Students should retain this bulletin for use throughout the year.

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GENERAL INFORMATION

INSTITUTE OF TECHNOLOGY

The Institute of Technology was established by action of the Board of Regents on October 19, 1935, to embrace the College of Engineering and Architecture, the School of Chemistry, and the School of Mines and Metallurgy, effective November 1, 1935.

COLLEGE OF ENGINEERING AND ARCHITECTURE

The College of Engineering and Architecture had its beginning in the College of Agriculture and the Mechanic Arts which was authorized by the legislative act of 1868. Courses in Civil and Mechanical Engineering were first offered in 1871. In the reorganization of the University, in 1872, the College of Mechanic Arts was established. It became the College of Engineering, Metallurgy, and the Mechanic Arts in 1892, the College of Engineering and the Mechanic Arts in 1897, and the College of Engineering and Architecture in 1916. A course in Electrical Engineering was first offered in 1887. Architecture was announced in 1912. In 1925, the name of the Department of Architecture was changed to the School of Architecture. The Agricultural Engineering course was offered in 1925, and the courses in Aeronautical Engineering in 1928. Combined courses with Business Administration were established in 1934.

The departments of this college occupy the following buildings on the Main campus: Main Engineering, Electrical Engineering, Mechanical Engineering, and the Experimental Engineering and Oak Street Laboratories. Portions of the School of Chemistry and the Armory are also utilized. The Hydraulic Laboratory is situated at the St. Anthony Falls of the Mississippi River about a mile upstream from the campus. Agricultural Engineering has its own building on the Agricultural campus. The libraries of Engineering and Architecture are situated in the Main Engineering Building.

The purpose of this college is to give the students a broad foundation in the fundamental principles of engineering and architecture, together with sufficient knowledge of professional practice to enable them to apply those principles successfully. It is not possible in college to educate a fully trained engineer, as the application of the principles to the practice of engineering is to be learned through experience. There are certain subjects, such as surveying and drafting, in which some proficiency is required. This enables a student upon graduation to fill satisfactorily a subordinate position while obtaining a basis for growth and advancement.

It is intended that all of the technical courses given in this college shall be taught by men who have had practical experience in their respective fields in addition to their professional training.

The fields of engineering and architecture are very broad and are continually becoming more extensive. From the technical lines of design, construction, maintenance, and operation, which have always belonged to them, the trained engineer and architect have been drawn into the business world to occupy positions of an executive character. To meet the demand for such service, the importance of the broader training in economic and commercial principles and industrial relations is recognized.

Withal, it is intended that the young graduate shall have obtained material assistance in developing those traits of character which will make him a loyal and exemplary citizen and a true gentleman.

SCHOOL OF CHEMISTRY

The School of Chemistry was established in 1897 as a school of analytical and applied chemistry, subsidiary to the College of Science, Literature, and the Arts. In 1904 it was made a separate unit of the University, and in 1919, its present name was adopted, and its administration was correlated with that of the College of Engineering and Architecture under one dean.

The courses in Chemistry and Chemical Engineering were developed from the beginning of the school. The course in Physics was established in 1936.

The school occupies a large modern building 180 x 200 feet, having six floors. Its laboratories are designed to afford facilities for instruction in the various branches of chemistry. The Chemistry library is well provided with complete sets of journals and compendia of chemical literature, among which are important sets not frequently found in university libraries. Many special laboratories for private research have been provided and ample facilities are available for graduate work leading to the higher degrees.

SCHOOL OF MINES AND METALLURGY

The School of Mines and Metallurgy was established by the Board of Regents in 1888, upon recommendation of the general faculty of the University. A course in Mining and Metallurgy was announced in 1889. The school was affiliated with the College of Engineering, under the name of the College of Engineering, Metallurgy, and the Mechanic Arts, until 1897, when the School of Mines was made an independent college. In 1926 the name was changed to School of Mines and Metallurgy.

The school occupies the building provided by the Legislature of 1913. This building contains the library of the school together with the offices, classrooms, drafting rooms, and laboratories necessary to administer the courses in Mining, Metallurgy, Metallography, and Petroleum Engineering. For other fields of work necessary to the completion of well-rounded curricula advantage is taken of the instruction afforded by various departments in other units of the University.

The Mines Experiment Station was established by the Board of Regents in 1911. It occupies a specially constructed laboratory building of which a portion is assigned to the North Central Station of the United States Bureau of Mines.

The mining districts of Minnesota are within a few hours of Minneapolis by rail or paved road. The heartiest co-operation exists between the officials of the various mining companies and the school. As a result, the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts.

Ample opportunity for field work in metallurgy is also available. Numerous fabrication and heat treating plants are located in the Twin Cities. Plants for the study of smelting and other processes can be reached with not more than an overnight trip by rail.

Students in the School of Mines and Metallurgy have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

ENGINEERING EXPERIMENT STATION

The Engineering Experiment Station of the Institute of Technology provides facilities for graduate research and technical investigations in a variety of fields. The St. Anthony Falls Hydraulic Laboratory located on Hennepin Island, and the Oak Street Laboratories on University Avenue are exceptionally well adapted to special large-scale investigations, many of which may be profitably conducted in co-operation with technical societies, associations, and industries. Several investigations of this type are now under way and provide an opportunity for advanced students in the institute to come in contact with industrial and technical problems. In many cases the projects provide graduate fellowships and part-time employment for advanced students.

COURSES AND DEGREES

The College of Engineering and Architecture offers four-year courses of study in Aeronautical, Agricultural, Civil, Electrical, and Mechanical Engineering, and a five-year course in Architecture. These courses lead to the degree of bachelor of aeronautical, agricultural, civil, electrical, or mechanical engineering, or architecture. In some of the courses, optional groups of electives are arranged for the guidance of students who desire to devote special attention to certain fields.

The Engineering Prebusiness course requires the first two years of work in this college. This is followed by two years in the School of Business Administration upon the completion of which the degree of bachelor of business administration is conferred.

