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SCHOOL OF ENGINEERING

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THE UNIVERSITY OF MISSOURI

The University of Missouri was located at Columbia, Missouri, in 1839, and courses of instruction in Academic work were begun in 1841. A Department of Education was established in 1867. The College of Agriculture and Mechanic Arts and the School of Mines and Metallurgy were made Departments of the University in 1870—the School of Mines being located at Rolla. The Law Department was opened in 1872; the Medical Department in 1873; the School of Engineering in 1877. The Experiment Station was established, under act of Congress, in 1888. The Missouri State Military School was created a Department in 1890. In 1896 the Graduate Department was established.

The University has the following buildings: The Academic Hall; separate buildings for Agriculture, Chemistry, Engineering, Geology and Zoology, Law, Mechanic Arts, and Medicine; the Parker Memorial Hospital; the Laws Observatory; the Power House; the President's house; Benton Hall and Lathrop Hall, two dormitories for men; the Gymnasium for men; the Agricultural Farm buildings and the Live Stock Judging and Dairy buildings; the horticultural building and green-houses, and Read Hall, the dormitory for women.

RESOURCES.

The buildings, grounds, books and other equipment, are valued at more than $1,600,000 not including the campus or the grounds for botany, horticulture and agriculture. The endowment (interest at 5 or 6 per cent), is $1,240,000. The income from the United States Government (Hatch and Morrill Acts) is $38,438 a year. The Legislature makes appropriations biennially. There is some income from fees for libraries and laboratories. There are 47,427 acres of unsold land. A State Collateral Inheritance Tax yields $120,000 or more a year. The income of the whole University, from all sources and for all Departments, in each of the years 1903 and 1904, was about $430,000.

THE SCHOOL OF ENGINEERING.

It is the aim of the School of Engineering to provide a substantial foundation for the general and technical knowledge needed by the successful engineer by giving its students thorough training in the fundamental principles which underlie all engineering practice, with such applications to problems met in the several fields of practice as may be feasible in a technical school. To this end five courses of instruction are offered, corresponding to various lines of practice, and leading respectively to the degrees of Bachelor of Science (B. S.) in Civil Engineering, Electrical Engineering, Mechanical Engineering, Sanitary Engineering and Chemical Engineering.

In each of these courses the first two years are mainly devoted to preliminary training in English, Mathematics, Physics, Chemistry, Drawing, Surveying and Shopwork as a preparation for the more technical work of the last two years which is given chiefly by the Engineering Departments.

The course in *Civil Engineering* covers a very wide field, embracing topographical, railway, hydraulic, structural, municipal, and sanitary engineering, and it is the aim to give a broad, general training which may later serve as a foundation for the development of any of the special lines of practice included under the general term, Civil Engineering.

The course in *Electrical Engineering* is intended to prepare students for electrical designing, manufacturing, contracting, and for the installation and management of light and power stations; in short, it is a thorough, broad training for Electrical Engineers. The technical work consists of the theory and prinples of electricity and magnetism; electrical measurements; calibration of instruments; tests of all kinds; design and construction; study of special problems in the generation, transmission, distribution and utilization of electrical energy. Special attention is paid to alterating current phenomena.

The course in *Mechanical Engineering* is intended to fit students to enter readily any of the principal divisions of Mechanical Engineering. Training is given in the underlying principles of the profession, all work being so arranged that the application of these principles to special problems which may arise in practice, may clearly be seen. The design of engineering structures and machines, and the development, application and

measurement of power in its various forms are covered in the different courses.

The course in *Sanitary Engineering* is arranged with the the purpose of combining a study of the principles of sanitary science with the fundamental training of the course in Civil Engineering.

The course in *Chemical Engineering* is offered to furnish training in engineering together with specialization in Chemistry. In view of the development of the applications of chemistry on a large scale in manufacturing, it is proposed to extend the course, making it more general on the engineering side, or to offer several parallel courses as the demands may require.

REQUIREMENTS FOR ADMISSION.

Fourteen (14) units are required for admission to the School of Engineering: but one (1) condition will be allowed. Beginning with June, 1906, fifteen (15) units will be required for admission, with two (2) conditions.

A unit represents the equivalent of a year's work of nine months in one subject, in a good high school, normal school or college with five periods a week in the class-room or laboratory, each period of about forty minutes.

Three of these units *must* be in English, one and one-half in Algebra, one in Plane Geometry. The additional units required may be selected from the following list.

English—one unit.

Solid Geometry or *Plane Trigonometry*—one-half unit.

Physics, Chemistry, Biology, Zoology, or *Botany*—one to two units.

Drawing, Manual Training, or *Physiography*—one unit.

History or *Latin*—one to four units.

German, French, Spanish or *Greek*—one to three units.

Beginning with June 1906, two units in foreign language and one unit in science will be a fixed requirement. It is strongly recommended that students present two units in French or German to meet the requirements in foreign language.

In 1907-8 one-half unit in Solid Geometry will be a fixed requirement in Engineering. The courses in Engineering require that the students be strong in mathematics and science. Those who are not strong in these lines are advised not to undertake work in Engineering.

Students from accredited schools will not be admitted subject to a condition unless they are graduates of such schools.

ENTRANCE EXAMINATIONS AND CERTIFICATES.

Examinations for admission will be held at the University September 11, 12, 13, 1905. All persons desiring to enter the University during the first semester of the session of 1905-6, except those holding certificates of graduation from Accredited Schools and those who have already fulfilled the entrance requirements must take these examinations.

The University will admit without examination such graduates of an Accredited School as bring proper credentials of the fact that they have completed the subjects required for entrance.

The diploma will not be accepted as a credential. The student must present the proper form of certificate signed by the Principal or Superintendent of the Accredited School. Blank certificates will be furnished by the Dean upon application. These certificates should be filled out and sent to the Committee on Entrance, Columbia, Missouri.

Students who do not hold certificates of graduation from an Accredited School may present their grades in any subject. In such cases they should have the grades certified to by the proper official of the school in which the grades were made.

As the necessity for correction appears in many instances, the student may avoid delay and inconvenience by sending certificates in advance of the opening of the session.

