force mains for city supply with assumed topography; and computations for capacity of a ground water supply. One lecture and two recitations a week. Assistant Professor SEERY. Five sections in recitations.

52. **Municipal Engineering.** Juniors. Second term, credit, four hours. Preparation required; course 23. Four hours per week, divided between lectures and recitations, as follows: Fifteen lectures and forty-five recitations. The lectures are divided as follows:

Specifications, earthwork, trenching, rockwork, illustrated description of sewer construction and sewage disposal plant, garbage collection and disposal.

The recitations are on the following books: Ogden's Sewer Design; Spalding's Roads and Pavements; Notes on Sewage Disposal.

There are also required from the students problems illustrating the matters taken up in the lectures as follows, one for each week: specifications of tennis court; city sewage flow; city outfall sewer; pipe flow diagram; septic tank design; sedimentation tanks; disposal plant; culvert design; road location; pavement designs; estimates and specifications. Professor OGDEN and Assistant Professor WALKER. Four sections in recitations.

53. **Purification and Control of Water Supplies.** Elective. Seniors and graduates. Second term, credit, three hours. Preparation required: course 23. 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. M W F, 11.

54. **Sewerage Works.** Seniors and graduates. First term, credit, three hours. Preparation required: course 52. Three hours per week for 15 weeks, divided between lectures and recitations. Text-book is Ogden's Sewer Construction. The lectures are upon the construction and operation of 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 in these lectures: 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; contact beds and sprinkling filters. 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. M W F, 11.

55. **Sanitary Laboratory.** Elective. Seniors and graduates. Either term, credit, three hours. Preparation required: course 52 and chemistry, course 6. This course offers a practical demonstration of some of the topics considered in courses 52, 53, and 54. Through the courtesy of the N. Y. State department of Health, students in Sanitary Engineering are permitted to work in the laboratory established by that department at Cornell University and may thereby become familiar with practical methods of water examination. Sand analyses are made, experiments in sedimentation carried on, and the operation of the city water filtration plant checked. Measurements of velocities and grades in the city sewers and a study of their inter-relation with sizes of pipes and depths of flow are made. Seven and one-half hours a week. Assistant Professor WALKER. T Th, 2–4:30; S, 9–11:30.

Railroad Engineering

60. **Railroad Surveying, Construction and Economics.** Juniors. Throughout the year, credit, four hours a term. Preparation required: courses 10 and 11. The campus field work includes the laying out of circular and transition curves; the fixing of grade lines, cross sectioning and the staking out of masonry structures; the realigning of track and the location of turnouts. The Saturday field work consists in making the reconnoissance, preliminary, and location surveys for some ten miles of railroad. The topography is taken, the line is cross sectioned and data are obtained for estimates of cost, including the structures and rights of way. The drawing includes a map and a profile of the located line and a plan for one or more of the structures. The earthwork is computed from the cross sections, and complete estimates are made of quantities and costs, including structures

The recitations and lectures take up the field problems; the computation of earthwork; the cost of graduation, including tunnels, sub grade and track structures; track work; and the economics of railroad location and operation. Mimeograph notes on Railroad Surveying and on Railroad Construction, Crandall's Transition Curve and Earthwork Tables, Beahan's Railway Location, and Gotshall's Electric Railway Economics, form the bases of the work. Professor CRANDALL, Assistant Professor BARNES and Instructors EDWARDS, LAWRENCE, UNDERWOOD, and ———. First term, two three-hour periods of field work a week, and alternate Saturdays. Six sections. Second term, three recitations a week, six sections; and one period of two and one-half hours a week in mapping, five sections.

61. **Railroad Maintenance of Way.** Elective. Seniors and graduates. First term, credit, three hours. Preparation required: 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 alignment. Camp's Notes on Track is used as a text. Lectures and recitations three hours a week. Professor CRANDALL. M W F, 11.

62. **Railroad Operation and Management.** Elective. Seniors and graduates. Second term, credit, three hours. Preparation required: course 60. The course is based on Byer's Economics of Railway Operation and Adam's The Block System, both of which are used as text-books. 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. Assistant Professor BARNES. M W F, 11.

63. **Railroad Construction and Maintenance.** Special course for students in Sibley College. Second term, credit, two hours. Preparation recommended: course 12. Second term. Webb's Railroad Construction is used as a text-book. Railroad Surveying; reconnoissance, preliminary survey and location, simple curves with methods of laying out; purpose and nature of transition and vertical curves. Railroad Construction; earthwork, surveys, methods and costs; rockwork; culverts and minor

structures; trestles and bridges; and tunneling. Railroad Maintenance; ballast, purposes, kinds and cross sections; ties, materials and treatment; rails and rail fastenings; joints; switches and crossings. Railroad Economics; statistics; cost of distance, curvature, rise and fall and change in rate of ruling gradient and tonnage rating. Attention is given to comparing capitalized cost of structures, changes in weight of locomotives, etc. Two recitations a week. Assistant Professor BARNES. Hours to be arranged.

Structural Engineering

71. **Structural Design.** Juniors. Throughout the year, credit, four hours a term. Preparation required: course 20.

Structural Details. 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 drawing 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. First term for 10 weeks. Computation and drawing, six 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. Text-books: Merriman and Jacoby's Roofs and Bridges, Parts I and II. First term. Recitations two hours a week for 10 weeks, thereafter four hours a week.