In co-operation with the College of Science, Literature, and the Arts, a six-year course in Arts and Architecture is offered. It leads to the degrees of bachelor of arts, at the end of four years in the College of Science, Literature, and the Arts, and bachelor of architecture at the end of the sixth year in the Institute of Technology.

The School of Chemistry offers four-year courses in Chemistry, Chemical Engineering, and Physics, leading to the degrees of bachelor of chemistry, bachelor of chemical engineering, or bachelor of physics, respectively.

Five-year combined courses in Engineering or Chemistry with Business Administration lead to two Bachelor's degrees, one in each of the two fields.

The School of Mines and Metallurgy offers four-year courses in Mining, Geological, Petroleum, and Metallurgical Engineering leading to the respective degrees of bachelor of mining engineering, B.Min.E.; bachelor of geological engineering, B.Geol.E.; bachelor of petroleum engineering, B.Pet.,E.; and bachelor of metallurgical engineering, B.Met.E.

These colleges also offer work in the Graduate School leading to the Master's degree in the appropriate branch of engineering, in architecture, or in chemistry, or to the Doctor's degree.

The professional degree of aeronautical, agricultural, chemical, civil, electrical, geological, mechanical, metallurgical, mining, or petroleum engineer will be conferred upon those who have received the degree of bachelor of aeronautical, agricultural, chemical, civil, electrical, geological, mechanical, metallurgical, mining, or petroleum engineering, when they have completed the equivalent of one additional year's college work, four years of engineering experience in positions of responsibility, and have presented a satisfactory professional thesis.

Graduates of these colleges may be granted permission to pursue the year of graduate study *in absentia* under the direction of the faculty. It is recommended, however, that this year be spent in residence at this University and that the Master's degree be obtained in this manner. There are many advantages in taking this year immediately following graduation, thus making a five- or six-year course leading to the Master's degree in the corresponding branch of engineering or in architecture. Then after four years of approved experience and the preparation of the professional thesis, the Engineer degree may be obtained. This procedure is especially recommended to those students whose undergraduate work is of high grade and who desire additional preparation for the higher positions which require strong character and leadership.

Candidates for the Engineer degrees register in the Graduate School.

ADMISSION

Detailed information concerning admission, entrance requirements, advanced standing, and expenses will be found in the Bulletin of General Information which will be sent to any address upon application to the director of admissions and records, University of Minnesota.

ADVANCED STANDING

Students who have pursued courses of study in other colleges of recognized standing may receive advanced credit under the rules of the University and of the institute. See Requirements for Graduation.

Students transferring from other accredited colleges to the Institute of Technology will receive credit in only those courses in which they present a grade of at least C.

A student entering the School of Chemistry as a sophomore (48-101 required credits) may transfer not more than one half of the total number of elective credits allowed for graduation; in the same manner a junior (102 or more required credits) will be permitted to transfer only three quarters of the total number of elective credits allowed for graduation.

REGISTRATION

All undergraduate students are required to pay the prescribed fees to the university bursar at the beginning of each quarter. Necessary classification blanks, showing the courses a student expects to pursue are to be filled out and filed at the beginning of each quarter during the college year. Classification and enrolment of students registering in Aeronautical, Agricultural, Civil, Electrical, Mechanical, or Prebusiness Engineering and Architecture take place in the Main Engineering Building; for those registering in Chemistry, Chemical Engineering, and Physics in the Chemistry Building; and in Mining, Metallurgical, Geological, and Petroleum Engineering in Appleby Hall.

All students entering the institute for the first time must send or present their credentials to the director of admissions and records of the University, who will notify each applicant in regard to his admission. Before registering, all new matriculants are required to take a medical examination, and the following tests:

1. Co-operative English test.
2. Impromptu English theme.

On the basis of his standing in these tests and his scholarship rank in preparatory school, a student will be classified in one of the two groups in English as follows:

1. Required to take English 4-5-6, nine (9) credits in composition.
2. Required to make up minimum essentials as a preliminary to English 4-5-6.

Any student who takes these tests when they are given in the high school and preparatory schools of the state and who applies for admission to the University will be mailed a card showing his classification in English. Those who have not taken the tests will be required to take them on Friday or Saturday preceding the regularly scheduled registration period. *No freshman will be allowed to register without presenting a card giving his assignment in English.*

Students should consult the university calendar in regard to registration dates.

Students will not be allowed to register for more than 19 credit hours without the approval of the Students' Work Committee.

Back work must be taken in preference to new work.

A substitution for formal prerequisites for any course must be approved by the department concerned.

Freshmen are not permitted to take additional courses (except Military or Naval Science and Tactics) without permission of the Freshman Students' Work Committee.

No change in registration will be permitted later than 10 days after the beginning of the quarter. A late fee of $2 is charged for changes in registration made after the second day of the quarter.

UNIT OF CREDIT

The standard unit of credit in the University is the quarter credit, or simply, the *credit.* It corresponds to one class period per week for one quarter. This class period may be a one-hour lecture or recitation, or a two- or three-hour class in laboratory,

drawing, surveying, or computations, but in any case one credit is supposed to require three actual hours of the average student's time per week for one quarter. One hour of recitation is assumed to require two hours of preparation or study. A two-hour laboratory period may require one hour of home work to complete the credit. A three-hour period usually carries one credit without additional work outside of class. The credit allowed for a lecture may be from one-third to one hour depending upon the amount of outside work or study required in connection with it.

CREDIT FOR OUTSIDE WORK

Credit for certain courses, as a result of work done outside of the regular classes, may be obtained by satisfactorily passing comprehensive examinations. This includes work done in extension classes, by correspondence study, by the aid of a private tutor, by individual study, through practical experience, or otherwise.

The comprehensive examination will be of such thoro and searching character as to determine whether the student has done all the work of the course. It should require at least three times the work of the usual final or condition examination and will be conducted by a committee appointed by the head of the department in which the course is given.