SPECIAL STUDENTS.

Persons who desire to follow special lines of work, and who have not had the preliminary preparation required for admission as regular students, may be admitted as special students for the purpose of pursuing courses for which their preparation fits them. Such students must satisfy the Dean that they can pursue the work selected with profit to themselves, and are required to maintain the same standard of excellence which is required of regular students. No special student may be a candidate for a degree until he makes up his entrance requirements and enters in regular standing before the beginning of the senior year.

ADVANCED STANDING.

Applicants for advanced standing are required to present credentials showing completion of courses equivalent to those for which they seek credit. Claims for advanced standing must be made by the student within one semester after entrance. Those who wish to have their claims passed upon before matriculation may present them at any time to the Dean.

FEES AND EXPENSES.

Tuition is free in all Departments of the University. Students in the School of Engineering, excepting state cadets, pay an annual entrance, library, and incidental fee of five dollars. A deposit of five dollars is required upon entrance into each laboratory course taken by the student. From this amount is deducted the fixed laboratory charge and any charges for materials or damage to property of the University, and the remainder is refunded to the student at the end of the session.

The estimated cost of board and room rent in the University dormitories for men varies from about $2.50 to about $3.50 per week. Board and lodging in private families may be had for from three and a half to five dollars a week. Private clubs also are formed in which the average cost is two and a half dollars a week. The rent of rooms is from seventy-five cents to one dollar and a half a week.

LIBRARY.

Each of the Engineering departments is equipped with an excellent working library of technical books, and the reading room is supplied with the best engineering magazines.

The general library of the University contains some 50,000 volumes and is open to all students of the University for consultation. Books may, under regulations, be drawn from the library. At present the general library occupies the west wing of Academic Hall.

The library and reading-room of the Missouri State Historical Society is also located in Academic Hall and is open for consultation to all students of the University.

ENGINEERING SOCIETY.

There is a flourishing Engineering Society composed of members of the junior and senior classes which affords opportunity for discussion of current engineering topics, and brings the students and faculty together in a social way.

ATHLETICS.

A new $70,000 gymnasium is now in course of construction. Work in physical training and athletics is thoroughly organized. The students have teams for football, baseball, basketball, track athletics and lawn tennis. There are excellent facilities for all forms of exercise—golf links, tracks, tennis courts, and several athletic fields.

COURSE IN CIVIL ENGINEERING.

Freshman Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Algebra, Trig. and Anal. Geom.	5	5	Math. 1aA, 2aE & 1bE
Composition and Rhetoric	3	3	English 1
General Inorganic Chemistry	3	3	Chemistry 2
Mechanical Drawing	3	0	Drawing 1a
Woodwork and Forging	2	0	Shopwork 1a
Descriptive Geometry	0	3	Drawing 2b
Topographical Drawing	1	0	Drawing 5a
Elementary Surveying	0	3	C. E. 1b

Sophomore Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Calculus	5	5	Math. 4E
Higher Sur. & Ry. Location	3	3	C. E. 2a & 4b
General Physics	6	6	Physics 3
Machine Dr. & Stereotomy	2	2	Drawing 4a & 6b
Elementary Construction	2	2	C. E. 6

Junior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Mechanics of Engineering	5	5	Mechanics 3
Railway Engineering	3	0	C. E. 5a
Spher. and Prac. Astronomy	0	3	Astronomy 5b
Steam Engineering	3	0	M. E. 1a
Frame Structures	3	3	C. E. 10
Municipal Engineering	2	2	C. E. 7
Testing Laboratory	0	1	C. E. 14b
Materials of Construction	0	2	C. E. 19b

Senior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Hydraulic Motors	2	0	M.E. 7a
Mechanical Lab.	0	1	M. E. 11b
Geodetic Surveying	0	3	C. E. 3b
Hydraulics	2	0	C. E. 9a
Bridge Design	5	0	C. E. 11a
Theory of Structures	0	3	C. E. 12b
Masonry Structure	3	0	C. E. 13a
Testing Laboratory	1	0	C. E. 14a
Specifications & Contracts	0	1	C. E. 16b
Construction	0	2	C. E. 20b
Thesis	0	2	C. E. 30b
Elective	2 to 5	2 to 5	

COURSE IN ELECTRICAL ENGINEERING.

Freshman Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Trig., Algebra and Anal. Geom.....	5	5	Math. 1aE, 2aE & 1bE
Composition and Rhetoric.....	3	3	English 1
Genl. Inorganic Chemistry.....	3	3	Chemistry 2
Mech. Drawing and Des. Geom. ...	3	3	Drawing 1a and 2b
Woodwork and Forging.....	3	3	Shopwork 1

Sophomore Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Calculus.....	5	5	Math. 4E
General Physics.....	6	6	Physics 3
Machine Work.....	2	2	Shopwork 2
Elementary Surveying.....	2	0	C. E. 1a
Elements of Machine Drawing.....	0	2	Drawing 3b
Steam Eng. and Kinematics.....	3	3	M. E. 1a & 2b

Junior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Mechanics of Engineering.....	5	5	Mechanics 3
Electrical Measurements.....	2	2	Physics 4
Electrical Machinery..... ..	4	4	E. E. 1
Alternating Currents..... .	3	3	E. E. 2
Seminary.....	1	1	E. E. 6

Senior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Hydraulic Motors.....	2	0	M. E. 7a
Mechanical Lab.....	2	2	M. E. 13
Advanced Alt. Currents	3	3	E. E. 3
Electrical Design.....	3	3	E. E. 4
Electrical Engineering.....	3	3	E. E. 5
Seminary	2	2	E. E. 6
Thesis.....	0	2	E. E. 7b

COURSE IN MECHANICAL ENGINEERING.

The Freshman and Sophomore years are identical with those of the course in Electrical Engineering.