Bridge Design. Computations and drawing for the complete design of a steel 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. Text-book: Merriman and Jacoby's Roofs and Bridges, Part III. Second term. Computation and drawing, 12 hours a week. Professor JACOBY, Assistant Professor DERICKSON, and Instructors DAVIS,

BOWMAN, and BURROWS. First term, eight sections in recitations and six sections in computations. Second term, four sections.

72. **Reinforced Concrete Arch.** Seniors. Throughout the year, credit, two hours a term. Preparation required: course 20 and 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 under partial and full live loading are made in accordance with the elastic theory. 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. Lectures, computation and drawing, six hours a week. Professor JACOBY, Assistant Professor DERICKSON and Instructor BOWMAN. Two sections in each term.

73. **Higher Structures.** Elective. Seniors and graduates. Either term, credit, three hours. Preparation required: courses 20 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. Text-book: Merriman and Jacoby's Roofs and Bridges, Part IV. Recitations, three hours a week. Professor JACOBY and Instructor DAVIS. First term, T Th S, 11. Second term, M W F, 11.

74. **Masonry and Foundations.** Elective. Seniors and graduates Either term, credit, three hours. Preparation required: course 20. Coffer dams, cribs, sheet piling, metal cylinder piers, pumping and dredging, the foundation, and the location and design of piers. Piles and pile driving. Pneumatic caissons. Open caissons. Caisson sinking. Deep and difficult foundations. Foundations of buildings: pile, caisson, steel, concrete. Underpinning. Examination of selected modern example described and illustrated in the engineering periodicals and transactions. Recitations, collateral reading and illustrated reports. Fowler's Ordinary Foundations. Three hours a week. Instructor DAVIS. First term, M W F, 11. Second term, T Th S, 11.

76. **Steel Buildings.** Elective. Seniors and graduates. Second term, credit, three hours. Preparation required: courses 20 and 71. Mill buildings and tall steel buildings. Framing, trusses, beams and columns. Eccentric loading, wind bracing, connections and details. Roofs and floors. Weights and costs. Specifications. Design of a small mill building. Investigation of the effect of wind on a knee-braced mill building bent. Recitations, lectures, and reports. Six hours a week for eleven weeks, after that three hours a week. Assistant Professor DERICKSON. T Th S, 11–1.

77. **Concrete Construction.** Elective. Seniors and graduates. Either term, credit, three hours. The purpose of this course is to continue the study of reinforced construction and design begun in courses 20 and 25. While examples of actual construction are continually cited, special atten-

tion is paid to fundamental principles of design, to theoretical discussions, and to the interpretation of the results of experiments. It is the aim to give theory and practice equal weight, and to present the limitations as well as the advantages of this type of construction. The text used is Turneaure and Maurer's Principles of Reinforced Concrete-construction, of which all chapters excepting Chapter VIII (on the arch) are studied. The subject matter covered is as follows: Properties of the material; general theory; tests of beams and columns; working stresses and general constructive details; formulae; diagrams and tables, building construction; retaining walls and dams; miscellaneous structures. At each recitation a problem is assigned, requiring about an hour's time to solve. One recitation and two drawing periods a week. Assistant Professor DERICKSON and Instructors DAVIS and BOWMAN. Four sections in recitations and three in computations and drawing for each term.

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 forces on construction, systems of payment, measurement of efficiency and cost keeping; with illustrative examples. Assistant Professor BARNES. T Th, 11.

90. **Specifications and Contracts.** Seniors. Second term, credit, two hours. Synopsis of the law of contracts as applied to engineering work. Study of the general and of the special clauses in specifications; classification of specifications; typical contracts and specifications. Practice 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. Johnson's Contracts and Specifications 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 CRANDALL, Assistant Professor BARNES. Six sections.

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

(a) **Hydraulic Engineering.** Second term. Preparation required: courses 23 and 29. Design of hydraulic works, plants and appliances, such as aqueducts, canals, irrigation works, locks, lift-locks, lock-gates, dams, reservoirs, stand-pipes, elevated tanks, systems of water works (gravity, pneumatic or pumping systems), drainage works, power plants, water turbines and other hydraulic motors and machinery, etc. Professor CHURCH and Assistant Professors SEERY and GEORGE.

(b) **Sanitary Engineering.** First term. This course must be preceded by or taken at the same time with 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 section.

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

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

4. Computations, design and detail drawings for flap valve at 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.

(c) **Railroad Engineering.** Second term. Must be preceded by, or taken with course 61. Individual problems are assigned in conference with the student. These include: designs for track layouts and details, small depot buildings and freight houses, culverts, bridge masonry, subway construction; grade separation structures; water tanks, track and elevated, of steel, timber or reinforced concrete; coaling plants, etc. Bills of material and estimates of cost are usually required. Professor CRANDALL.

(d) **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, course 72 being taken at the same time as engineering design, or previously. Professor JACOBY, Assistant Professor DERICKSON.

92. **Thesis.** Seniors. Credit, three hours. The thesis is intended to demonstrate the ability of the student for independent investigation, or his capacity 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 completed thesis is June 1. Regarding the approval of the subject or substitution for thesis see notes under the requirements for the four-year course.

Special and Graduate Courses

All of 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 being usually free from the restrictions of the class room and working either independently or in conjunction with others taking the same course. See p. 8.

OFFICIAL PUBLICATIONS OF CORNELL UNIVERSITY

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

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Courses of Instruction in the College of Arts and Sciences,
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Announcement of the College of Civil Engineering,
Announcement of the College of Law,
Announcement of the College of Architecture,
Announcement of the Medical College,
Announcement of the New York State College of Agriculture,
Announcement of the Winter Courses in the College of Agriculture,
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