Permission to take the examination must be obtained from the Students' Work Committee, and the usual fee of $5 for each special examination must be paid unless it be taken within six weeks after first entering the University.

EXTENSION COURSES

Courses in engineering, architecture, and chemistry are offered by the General Extension Division of the University in evening classes and by correspondence study. Persons who are unable to attend the regular university courses may obtain valuable instruction in this manner.

Credits will be accepted from the Extension Division for the following types of courses:

1. Nontechnical courses taken in residence (residence as defined by the University Senate ruling).
2. Such other residence courses as have been approved by the department concerned of the Institute of Technology and by the dean, which courses shall have been designated as credit courses by the Extension Division.
3. Credits obtained by correspondence study courses in College Algebra, Trigonometry, and Analytic Geometry not to exceed a total of 15 credits, and in English and in other subjects not required in the student's curriculum not to exceed a total of 9 credits, will be accepted.

ATTENDANCE

It is expected that all students will be regular in attendance at all class exercises and that they will do all the work of their courses. Neglect of work, as indicated by irregularity in attendance or low scholarship, will be sufficient reason for exclusion from class. Any student who has unexcused absences equal to the number of credits in a course, but in no case less than two, may be dropped from the class with a record of failure in the course.

INSPECTION TRIPS

All seniors registered in Chemical Engineering are required to go on a trip of inspection and observation through certain large industrial plants. This trip is usually taken during the spring vacation and is under the personal supervision and guidance of members of the faculty. It includes plants in Milwaukee, Chicago, and near-by points.

The expenses of the trip are minimized as far as possible, and must be defrayed by the individual student. They amount to from $75 to $100 per student.

Seniors in Aeronautical Engineering are required to take an inspection trip during the spring vacation to visit aeronautical manufacturing, operating, and research establishments in the central and eastern portions of the United States. The expense to each student is estimated at about $75.

In Mines and Metallurgy, field trips are required at the end of the sophomore and junior years. The sophomore trip embraces mine surveying on the iron ranges in northern Minnesota for four weeks beginning about June 15, the expense amounts to about $60. Field work in geologic mapping is also required. The junior mining and nonferrous metallurgy, and petroleum trips cover a study of mine plants and operations in leading mining or oil fields in the western part of the country for nearly three weeks beginning early in September. Reports on the junior field trips of the School of Mines and Metallurgy must be prepared under the direct supervision of the department concerned, beginning the first day of the fall quarter and continuing for a period of two weeks. A limited program will be carried in addition to work on the field report. Final reports must be typewritten and contain drawings, to scale, made from the field sketches, covering operations, and details of plants and equipment. These reports shall become the property of the school. Class work in the remaining subjects of the first quarter, senior year, will begin when the field work reports are accepted. The expense amounts to approximately $125. The junior geology trip embraces standard types of geological field work in the Black Hills region. The expense amounts to about $100. The junior ferrous metallurgy trip includes inspection and reports from iron and steel plants, fabrication plants, and heat treating plants in the Middle West. The expense amounts to approximately $100.

An inspection trip, carrying two credits, and under faculty supervision, is a required part of the senior curriculum for electrical engineers. Industrial plants in Minnesota and neighboring states are visited. The trip is taken during the spring vacation. Costs are borne individually by the student. Expense is estimated at about $40.

Seniors in Mechanical Engineering are required to take an inspection trip during the spring vacation to various industrial plants to study mechanical equipment, manufacturing methods and processes. The expense to each student is estimated at about $40.

The inspection trips for aeronautical, electrical, and mechanical engineers are subject to cancellation during the war.

REQUIREMENTS FOR GRADUATION

To be recommended for the degree of bachelor of aeronautical, agricultural, civil, electrical, or mechanical engineering, chemistry or physics, the student must satisfactorily complete all of the courses prescribed in the corresponding curriculum together with sufficient electives to make a total of at least 207 credits. In the five-year course in Architecture, 225 credits are required for graduation. For the degree of bachelor of chemical engineering, 218 credits are required. For the degree of bachelor of business administration in combination with engineering or chemistry, a student must complete the requirements for the Bachelor's degree in one of the engineering or chemistry curricula and include the 74 prescribed credits in business subjects. In Mining and Petroleum Engineering a total of 233 credits must be completed. Metallurgical Engineering requires 224 credits and Geological Engineering, 231 credits.

Students entering with advanced standing from other colleges or universities must spend at least one year in residence here before they will be recommended for graduation. If the term of residence is only one year it must be the senior year; and in any case such a student must spend two "quarters" of his senior year in residence.

College of Engineering and Architecture
School of Mines and Metallurgy

Every student entering the College of Engineering and Architecture or School of Mines and Metallurgy on or after the fall of 1940 will be required to have a *cumulative honor point average* of at least 1.00 in order to be eligible for a degree.

School of Chemistry

1. Students registered in the School of Chemistry shall be assigned honor points on the completion of any course.

2. As a requirement for graduation, a student must obtain at least one honor point per credit in each quarter of the prescribed courses of the freshman and sophomore years in inorganic chemistry and qualitative analysis, and an *average* of one honor point per credit in Analytical Chemistry 1-2. The satisfying of this requirement in any quarter of the courses in inorganic chemistry and qualitative analysis is a prerequisite to registration for work of any succeeding quarter. A student who fails to satisfy this requirement in any course must repeat the course in class the next time the course is offered.

3. As a requirement for graduation a student must obtain an average of at least one honor point per credit for his total work in courses which do not belong to his freshman or sophomore years.

Excess Honor Points and Quality Credits

4. The term "excess honor points," for any course is defined as the total number of honor points received by a student for that course minus the number of honor points associated with a grade of C.

5. For every course in which a student obtains a grade above C he shall receive not only the stated credits for the course but, in addition, quality credits equal to the excess honor points divided by the factor ten. These quality credits are to be accepted on the same basis as the nominal or stated credits in satisfying the credit requirement for graduation.