Junior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Steam Boilers.....	3	1	M. E. 3
Thermodynamics.....	0	3	M. E. 4b
Mechanical Laboratory..	1	1	M. E. 11
Graphics of Machines..... .	2	0	M. E. 14a
Electrical Machinery.....	4	3	E. E. 1
Mill Structures.....	0	2	C. E. 18b
Mechanics of Engineering.....	5	5	Mechanics 8

Senior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Heat Engines	3	0	M. E. 5a
Steam Engine Design	3	2	M. E. 6
Hyd. Motors and Pumping Mach.	2	2	M. E. 7a and 8b
Machine Design	2	2	M. E. 9
Mechanical Lab.	2	1	M. E. 12
Thesis	0	2	M. E. 19b
Alternating Currents	3	3	E. E. 2
Contracts and Specifications	0	1	C. E. 16b
Electives	0 to 3	2 to 5	

COURSE IN SANITARY ENGINEERING.

The Freshman and Sophomore years are identical with those of the course in Civil Engineering. In the Junior year Technical Chemistry (Chem. 12) is substituted for the Railway Engineering and Astronomy of the C. E. Course.

Senior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Mechanical Laboratory	0	1	M. E. 11b
Hygiene and Gen. Bacteriology	3	3	Bact. 1a and 7b
Bridge Design	5	0	C. E. 11a
Hydraulics	2	0	C. E. 9a
Specification and Contracts	0	1	C. E. 16b
Masonry Structures	3	0	C. E. 13a
Sanitary Engineering	0	3	C. E. 8b
Engineering Laboratory	1	0	C. E. 14a
Hyd. Motors and Pumping Mach.	2	2	M.E. 7a and 8b
Construction	0	2	C. E. 20b
Thesis	0	2	C. E. 21b

COURSE IN CHEMICAL ENGINEERING.

Freshman Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Trig. and Anal. Geom.	3	5	Math. 1aE and 1bE
Composition and Rhetoric	3	3	English 1
General Inorganic Chem.	3	3	Chemistry 2
Mechan. Drawing and Des. Geom.	3	3	Drawing 1a and 2b
Steam Eng. and Kinematics	3	3	M. E. 1a and 2b

Sophomore Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
General Physics	6	6	Physics 3
Calculus	5	5	Math. 4E
Organic Chemistry	3	3	

Junior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course.*
Mechanics of Engineering	5	5	Mechanics 3
Technical Chemistry	3	3	Chemistry 12
Electrical Measurements	2	2	Physics 4
Thermodynamics	0	3	M. E. 4b
Electrical Machinery	4	4	E. E. 1
Elements of Machine Drawing	0	2	Drawing 3b

Senior Year.	*1st Sem.*	*2nd Sem.*	*No. of Course*
Physical Chemistry	3	3	Chemistry 10
Plants and Processes	1	1	M. E. 15
Heat Engines	3	0	M. E. 5a
Elective(to be chosen from Chemistry, E. E. and M. E.)	8	8	
Thesis	0	3	

ADVANCED DEGREES.

The degree of Civil Engineer (C. E.), Electrical Engineer (E. E.), and Mechanical Engineer (M. E.) will be conferred on candidates who, after receiving the first degree from this University, or from one of equivalent standing, have spent in the same course one year (at least ten hours a week) in graduate work in the University, or two years in professional practice and graduate work *in absentia*. The candidate must pass an examination on his graduate work and present a satisfactory thesis. The thesis subject shall be presented to the Dean on or before November 1, and the thesis shall be presented on or before May 1st of the given year. Those who with professional practice pursue graduate work *in absentia* must be regularly enrolled as graduate students, paying the usual fees.

DEPARTMENTS OF INSTRUCTION.

Civil Engineering.

F. P. SPALDING, Professor ; W. S. WILLIAMS, A. LINCOLN HYDE, Assistant Professors ; L. M. FRY, Assistant.

This department is well equipped with instruments for teaching and surveying. There are 14 transits, 9 levels, 2 plane tables, 4 compasses, sextants, tapes, and small instruments for land topographical and railway surveys; and an 8-inch Fauth theodolite, Brandis triangulation transit, Saegmuller precise level, base apparatus, etc., for geodetic surveys.

In the laboratory for testing materials there are, a Standard abrasion cylinder for paving brick, three testing machines arranged for tension, compression and transverse tests, an Olsen torsion machine, extensometers, deflective gages, compression micrometers, and small tools and instruments needed for tests of iron, steel, wood, brick, etc. The cement laboratory is fitted for all of the standard tests. There are Olsen and Fairbanks testing machines, mortar mixer, briquette press, apparatus for heat tests, Vicat and Gilmore needles for rate of setting, appliances for fineness and specific gravity tests, glass mixing tables, and a good outfit of molds and other small instruments.

For office work there are rolling and polar planimeters, a pantagraph, topographical protractors, stadia charts and slide rule, Thatcher calculating instrument, beam compass, etc. About 500 drawings of recent bridges, presented by Mr. T. G. Wilkerson (class of 1890) of Pittsburg, and a set of 130 drawings, carefully arranged, indexed, and presented by Dr. J. A. L. Waddell, illustrating recent practice in bridge design, are available for instruction.

1a. **Elementary Surveying.** Use and adjustment of ordinary surveying instruments. Methods employed in land and topographical surveying. Course for Sophomores in Electrical and Mechanical Engineering. M. F., 1:30-4; W., 1:30-4; S., 9-11:30; T. Th., 1:30-4. Assistant Professor WILLIAMS and Mr. FRY.

1b. **Elementary Surveying.** Course for Freshmen in Civil Engineering. M. W. F., 1:30-4; M. W. F., 9-11:30; T. Th., 1:30-4; S., 9-11:30; T. Th. F., 10-12:30. Assistant Professor WILLIAMS and Mr. FRY.

2a. **Higher Surveying.** City, topographical, mining, and hydrographic surveying. T. Th., 8-10; S., 8-11:30; M., 8-11:30, W. F., 10:30-12:30. Assistant Professor WILLIAMS and Mr. FRY.

3b. **Geodetic Surveying.** Elements of Geodesy with practice in use of precise instruments and reduction of triangulation. Precise level work. Determinations of azimuth. M. W. F., 1:30-4. Assistant Professor WILLIAMS.

4b. **Railway Location.** Theory and practice of railroad surveying, including the field location for a short line of railway. T. Th., 8-10; S., 8-11:30; M., 8-11:30; W. F., 10:30-12:30. Assistant Professor WILLIAMS and Mr. FRY.

5a. **Railway Engineering.** Complete estimate for railway line; track construction; railway structures; railway economics. T. Th. 1:30-5, S., 1:30-2:30; M. W., 9-12:30, F., 9-10. Assistant Professor WILLIAMS and Mr. FRY.

6. **Elementary Construction.** Material and methods employed in engineering construction; masonry construction; roads and pavements. W. F., at 9. Professor SPALDING.

7. **Municipal Engineering.** Discussion of general problems of municipal public works, with more detailed study of water supply and sewerage. *First Semester*, T. Th., 10:30; *Second Semester*, M. W., 10:30. Professor SPALDING.

8b. **Sanitary Engineering.** Sewerage disposal, water purification and general sanitation. M. F., 11:30. Professor SPALDING.

9a. **Hydraulics.** Problems in hydraulics; conduits; pipe lines; water towers and stand pipes; dams and gates; measuring devices, etc. T. Th., at 9. Professor SPALDING.

10. **Framed Structures.** Analysis of simple trusses. Graphic statics. Design for small roof truss. M. W. F., 1:30-4. Assistant Professor HYDE.

11a. **Bridge Design.** Design for plate girder bridge and steel railway bridge of short span, with working drawings and estimates. M. W. F., 8-10; T. Th., 10:30-12:30. Assistant Professor HYDE.

12b. **Theory of Structures.** Swing bridges, arches, suspensions and cantilever bridges, deflection of trusses. T. Th. S., at 8. Assistant Professor HYDE.

13a. **Masonry Structures.** Theory of masonry and concrete structures; reinforced concrete; design and estimate for masonry arch. M. W. F., 1:30-4. Professor SPALDING.

14b. **Testing Laboratory.** Tests for strength and elasticity of wood, iron, and steel in tension, compression, torsion and flexure; standard tests for cement and for paving brick. T., 1:30-4; Th., 1-30-4. Assistant Professor HYDE.

14a. **Testing Laboratory.** Continuation of Course 14b, with independent investigations by students. S., 9-11:30 or T., 1:30-4. Assistant Professor HYDE.

15. **Hydraulic Engineering.**(a) Institutions and practice of irrigation; a discussion of special problems arising in irrigation work.

First Semester, W. F., 10:30. (b) Rivers, canals, harbors, docks, etc. *Second Semester*, T. Th., 10.30. Professor SPALDING.

16b. **Specifications and Contracts.** S., 10:30. Professor SPALDING.

17b. **Geodesy.** T. Th. 10:30. Assistant Professor WILLIAMS.

18a. **Mill Structures.** Graphical analysis of framed structures; designs for simple roof truss, plate girder, and building details. M. W., 9-11:30. Assistant Professor HYDE.

19b. **Materials of Construction.** Properties of the more common materials used in engineering construction, with description of processes of manufacture and methods of testing and inspection. T. Th., 11:30. Professor SPALDING.

20b. **Construction.** Methods employed in engineering construction; foundations; walls; embankments; tunnels; hydraulic construction. T. Th., 9. Professor SPALDING.

30b. **Thesis.** An independent investigation or design with complete report or discussion of results.

For Graduates.

31. **Railway Engineering.** Special advanced courses in construction, maintenance and management. *Three to six hours a week.*

32. **Bridge Engineering.** Problems in theory and design of framed structures. *Three to six hours a week.* Assistant Professor HYDE.

33. **Sanitary Engineering.** Investigations and special problems in Sanitary Science. *Three to six hours a week.* Professor SPALDING.

34. **Hydraulic Engineering.** Problems in hydraulics, irrigation, river and harbor improvements. Hydraulic constructions. *Three to six hours a week.* Professor SPALDING.

35. **Concrete Structures.** Theory of reinforced concrete. Special laboratory investigations. *Three to six hours a week.* Professor SPALDING and Assistant Professor HYDE.

Electrical Engineering.

H. B. SHAW, Professor; A. E. FLOWERS, Instructor; D. W. RICHARDS, Assistant.

The aim of the course is to furnish thorough training for Electrical Engineers. For this purpose the individual studies have been very carefully selected and arranged, the technical subjects being varied slightly from year to year to meet the demands of a rapidly developing profession. The first two years are devoted to preliminary training in English, Mathematics, the Sciences, and in Drawing and Shopwork. Studies 1 to 7b on the following page are given in the junior and senior years.

Instruction is given by means of recitations, lectures, and laboratory work thoroughly correlated, the idea being to present the subject to the student as a whole, and from all points of view. A feature of considerable interest in the work is the student meetings of the American Institute of Electrical Engineers held in connection with the Seminar. The department of Physics has charge of the special course —lectures and laboratory work—in Electrical Measurement for students in Electrical Engineering.

Attention is called to the studies, Steam Engineering, Kinematics, Hydraulic Motors, and Mechanical Laboratory under the direct charge of the department of Mechanical Engineering.

For the laboratory work in Electrical Engineering distinctively there are the following laboratories: Dynamo laboratory for Direct and Alternating Currents. Standardizing laboratory for the calibration of instruments, laboratory for the testing of materials used in Electrical Construction. These laboratories are already fairly well equipped wifh different types, makes and sizes of motors and generators, together with ammeters, volt-meters and other instruments and accessories. Apparatus is being continually added as necessary. Facilities for research work are continually being improved, each student being required to present a thesis evidencing original research. As the result of such research work may be mentioned a 40,000 volt testing transformer and an oscillograph constructed by students.

1. **Electrical Machinery.** Theory, construction, and operation of continuous current generators, motors, measuring instruments and accessories. Laboratory: characteristics, efficiencies, heating tests, diseases and remedies. Lecture: F., at 9. Recitations: I. Th., at 9, II. Th., at 8. Laboratory I. T. Th., 1:30–4; II. M. W., 10-12:30. Professor SHAW and Mr. RICHARDS.