Special Regulations for Students Proceeding to the Degree of Bachelor of Chemistry

6. Students who at the end of the junior year have an honor point average of less than 1.9 in all courses taken while registered in the school will pursue in their senior year the prescribed curriculum and will be eligible for graduation when their total credits (stated plus quality) amount to the required number, namely 207. Students with an honor point average *close to 1.9* should be able, in the spring quarter of their senior year, to register in the Graduate School and obtain *some* residence and graduate credit.

7. A student who at the end of the junior year has an honor point average of more than 1.9 in all courses taken while registered in the school will pursue in his senior year *a course of study prescribed for him* by an adviser after thoro study by the adviser of the needs, qualifications, and desires of the student. Toward the end of his junior year or at the beginning of his senior year, the student shall select an adviser from among the chiefs of the divisions of the school. An adviser so selected may delegate his duties in this connection to a member of his staff.

8. As soon as the senior student, following the course of study prescribed by his adviser, has accumulated a total of 207 quarter credits (stated plus quality) he shall be eligible to be recommended for the Bachelor's degree.

Special Regulations for Students Proceeding to the Degree of Bachelor of Chemical Engineering

9. Students in the Chemical Engineering Curriculum will be recommended for graduation when they have *completed the prescribed courses,* have satisfied the requirements of paragraphs (2) and (3), and have accumulated at least 218 quarter credits (stated plus quality). Students whose honor point average at the end of the junior year *does not greatly exceed unity* will register in the senior year for the prescribed courses and usual electives. Students with an honor point average *considerably greater than unity* will consult with the chief of the Department of Chemical Engineering or with an adviser assigned by him, who will *prescribe the work* to be undertaken in the senior year. In exceptional cases, the adviser is authorized to *waive the requirement* that *any* given courses are prerequisite to graduation. In any case, gifted students will be able in the spring quarter of their senior year to obtain credit in the Graduate School for an appreciable fraction of the work of that quarter.

Special Regulations for Students Proceeding to the Degree of Bachelor of Physics

10. As soon as the senior student, following the course of study prescribed by his adviser, has accumulated a total of 207 quarter credits (stated plus quality) he shall be eligible to be recommended for the Bachelor's degree.

Students Entering with Advanced Standing

11. The above regulations shall apply to students entering with advanced standing as far as the work taken by them after entering the University of Minnesota is concerned. Honor point averages and quality credits will be computed from grades received in courses taken at the University of Minnesota.

SCHOLARSHIPS AND PRIZES

Research fellowships—In the Engineering Experiment Station research fellowships are available from time to time which are open to engineering graduates, including chemical engineers. The holder is required to give twenty hours per week, that is, about half of his time, to such research service as may be assigned him. In addition he is expected to carry half-time work in the Graduate School toward an advanced degree.

Teaching fellowships in civil and electrical engineering are open to graduates in these fields. Each fellow renders part-time service in instruction while pursuing graduate study.

The Shevlin Fellowship in Chemistry—The Shevlin Fellowship in Chemistry, established by the late Thomas H. Shevlin, of Minneapolis, is awarded annually and yields $500. Candidates for this fellowship should file their application before March 1 with the dean of the Graduate School. The Shevlin fellow devotes his entire time to graduate work and is not required to render any service to the University.

The du Pont Fellowship in Chemistry—This fellowship was founded by E. I. du Pont de Nemours and Company, Wilmington, Delaware, and yields $750 annually. The holder devotes his entire time to graduate work and is not required to render any service to the University. Applications for this fellowship should be submitted to the dean of the Institute of Technology before March 15.

The Hormel Fellowships in Chemical Engineering and Organic Chemistry—In the establishment of the Hormel Foundation at the University of Minnesota by the Hormel Company of Austin, Minnesota, provision was made for two fellowships of $750 each in the School of Chemistry. The holder devotes his entire time to graduate work and is not required to render any service to the University. Applications for this fellowship should be submitted to the dean of the Institute of Technology before March 15.

The Superior Metal Products Research Fellowship in Metallurgy—This fellowship is awarded to a qualified graduate student devoting half time to research on tin plate and the remainder to graduate work. It yields $600 annually. Candidates should file application before March 15 with the dean of the Institute of Technology.

Fellowships in public administration—The University of Minnesota awards annually a limited number of *pre-service fellowships in public administration* to college and university graduates without previous experience in government service. These fellowships carry stipends of $650 plus an additional amount sufficient to pay tuition and fees in the Graduate School. Holders of these fellowships devote their entire time to graduate study. They are open to graduates of professional and technical schools, preference being given to applicants who have had preparation in political science and related social sciences. Upon the satisfactory completion of a year of resident study, the fellowship will be renewed for a second year to provide internship training with some governmental agency in the particular field of government service in which the student is especially interested.

The University also offers several *in-service fellowships in public administration* to college and university graduates who are employed in government service and who have been in such service for at least three years. The stipends for these fellowships vary from $1,000 to $1,500. The period of training includes the three quarters of the regular academic year and the first term of the Summer Session. Persons holding professional and technical positions in national, state, and local governments are eligible to apply. Preference is given to those who have had at least some preparation in political science and related social sciences.

The Structural Clay Products Institute Scholarship in Agricultural Engineering—Four $200 scholarships are available to junior and senior students in agricultural engineering who specialize in drainage engineering. Candidates should file application before March 1 of their junior year, with the dean of the Institute of Technology.

Assistants—The School of Chemistry employs 42 graduate assistants at from $500 to $600 per year, on part time. They devote from eight to twelve hours per week to instruction and other assigned work, thereby obtaining valuable experience in laboratory teaching under competent direction. In addition to these duties, each assistant is expected to pursue graduate work toward a higher degree. Application should be made to the dean of the Institute of Technology.

Prizes—Various prizes in the University are open to students in these colleges. Certain prizes are awarded to students in Engineering only, such as the prizes of the Northwestern section of the American Society of Civil Engineers and the Twin Cities section of the American Society of Mechanical Engineers. The Tau Beta Pi, Chi Epsilon, Eta Kappa Nu, and Pi Tau Sigma, honorary engineering fraternities, also offer prizes.