2. **Alternating Currents.** Alternating current phenomena. Theory of current flow. Single and multiphase generators, motors, transformers, and instruments. T. Th. S., at 11.30. Mr. FLOWERS.

3. **Advanced Alternating Currents.** A continuation of course 2 with laboratory tests as to operation, regulation, efficiency, etc. M. W. F., 1:30-4. Professor SHAW and MR. RICHARDS.

4. **Electrical Design.** Critical study of electrical apparatus and design of rheostats, transformers, generators, motors, and switchboards. M. W. F., 8-10. Mr. FLOWERS.

5. **Electrical Engineering.** The generation, transmission, distribution and utilization of electrical energy. Study of lighting, power, and transmission systems, including street railways, with regard to estimates and specifications, selection and arrangement of machinery, installation, testing, operation, and management. M. W. F., at 11:30. Professor SHAW.

6. **Seminary.** Discussion of current technical literature. Student meetings of the American Institute of Electrical Engineers are held

regularly, and work for the same will constitute part of the course. Juniors, T., 10:30; Seniors, T. F., 10:30. Professor SHAW.

7b. **Thesis.** Original investigations, and presentation of results in the form of a final thesis. Hours to be arranged.

Primarily for Graduates.

8. **Design.** Special problems. Thorough study and design of a single piece of apparatus, such as an induction motor, direct current generator, or rotary. Hours to be arranged. Mr. FLOWERS.

9. **Telephony and Telegraphy.** Apparatus and systems. Lines: their properties, with special reference to effects of inductance and capacity. Wireless telegraphy. Hours to be arranged. Professor SHAW.

10. **Long Distance Transmission.** A thorough study of details. Hours to be arranged. Professor SHAW.

11. **Electric Railway Engineering.** Street, interurban and high speed electric railroading. Electric railway economics. Hours to be arranged. Mr. FLOWERS.

12. **Storage Battery Engineering.** Hours to be arranged. Professor SHAW.

13. **Electrical Engineering Economics.** Hours to be arranged. Professor SHAW.

14. **Research.** Work and hours to be arranged to suit individuals. Professor SHAW and Mr. FLOWERS.

Mechanical Engineering.

A. M. GREENE, JR., Professor; A. F. VAN DEINSE, Instructor; J. R. WHARTON, Assistant.

The aim of this course is to train the student in the underlying principles of the profession so as to enable him to readily take up any special branch of Mechanical Engineering. For this purpose the design of engineering structures and machines and the application, measurement and production of power are studied. Instruction is given principally by the aid of text books and laboratory work, lectures being used in few of the courses and to supplement the text books. In the class rooms advanced problems taken principally from practice are given for solution, the aim being to prepare the student for the practical work which is to come after graduation.

The department is equipped with an excellent working library of books which are always accessible to the student. The reading room, which is also open at all times, is supplied with the best engineering magazines. The laboratory is equipped with steam, gas and oil engines, steam turbine, water wheels, injectors, pumps, air compressors, fans, blowers, hoisting appliances, and apparatus for testing the standardising instruments. A large number of indicators, planimeters, thermometers, and water meters are used on tests, and the

properties of oils, coals, transmission material and gases are determined by apparatus for these purposes.

The work in the laboratory is to familiarize the student with the use and the care of these machines as well as the principles underlying their design, construction and use. In equipping the laboratory it has been the aim to select apparatus which would bring the student in contact with most of the important forms or types of machines for developing and measuring power. It is also the intention to have him make most of the tests which a mechanical engineer is called upon to execute, and at the same time an attempt is made to have the student make original investigations on simple problems.

1a. **Steam Engineering.** Fuels, boilers, engines and accessories. An elementary descriptive course intended to give the student the names, purposes, construction and operation of the various parts of the apparatus found in a steam power plant. T. Th. S., at 9; T. Th. S., 11:30. Professor GREENE, Mr. VAN DEINSE.

2b. **Kinematics.** Elementary mechanisms: pulleys, belts, link work, gearing, cams. T. Th. S., at 9; T. Th. S., at 11:30. Mr. VAN DEINSE.

3. **Steam Boilers.** Value of fuels, determination of the sizes of grate, heating surface, stays, and chimney, for a given boiler. Types of boilers for various purposes, methods of testing boilers. Boiler room accessories. Design of a boiler house. Each student is required to make a working drawing of a boiler designed by him. This course must be preceded by or taken co-ordinately with Mech. 3. *First Semester*, M. W., at 9; F., 10:30-12:30; *Second Semester*, F., 10:30-12:30. Mr. VAN DEINSE.

4b. **Thermodynamics.** Mechanical theory of heat. Cycles and analyses. T. Th. S., 10:30. Professor GREENE.

5a. **Heat Engines.** The application of thermodynamics to the various forms of heat engines, air compressors, and refrigerating machines. Form of plants using such apparatus. Discussion of tests, installation and maintenance. This course must be preceded by course 4. T. Th. S., 10:30. Professor GREENE.

6. **Steam Engine Design.** The determination of the size of the parts of a steam engine to develop a given power. Discussions of vibrations, fly wheels, balancing, transmission of power by belts, ropes and gears, steam piping, shafts. Each student is required to make freehand sketches of the various parts of the complete engine as designed by him. Must be preceded by Mech. 3 and M. E. 1 and 2. *First Semester*, M. W. F., 10:30-12:30; *Second Semester*, W. F., 10:30-12:30. Professor GREENE.

7a. **Hydraulic Motors.** The theory of the action of turbines, measurement of power, discussion of experiments, design of wheels for specific duty. Must be preceded by Mech. 3. T., 8-10; Th., at 8. Professor GREENE.

8b. **Pumping Machinery.** The design of pumps for waterworks and power transmission. Hydraulic presses and machinery. Pipe lines. Plants. T. Th., at 8. Professor GREENE.

9. **Machine Design.** Design of special machinery. Continuation of work in mechanical drawing and engineering mechanics. The student is required to design a machine tool, crane, pump, girder, or some similar engineering structure and make finished working drawings of the same. Must be preceded by Drawing 1 and 2 and Mech. 3. T. Th., 1:30-4. Mr. VAN DEINSE.