Two prizes are open to sophomores in Chemistry and Chemical Engineering. These have been established by Phi Lambda Upsilon, honorary chemical fraternity, and the Twin City Alumni Association of Alpha Chi Sigma, chemical fraternity. The chemistry faculty offers a prize to seniors.

Prizes and medals are open to students registered in the School of Architecture. Medals are offered by the American Institute of Architects, Alpha Rho Chi, and the Scarab Fraternity. Prizes have been established, respectively, by the Alpha Alpha Gamma Sorority, the Gargoyle Club, and the Northern States Power Company.

Loan funds—Various loan funds are available from which worthy students may obtain financial assistance after they have been in attendance a sufficient length of time to establish satisfactory records of accomplishment. Application should be made to the dean of students and to the head of the student's department.

RESERVE OFFICERS TRAINING CORPS

Army

The War Department has established at this University units of medical, coast artillery (anti-aircraft), and signal corps, in which both basic and advanced courses are given. The coast artillery and signal corps units are made up almost entirely of students in the Institute of Technology for whom this technical and military training is particularly valuable. The Basic Course is open to all physically fit male students and carries one credit per quarter for six quarters; the Advanced Course is open to selected students who have completed the Basic Course. (Advanced Course closed for the duration of the war.)

Students in the institute who are admitted to the Advanced Course of the signal or coast artillery corps under the prescribed regulations receive for this work fifteen and eighteen elective credits toward graduation, respectively. They receive an allowance of cash and clothing from the government during the two years of the course, pay and transportation to attend one summer training camp and, if successful, a commission as a second lieutenant in the Officers Reserve Corps of the United States Army after graduation.

Besides receiving technical instruction, the student in the Advanced Course has the opportunity to develop and exercise leadership and discipline which will be of value to him in his professional career. Special arrangements may be made in the student's program to enable him to take this course, the advantages of which are recognized.

Navy

The Naval Reserve Officers Training Corps of the University of Minnesota provides a four-year course for selected, physically qualified male students. A student who completes this course is eligible for a commission as ensign, United States Naval Reserve, or, as second lieutenant, United States Marine Corps Reserve, provided he applies for the commission, obtains a degree from the University, is recommended by the professor of naval science and tactics, and passes the prescribed physical examination. If the graduate is commissioned as ensign, U.S.N.R., he may, upon graduation, apply for one year of active duty at sea, upon completion of which he may be permitted to take an examination for a commission as an ensign in the regular line of the Navy, provided he is recommended by his commanding officer and is less than twenty-six years of age on June 30 of that year.

Cruises on board battleships, cruisers, and destroyers are held in the Atlantic and Pacific during the summer months of each year. As a prerequisite to a commission, a cruise is required of all students upon the completion of the third year of the course, but all N.R.O.T.C. students are eligible for a cruise each summer.

For the duration of the war, only students in the V-12 Program are accepted.

CHANGES IN BULLETIN

The faculties of the Institute of Technology reserve the right to change their curricula and to cancel or change without notice any course printed in this bulletin. The bulletin is a statement of present conditions, and is subject to modification in any particular by faculty action.

SOCIETIES

Branches of the following national professional societies are maintained at the University of Minnesota by students and faculty members: American Chemical Society, American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, American Society of Agricultural Engineers, and the Institute of Aeronautical Sciences. In addition there are the Architectural Society, the School of Mines and Metallurgy Society, and the University of Minnesota Flying Club.

CURRICULA

COLLEGE OF ENGINEERING AND ARCHITECTURE

Aeronautical Engineering
Agricultural Engineering
Architecture
Civil Engineering
Electrical Engineering
Engineering and Business Administration
Engineering Prebusiness
Mechanical Engineering

SCHOOL OF CHEMISTRY

Chemistry
Chemical Engineering
Physics

SCHOOL OF MINES AND METALLURGY

Mining Engineering
Metallurgical Engineering
Geological Engineering
Petroleum Engineering

STUDENTS ENTERING WITHOUT CHEMISTRY, HIGHER ALGEBRA, OR SOLID GEOMETRY AND THOSE REQUIRED TO TAKE THE COURSE IN PREPARATORY ENGLISH

Applicants deficient in either or both higher algebra and solid geometry will be admitted provisionally. Students entering without high school chemistry will be required to carry a special course in college chemistry during their freshman year. Students entering with deficiencies in higher algebra or solid geometry or both and all students required to take the course in Preparatory English must register for such deficiencies in the first quarter in residence. In order to continue in the Institute of Technology these deficiencies must be removed during this quarter. Applicants deficient in either higher algebra or solid geometry will not be admitted at the beginning of the spring quarter.

Chemistry—Students entering the engineering divisions of the College of Engineering and Architecture and the School of Mines and Metallurgy who have not had high school chemistry will take Inorganic Chemistry 14-15, four credits per quarter, instead of Inorganic Chemistry 4-5. Those entering the School of Chemistry who have not had high school chemistry will take Inorganic Chemistry 6-7-12, five credits per quarter, instead of Inorganic Chemistry 9-10-12.

Higher algebra—Freshmen entering without higher algebra will take Course 9 (Higher Algebra) without credit, and all students who have had higher algebra will register for Course 11 (College Algebra). Course 9 will be followed by Courses 11, 12, and 13.

During the first week all entering freshmen will be given a placement examination in algebra. Students who do not show satisfactory results in this examination will be advised to register in Higher Algebra, M.&M. 9.

Solid geometry—Students who do not offer solid geometry for entrance will take Drawing 10 (Solid Geometry) during their first quarter and without university credit. Students in the engineering courses in the College of Engineering and Architecture and the School of Mines and Metallurgy should follow this by Drawing 1, 2, and 3; in the School of Chemistry, by Drawing 7 and 8. Students in architecture will add solid geometry to their fall quarter program.

English—Students who are required to take the course in Preparatory English will take this course during their first quarter without university credit. The required courses in Composition, English 4-5-6, should follow. Students register in Preparatory English in the Extension Division. Fee $7.50.

AERONAUTICAL, AGRICULTURAL, CIVIL, ELECTRICAL, GEOLOGICAL, MECHANICAL, METALLURGICAL, MINING, AND PETROLEUM ENGINEERING, AND PREBUSINESS

FRESHMAN YEAR§

(For students entering with chemistry, higher algebra, and solid geometry and who pass their English tests.)

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 11	College Algebra	5	5	.....	.....
Inorg.Chem. 4	General Inorganic Chemistry	4	1	3	3
Engl. 4	Composition	3	3	.....	.....
Draw. 1	Engineering Drawing	3	.....	.....	8
M.E. 11*	Metal Working (for Prebusiness)	2	.....	2	3
G.E. 11	Orientation	0	.....	1	.....

Second Quarter

M.&M. 12	Trigonometry	5	5	.....	.....
Inorg.Chem. 5	General Inorganic Chemistry	4	1	3	3
Engl. 5	Composition	3	3	.....	.....
Draw. 2	Engineering Drawing	3	.....	.....	8
M.E. 9	Foundry Practice (for Prebusiness)	2	.....	2	3
G.E. 12	Orientation	0	.....	1	.....

Third Quarter

M.&M. 13	Analytic Geometry	5	5	.....	.....
Inorg.Chem. 16	Semimicro Qualitative Analysis	5	.....	3	6
Engl. 6	Composition	3	3	.....	.....
Draw. 3	Descriptive Geometry	3	.....	.....	8
M.E. 4*	General Woodwork (for Prebusiness)	2	.....	2	3
G.E. 13	Orientation	0	.....	1	.....

AERONAUTICAL ENGINEERING

Four-year course leading to the degree of bachelor of aeronautical engineering, B.Aero.E.

In addition to the prescribed courses, sufficient electives must be taken to complete a total of at least 207 credits for graduation.

The course in Aeronautical Engineering is intended to provide instruction and training for students who wish to enter this field of engineering as a profession. With the rapid development of aviation in recent years, aeronautical engineering has assumed a prominent and important position among the engineering professions. The production of airplanes in the United States is increasing at a rapid rate. Attention is given to lighter-than-air craft. Extensive optional courses are available for those who wish to specialize in meteorology. Aeronautical engineers are required in all stages of the process, from the research work preliminary to improvements in design to the actual construction, testing, operation, and maintenance. Students trained in aerodynamics and the designing of light structures have been in demand in recent years in many industries.

The aeronautical engineering course is similar to other professional engineering courses. The first three quarters of the course are the same as those of agricultural, civil,

* Freshmen in Engineering Prebusiness are required to take Shop Practice, M.E. 4, 9, and 11, 2 credits per quarter; not required of the others.

§ See statement on page 15.

electrical, geological, mechanical, metallurgical, mining, and petroleum engineering. The fundamental studies are the same. As a result, the graduates in aeronautical engineering should be prepared to enter various branches of the engineering field if, for any reason, they should prefer to do so.

As in other technical courses, so in aeronautical engineering, mathematics plays an important part. No student should enter this course who feels poorly prepared in mathematics.

It should be understood that this is a professional engineering course and not a training course for airplane pilots. It deals with the preparation of students for research, design, construction, operation, management, and maintenance of aircraft from the standpoint of the engineer or manager. However, practical flight training is important for aeronautical engineers, and students are urged to take advantage of their opportunities to obtain it through the University of Minnesota Flying Club, Army Air Corps, National Guard, Naval Reserve, Civil Aeronautics Authority's Flight Training Program, or private organizations.

Students taking the five-year combined course in Aeronautical Engineering and Business Administration may substitute business courses for Aero.E. 160, C.E. 17, Met. 152, and M.E. 151 or M.E. 154.

For freshman year, see page 16.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics	5	1	4	2
Draw. 28†	Drafting	2	.....	.....	6
Aero.E. 3	Aeronautics	3	3	.....	.....
M.E. 5*	Pattern Practice	2	.....	2	3
or					
M.E. 13*	Forging, Welding, and Heat Treating	2	.....	2	3
or					
C.E. 17*	Surveying	3	.....	1	7
M.E. 70	Mechanical Technology	1	.....	2	.....

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics	5	1	4	2
Aero.E. 2	Aircraft and Auto Engines	3	1	2	2
M.E. 5*	Pattern Practice	2	.....	2	3
or					
M.E. 13*	Forging, Welding, and Heat Treating	2	.....	2	3

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics	5	1	4	2
Aero.E. 1	Aeronautics	3	3	.....	.....
C.E. 17*	Surveying	3	.....	1	7
or					
M.E. 5*	Pattern Practice	2	.....	2	3
Draw. 29	Drafting	2	.....	.....	6

* M.E. 5, 13 and C.E. 17 must be taken during sophomore year.

† For permissible substitute, see page 54.

JUNIOR YEAR§

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 129	Hydraulics	4	3	1	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
Aero.E. 100	Aerodynamics	3	3	.....	.....
Aero.E. 158	Physics of the Atmosphere	2	1	2	.....
M.E. 18**	Machine Shop Practice	2	.....	2	3
M.E. 32	Elementary Mechanical Laboratory	2	.....	.....	4
M.E. 131	Thermodynamics	3	3	.....	2
	Electives*				

Second Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Testing Laboratory	2		1	2
Aero.E. 101	Aerodynamics	3	3	.....	.....
M.E. 26	Mechanism and Kinematics	3	3	.....	.....
M.E. 132	Thermodynamics	3	3	.....	.....
	Electives*				

Third Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Aero.E. 83	Stresses in Simple Structures	3	3	.....	.....
Aero.E. 102	Aerodynamics	3	3	.....	.....
Aero.E. 140	Aeronautical Laboratory	2	.....	.....	6
Aero.E. 170	Air Transport	2	2	.....	.....
M.E. 27	Machine Design	3	.....	2	3