10b. **Heating and Ventilating.** The arrangement and design of systems for heating and ventilating buildings. Application to a specific building. Elective for Seniors. T. Th., at 9. Professor GREENE.

11. **Mechanical Laboratory.** The calibration and adjustment of instruments, measurements of leverage, determination of the efficiency of machines, tests of materials of engineering, measurements of power, hydraulic measurements, valve setting, coal and gas calorimetry. W., 1:30-4. Mr. VAN DEINSE.

12. **Mechanical Laboratory.** Testing boilers, engines, pumps, turbines, injectors, air compressors, and refrigerating machinery for efficiency and duty. Studies in generation, transmission and application of power. Heating and ventilating. Calorimetry. *First Semester*, M. F., 1:30-4; *Second Semester*, F., 1:30-4. Professor GREENE.

13. **Mechanical Laboratory.** A course for electrical engineers. Calibration of instruments and tests of engines, pumps, turbines, and boilers for efficiency and duty. T., 1:30-6. Professor GREENE.

14a. **Graphics of Machines.** Graphical Analysis of machines. Moment diagrams for shafts, friction of axles, gears, screws. M., 1:30-4; W., 10:30-12:30. Mr. VAN DEINSE.

15. **Plants and Processes.** A course in the layout and arrangement of plants for different engineering works. Engineering manufacturing processes. Elective for Juniors and Seniors. F., 8-10. Professor GREENE.

16a. **Valve Gears.** A study of the various forms of gears and their design, using the Zeuner and Bilgram diagrams. Elective for Juniors and Seniors. M., 10:30-12:30. Mr. VAN DEINSE.

17. **Marine Engineering.** A study of the marine engine and boiler together with the auxiliary machinery used on shipboard. Elective for Juniors and Seniors. Given in alternate years, beginning 1904-5. M., 8. Professor GREENE.

18. **Naval Architecture.** Buoyancy, stability, metacentric heights, weights, curves, strength, propulsion and steering. Elective for Juniors and Seniors. Given in alternate years, beginning 1903-4. M., 8. Professor GREENE.

19b. **Thesis.** An original investigation of an engineering prob lem. M., 9-12:30, 1:30-4. Professor GREENE.

20. **Technical Literature.** Reports on reading of technical magazines. S., at 9.

Students in Civil and Electrical Engineering with the required training may elect any of the above courses with the consent of the head of the department in which they are working.

Primarily for Graduates.

21. **Generation of Power.** Advanced work in the Theory and Design of steam, gas and oil engines, air compressors and motors, steam turbines and hydraulic motors. Hours to be arranged. Professor GREENE.

22. **Transmission of Power.** Study of methods of the transmission of power, heating, lighting, and arrangement of shops, plants, industrial institutions and towns. Transportation of materials. Hours to be arranged. Professor GREENE.

23. **Advanced Laboratory Work.** Determination of physical characteristics of fuels, oils, metals. Thermodynamics of heat engines. Tests of complete plants. Original Investigations. Hours to be arranged. Professor GREENE.

24. **Railway Engineering.** Design, construction and operation of motive power, rolling stock and the auxiliary apparatus employed. Hours to be arranged. Mr. VAN DEINSE.

25. **Kinematics and Machine Design.** Advanced work in Kinematics and the design of apparatus for specific work. Hours to be arranged. Mr. VAN DEINSE.

26. **Refrigeration.** Advanced work in the layout and operation of Plants for Refrigeration. Hours to be arranged. Professor GREENE.

27. **Engineering Office Work.** Keeping of costs, estimates, organization of shops, advertising. Hours to be arranged. Professor GREENE and Mr. VAN DEINSE.

Mechanics.

L. M. DEFOE, Professor.

3. **Mechanics of Engineering.** Statics, dynamics, strength of materials, hydrostatics and hydrodynamics. Lectures, W. F., at 8; Recitations, Section I, T. Th. S., at 8; Section II, T. Th. S., at 9.

4. **Elasticity.** Mathematical theory of elasticity. T. Th. S., at 10:30.

9. **Hydromechanics.** An elementary course in hydrostatics and hydrodynamics. M. W. F., at 10:30.

12. **Fourier's Series and Potential Functions.** Recitations and lectures. Hours to be arranged.

20. **Problems in Mechanics.** Dynamics of a rigid body. M. W. F., at 11:30.

27. **Theory of Sound,** with special reference to the Partial Differential Equations of Mathematical Physics. Reading Course, based on Rayleigh's Theory of Sound. *Three hours.* Hours to be arranged.

Mathematics.

E. R. HEDRICK, Professor; G. A. BLISS, Assistant Professor; L. D. AMES, LOUIS INGOLD, Instructors; EMILY E. DOBBIN, MARY S. WALKER, Assistants.

1. (E). **Trigonometry.** *Three hours.* This course may be taken *only* together with 2a (E) or 2a, and therefore contains no algebra. Eight sections. Hours and instructors posted in advance.

1b. (E). **Plane (and Solid) Analytic Geometry.** *Five hours.* This course will also contain introductory work on graphs, and will include the Solid Analytic Geometry. Eight sections. Hours and instructors will follow 1a (E).

2a. (E). **Advanced Algebra.** *Two hours.* Open only to those who have offered one and one-half units of Algebra for entrance. Eight sections. Hours and instructors posted in advance.

4. (E). **Differential and Integral Calculus, with Applications.** *Five hours.* This course should be elected by those who feel inclined toward mathematics; in it they can decide whether or not they can succeed in further mathematical work. The course will be followed by short supplementary courses on Differential Equations and on the Applications to Mechanics. Five sections. Hours and instructors posted in advance.

6b. **Theory of Equations and Determinants.** Recitations, following Burnside and Panton. Theory of Equations. *Three hours.* Hours to be arranged. Mr. INGOLD.

10b. **Elements of Differential Equations.** Problem course. Recitations, supplemented by reading and recitations. Text: Forsyth, Differential Equations. *Three hours.* Hours to be arranged. Mr. INGOLD.

Other courses in mathematical subjects given in Academic Department and Teachers College are open to Engineering Students.

Astronomy.