SENIOR YEAR§

First Quarter

E.E. 46	Electric Power	3	3	.....	.....
M.E. 150	Internal Combustion Engines	3	3	.....	.....
Met. 152	Metallography	3	.....	2	2
Aero.E. 115¶	Airplane Stresses	3	2	.....	2
or					
M.&M. 180	Advanced Strength of Materials	3	3	.....	.....
Aero.E. 120	Airplane Design	3	2	.....	3

Second Quarter

E.E. 47	Electric Power	3	2	..	2
M.E. 151†	Advanced Internal Combustion Engines	3	3	..	.....
M.E. 154†	Design of Airplane Engines	2	..	..	6
Aero.E. 121	Airplane Design	4	2	....	6
Aero.E. 141	Aerodynamics Laboratory	3		1	6
Aero.E. 190	Seminar	1	1	...	.....
	Electives*				

Third Quarter

M.E. 158	Aero Engine Testing	2	.....	.....	6
Aero.E. 122	Airplane Design	3	1	....	6
Aero.E. 155	Aeronautical Calculation	2	2	.....	.....
Aero.E. 159	Inspection Trip (spring vacation)	1		.....	.....
Aero.E. 160†	Airships	3	2	.....	3
Aero.E. 191	Seminar	1	1	.....	.....
	Electives*				

* For list of elective courses in other colleges, see page 53.

† Any one or two of the following courses: Aero.E. 160, Airships, and M.E. 151, Advanced Internal Combustion Engines, or M.E. 154, Design of Airplane Engines, but not *both* of these M.E. courses, may be replaced by an equal number of approved elective credits in any of the following fields: aerodynamics, airplane design and stresses, internal combustion engines, and air transport and meteorology; also in business for students taking the five-year combined course with business administration.

§ Students who contemplate an extra quarter in residence should arrange their programs for this time from such courses as Aero.E. 159, 160, 164, 165, 170, 173, 174, 175, 190, 191, 193, 194, 195, in order to have the proper sequence of courses.

¶ Students may substitute M.&M. 180w, Advanced Strength of Materials, 3 cred., for Aero.E. 115f.

** M.E. 18 may be taken in either the first or second quarter.

AGRICULTURAL ENGINEERING

Four-year course leading to the degree of bachelor of agricultural engineering, B.Ag.E., in co-operation with the College of Agriculture, Forestry, and Home Economics.

Requirements for graduation include all prescribed courses with sufficient approved electives to make a total of at least 207 credits. This is an average of 17¼ credits per quarter for 12 quarters.

Agricultural engineering activities are usually grouped under the heads of *farm power and machinery, rural electrification, farm structures,* and *soil moisture relations.* There is also need for service in the entire field necessitating general preparation in all four lines.

The farm machinery field covers the selection and management of machinery and equipment best suited to produce good results locally on any given type of farm, the design and construction of such machinery or equipment where it does not yet exist, the improvement of such design to meet special needs, and the adaptation of available types of power to local farm conditions. The farm structures field covers arrangement of the structures on the farmstead for economy, convenience, and comfort; the design and construction of farm buildings and related structures; and the adaptation of available types of structural materials to local farm conditions. The soil moisture relations field covers development of virgin lands suited to agriculture and the improvement of lands already under cultivation through soil conditioning by means of effective design and proper installation of drainage, and irrigation works and control of soil erosion.

The field, as yet comparatively new and uncrowded, offers many opportunities among which the following are prominent: with manufacturers of farm machinery, equipment, and building materials; as executives, research engineers, publicity and sales managers, and technical field experts; as managers of large farms requiring extensive machinery or equipment; as engineers with the local, state, and federal government, and with development companies; as agricultural advisers with power companies in development of rural service; as engineering specialists in soil erosion control, farm drainage, and irrigation; as agricultural engineering editors for farm papers and trade journals; as rural architects and builders; as teachers, investigators, and extension specialists in state agricultural colleges, experiment stations, and in the United States Department of Agriculture; as consulting agricultural engineers in general practice.

Students taking the combined five-year course in agricultural engineering and business administration may fill all junior and senior elective opportunities in the junior and senior years with required business courses under the direction of the agricultural engineering adviser and with the approval of the School of Business Administration.

For freshman year, see page 16.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics	5	1	4	2
Ag.E. 5	Farm Structures Laboratory	3	.....	2	4
Ag.E. 43	Mechanical Laboratory	3	.....	1	5
Econ. 8	General Economics	3	3	.....	.....

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics	5	1	4	2
Soils 4	Soils	3	3	.....	.....
Econ. 9	General Economics	3	3	.....	.....

Third Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics	5	1	4	2
Ag.E. 18	Agricultural Automotives	4	.....	2	6
Ag.E. 21	Elements of Surveying	5	.....	1	12

JUNIOR YEAR

First Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.&M. 129	Hydraulics	4	3	1	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
Ag.E. 52	Elements of Farm Machinery	3	1	1	3
Geol. 5	Engineering Geology	3	.....	3	.....
M.E. 131	Thermodynamics	3	3	.....	2

Second Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
Ag.Econ. 102	Farm Management: Organization	3	3	.....	.....
Ag.E. 51†	Soil Moisture Relations	5	1	4	.....
or					
Soils 108	Physical Properties of Soils	3	.....	1	6
M.E. 26	Mechanism and Kinematics	3	3	.....	.....
Rhet. 22	Public Speaking	3	3	.....	.....

Third Quarter

Agron. 1	General Farm Crops	3	3	.....	.....
Ag.E. 37	Rural Sanitation	3	.....	3	.....
Ag.E. 53	Farm Structures	3	.....	2	4
Ag.E. 72†	Applied Electrictiy	3	.....	2	4
or					
Ag.E. 73*	Steam Boilers and Heat Engines	3	1	1	4
M.E. 27	Machine Design	3	.....	2	3

SENIOR YEAR

First Quarter

Ag.E. 67	Advanced Farm Structures Design	3	1	1	4
Ag.E. 71	Design and Economics of Agricultural Machinery	3	.....	1	4
C.E. 37	Structural Engineering	3	.....	1	3
Dy.Husb. 1	Elements of Dairying	3	.....	3	.....
	Electives to complete program.				