F. H. SEARES, Professor.

The practical work of the Department of Astronomy is carried on with the instruments of the Laws Observatory.

The observatory is a building 84 feet long and from 14 to 30 feet wide. The equipment consists of a 7 1-2 inch equatorial refracting telescope by Merz and Soehne, of Munich, a 2 1-10 inch transit instrument by Brunner, of Paris, a 2 1-8 inch altitude and azimuth instrument

by E. & G. W. Blunt of New York, a Pickering stellar photometer and a disc photometer by Brashear, a theodolite, sidereal and mean-time clocks, sidereal break circuit chronometer, chronograph, sextants, micrometer, spectroscope, and outfit of smaller instruments.

Clocks and instruments are mounted on piers of solid masonry, isolated from the floors and walls of the buildings, and are provided with the usual electrical connections. The dome covering the telescope is 18 feet in diameter. A cone 14 feet in diameter, revolving on balls, shelters the altitude and azimuth instrument.

3a. **General Astronomy.** Open to students of junior standing who have completed the courses in Elementary Mathematics and General Physics. M. W. F., at 9.

4a. **Observatory Practice.** Practical work with the instruments of the Laws Observatory. Open to students taking course 3a. T. Th., 7:30-10 P. M.

5b. **Spherical and Practical Astronomy.** Open to students who have completed Differential and Integral Calculus and General Physics. T. Th., at 10:30; one Observatory period, hours to be arranged.

6a. **Spherical and Practical Astronomy.** Open to students who have completed course 5b. Lectures and Recitations. T., at 10:30; Observatory practice. T. Th., 7:30-10 P. M.

8b. **Method of Least Squares,** with applications to the problems of Astronomy and Geodesy. M. W., at 10:30.

10. **Celestial Mechanics, General Introduction and Theory of Cometary Orbits.** Open to students who have completed Analytic Mechanics and Elementary Differential Equations and who have a reading knowledge of French and German. Hours to be arranged.

Chemistry.

W. G. Brown, Professor; Sidney Calvert, Herman Schlundt, Assistant Professors; H. W. Doughty, E. E. Morlan, Instructors; F. W. Liepsner, Assistant.

1. **General Inorganic Chemistry.** Lectures, laboratory work, problems and recitations. Lectures, Section I, M. W., at 9, and Section II, M. W., at 11:30; Recitation, F., at 8, 9, 10:30 and 11:30; Laboratory (see schedule of hours). *Six hours.*

2. **General Inorganic Chemistry.** Lectures, laboratory work problems and recitations. Lectures, Section I, M. W., at 9, and Section II, M. W., at 11:30; Recitation, F., at 8, 9, 10:30 and 11:30; Laboratory (see schedule of hours). *Four hours.*

5a or 5. **Qualitative Chemical Analysis.** Laboratory work, recitations and lectures. M. W. F., at 1:30. *Three times a week.*

6a and 6b. **Quantitative Chemical Analysis.** Laboratory work. *Three times a week.*

4. **Organic Chemistry.** Lectures and recitations. M. W., at 4; laboratory (one). *Three hours.* Assistant Professor CALVERT.

4. **Organic Chemistry.** Lectures and recitations (the same as 4). Laboratory (two). *Four hours.* Assistant Professor CALVERT.

7. **Preparation of Organic Compounds and Organic Analysis.** *Three times a week.* Assistant Professor CALVERT.

8b. **Chemical Theory.** Lectures and recitations. *Three times a week.*

9a. **History of Chemistry.** Lectures and recitations. *Three times a week.*

Courses 8b and 9a should be preceded by courses 1 or 2 and 4.

10. **Physical Chemistry.** Lectures, laboratory work, and recitations. *Three times a week.* Dr. SCHLUNDT.

11a. **Electro-Chemistry.** Lectures, laboratory work, and recitations. *Three times a week.* Dr. SCHLUNDT.

12. **Technical Chemistry.** *Three times a week.* Required of Chemical Engineering students.

14. **Inorganic Preparations.** *Three times a week.*

15. **Advanced Quantitative Chemical Analysis.** *Six times a week.*

16a or 16b. **Advanced Organic Chemistry.** Selected chapters. Lectures. *Three times a week.* Assistant Professor CALVERT.

17. **Quantitative Organic Analysis.** The determination of the proximate constituents of natural (vegetable and animal) and artificial organic substances. *Three times a week.* Assistant Professor CALVERT.

18a or 18b. **Radio-activity.** Lectures, experimental work and recitations on the radio-active types of matter and atomic disintegration. *Three times a week.* Dr. SCHLUNDT.

Primarily for Graduates.

20. **Research.** This will consist principally of original work and investigation in Inorganic, Organic, and Physical Chemistry, and will be adapted in some measure to individual cases.

A meeting is held weekly, at which reports on current literature, abstracts of special lines of research and the results and progress of investigations are presented for the information and discussion of those particularly interested in Chemistry and its applications. F., at 3:30.

Physics.

O. M. STEWART, Professor; C. A. PROCTOR, H. M. REESE, Instructors; H. E. HOWE, Assistant.

Instruction in the elements of Physics is by means of lectures, quizzes and laboratory work. In the lectures the general principles of heat, sound, mechanics, optics, magnetism and electricity are given and illustrated at all stages by demonstration experiments. The large

collection of lecture room apparatus possessed by the department makes it possible to illustrate all the more important phenomena. The laboratory work is designed to enable the student to obtain clearer conceptions of the fundamental principles and phenomena, and to give an opportunity to attain some skill in the use of instruments and a knowledge of the simpler methods of physical manipulation.

In the laboratory for electrical measurements is found a valuable collection of galvanometers, resistances, condensers, electrometers standards of electromotive force and resistance, self-induction, capacity, etc. The student is instructed in the important methods of comparing and calibrating instruments by such methods as Kelvin double bridge, potentiometers, etc.

The laboratory for advanced work in general physics contains standards of length, mass and temperature, and many pieces of high grade apparatus. The entire equipment has cost more than $10,000.

3. **General Physics.** A longer elementary course—an elementary knowledge ot Trigonometry is required. *Six times a week.* For 1905-6 this will be divided into courses 3A and 3B. 3A may be taken alone. 3B may be taken in conjunction with 3A or subsequently.

3A. **Lectures and Recitations.** *Four times a week.* Lectures T. Th., at 10:30 or W. F., at 10:30. Assistant Professor STEWART. Recitations: Section I, W. F., 1:30; Section II, T. Th., 8; Section III, W. F., 11:30; Section IV, W. F., 8; Section V, T. Th., 11:30. Professor STEWART; Mr. PROCTOR; Dr. REESE.

3B. **Laboratory.** *Twice a week.* Section I, W. F., 8-10:30; Section II, M. F., 1:30-4; Section III, T. Th., 9-11:30; Section IV, M., 8-10:30, W., 1:30-4; Section V, T. Th., 1:30-4. Mr. PROCTOR; Dr. REESE; Mr. HOWE.

4. **Electrical Measurements.** *Two or three times a week.* Lectures, M., 9. Laboratory, W. Th., 1:30-4. A knowledge of Calculus is required. Professor STEWART.

7. **Theory of Electricity and Magnetism.** *Three times a week.* M. W. F., at 11:30. Professor STEWART.

10. **Seminary.** Critical reading and discussion of current research work in physics. A colloquium in which all members of the teaching staff of the department and students of sufficient attainments take part. *Once a week.* M., at 4.

11. **Research Work.** Hours to be arranged. Professor STEWART.

Drawing.

T. J. RODHOUSE, Instructor (in charge); E. F. ROBINSON, OMER DENNY, Assistants.

Instruction is given to all regular Engineering students in the principles of geometrical and mechanical drawing and in freehand sketching. A large amount of time is devoted to practice in the drawing-room

to enable the student to acquire the skill necessary for his future work. Drawing is continued also in connection with the student's professional studies.

1a. **Mechanical Drawing.** Selected geometrical problems. Shading and sectioning; tracing; isometric drawing; mechanical lettering and plain freehand lettering. I. T. Th. S., 10:30-12:30; II. T. Th. S., 8-10; III. M. W. F., 1:30-3:30; IV. M. W. F., 10:30-12:30; V. M., 8-10; T. Th., 1:30-3:30; VI. T. Th. S., 10:30-12:30; VII. M. W. F., 8-10; VIII. T. Th. S., 8-10.

2b. **Descriptive Geometry.** Orthographic projections, problems relating to points, lines, and planes, preceded by a short course in elementary mechanical lettering and plain freehand lettering. Representation of surfaces, their tangencies, intersections and developments. Shades and shadows. Isometric, cabinet, and perspective views. Schedule same as 1a.

3a. **Machine Drawing.** See 3b for statement of course. IV. T. Th., 1:30-4; V. M. F., 1:30-4.

3b. **Machine Drawing.** Assembly drawings and tracings are made from especially prepared sketches of details for the purpose of familiarizing the student with conventions used in engineering practice. The parts of complete machines of approved design are then sketched freehand and the dimensions given on the sketches. Working drawings, assembly and detail, are made from these sketches without further reference to the parts. Blue prints are made by each student from his own tracings. I. M. F., 1:30-4; II. W., 1:30-4; S., 9-11:30; III. T. Th., 1:30-4.

5a. **Topographical Drawing.** Topographical signs; map drawing, V. F., 1:30-4; VI. M., 9-11:30; VII. W., 1:30-4; VIII. F., 10-12:30.

6b. **Stereotomy.** Problems in stone-cutting; drawings for masonry structures. IV. T. Th., 1:30-4; V. M. F., 1:30-4.

Shops.

W. H. Cook, Instructor (in charge); A. C. Duncan, Instructor; M. S. Bowen, A. W. Spaht, Assistants.

The shops of the Engineering school are intended primarily to give the student an idea of the properties of the various materials used in engineering, as well as to teach the methods of using tools. This work is carried on in the joinery shop, the pattern shop, the forge shop and the machine shop. In the first of these the student receives instruction in the manner of handling wood for structural purposes, the fundamental points of form being emphasized. Instruction is also given in the care and manipulation of all kinds of wood-working tools.

In the pattern shop the student is taught, not only the methods of constructing patterns, but also the peculiarities of melted metals, and the design of patterns for the purpose of making an efficient casting.

It is the intention to test the patterns studied in this course by actually making castings from patterns constructed by the student.

In the forge shop the fundamental operation of reducing, upsetting, welding and general forging are taught as well as the methods employed in tool making. The students are required to construct different tools and temper them for different purposes.

In the machine shops the fundamental operations are taught and a comparative study is made of the different methods of producing certain results. The time element for the different operations is studied, and it is the intention to have the student trained in selecting the best method for machining the various portions of a structure as well as to know the manner in which these operations may be performed. The intention in this work is to bring the student in contact with the modern methods of shop practice.

The equipment of the various shops is large enough to accommodate sections of twenty-four students. In the joinery shop work-benches and tools are supplied for each student, and in the pattern shop wood turning lathes are provided in addition to the work-benches for pattern-making. The forge shop is supplied with individual forges and anvils, and a power hammer is used for the purpose of reducing large stock, or for performing special work.

The machine shop is equipped with engine lathes, a planer, two shapers, a Universal milling machine, a Universal grinder, a screw machine, a drill press and two power saws, in addition to the emery wheels and small tools. Several vises are equipped with proper tools for bench work.

1. **Wood-work, Forging, Pattern-making and Foundry Practice.** *Six hours a week,* five sections.

1a. **Wood-work and Forging.** *Four hours a week,* four sections.

2. **Machine Work.** The aim of this course is to give the student an acquaintance with the improved methods of machine construction and of modern machine shop practice. Chipping, filing, and fitting, as well as the assembling of small machines, are carefully supervised and graded. *Five hours a week,* three sections.

3. **Advanced Machine Work.** This course is intended for students who desire to specialize in this work, and requires more experience than course 2 will give. This course will be given, if there is a demand for it.

For further information concerning the School of Engineering, address F. P. Spalding, Junior Dean, Columbia, Mo.