Second Quarter

Ag.E. 51†	Soil Moisture Relations	5	1	4	.....
or					
Soils 108	Physical Properties of Soils	3	.....	1	6
G.E. 101	Contracts and Specifications	3	.....	3	.....
An.Husb. 1	Livestock Production	3	.....	3	3
	Electives to complete program.				

Third Quarter

Ag.E. 72†	Applied Electricity	3	.....	2	4
or					
Ag.E. 73*	Steam Boilers and Heat Engines	3	1	1	4
C.E. 146	Plain Concrete	3	.....	2	4
	Electives to complete program.				

* Given only in alternate years, 1944-45, 1946-47, etc.
† Given only in alternate years, 1945-46, 1947-48, etc.

RECOMMENDED ELECTIVES§

The following courses are suggested for the guidance of students who wish to elect work along the general lines indicated.

Farm Structures

Course No.	Title	Credits
Ag.E. 44	Advanced Drawing	2
Ag.E. 111,112,113	Farm Building Problems, per quarter	2-6
Arch. 57,58,59	Building Materials and Methods, per quarter	2
For. 10	Farm Forestry	3
Hort. 24	Principles of Landscape Design	3

Farm Power and Machinery

Ag.Econ. 191	Advanced Agricultural Statistics	3
M.E. 18	Machine Shop Practice	2
M.E. 121	Machine Design	2
M.E. 150	Internal Combustion Engines	3
Met. 156	Metallography	3
Ag.E. 121,122,123	Farm Power and Machinery Problems, per quarter	2-6
Ag.E. 126	Selection of Farm Equipment	3
E.E. 43,44,45	Electric Power, per quarter	3
Soils 5	Soils Management	3

Land Reclamation and Development

Ag.Econ. 191	Advanced Agricultural Statistics	3
Ag.E. 101,102,103	Advanced Drainage Problems, per quarter	2-6
C.E. 161	Power	4
M.&M. 130	Open Channel Flow	3
M.&M. 190	Mechanics of Similitude and Dimensional Analysis	3
Soils 103	Soils Erosion	3
Soils 104	Soil Mapping	3

General

Ag.Econ. 9	Agricultural Statistics	5
Ag.Econ. 103	Farm Operation	3
Bot. 1	General Botany	3
Hort. 6	Fruit Growing	3

ARCHITECTURE

The work in architecture offered by the Institute of Technology includes courses dealing with the history, theory, and practice of architecture and the allied arts of design. It is organized into general and professional courses as follows:

GENERAL COURSE

Four-year course leading to the degree of bachelor of arts (B.A.) with a major in architecture, in the College of Science, Literature, and the Arts. Major Adviser, Professor Roy Jones.

The general course is intended for students who want to combine with their academic training, whether for cultural or vocational reasons, some study of architecture. It offers an advantageous approach to the professional courses in architecture described

§ Students taking the combined five-year course in agricultural engineering and business administration see statement on page 19.

below, or to further training in the special fields of city and regional planning, landscape architecture, or decorative, industrial, and interior design. For further information see the Bulletin of the College of Science, Literature, and the Arts and the Combined Class Schedule.

PROFESSIONAL COURSES

Special wartime four-year (or accelerated three-year) course leading to the degree of bachelor of architecture (B.Arch.) in the Institute of Technology.

Five-year course leading to the degree of bachelor of architecture (B.Arch) in the Institute of Technology. (Discontinued for duration of the war.)

Six-year course leading to the degree of bachelor of arts (B.A.) with a major in architecture, in the College of Science, Literature, and the Arts and the degree of bachelor of architecture (B.Arch.) in the Institute of Technology.

The professional courses are intended primarily for students who expect to enter the professional practice of architecture in any of its many recognized phases. It is assumed that the students taking them have a definite interest in architecture and a natural aptitude for the actual processes of designing buildings. They provide training which, when supplemented by practical experience in architects' offices, places the student in line for recognition as a practicing architect according to the registration laws of the various states. They also serve as advantageous approaches to various fields in government and industry where architectural skill and knowledge are valuable. For further information see page 24 for the six-year course.

The work in architecture included in these courses falls into three general divisions. One is theory, presenting the technical, analytical, and historical knowledge on which architecture is based. The second is practice in drawing and modeling as a means of expression. The third and principal division is continued practice in all phases of architectural design, including both composition and construction.

As high school preparation for the professional courses higher algebra and solid geometry are essential; physics, chemistry, history, and foreign language are strongly recommended; instrumental and freehand drawing are advantageous.

Whether the student elects the longer or the shorter course will depend on the time and means at his disposal. He will find it highly desirable to supplement and broaden his technical training by as much general academic work of the college grade as he finds possible. College work taken at institutions other than Minnesota can be readily adjusted to each professional course. In any such work college algebra, trigonometry, and analytic geometry must be included as essential prerequisites to certain courses in structural design. Selections from language, history, economics, political science, sociology, physics, and chemistry are recommended. Prospective students should note that it takes normally four years to complete the required technical work, regardless of how much other work they may have to their credit, and should calculate their time accordingly.

Special Wartime Course

In addition to the prescribed courses, sufficient approved electives must be taken to make a total of 200 credits, which can be completed, at the option of the student, in three accelerated years of four quarters each, or in four regular academic years of three quarters each.

This course is intended to provide a balanced basic training in all phases of architectural theory and practice. In addition, a certain amount of specialization is possible in such phases as community planning, interior design, or construction and building equipment (sometimes called "architectural engineering"). This specialization is accomplished by (1) a choice of electives and (2) a choice of problems in architectural design.

New students should consult the Bulletin of General Information for entering dates to the Institute of Technology. The following program is typical for students who present credits in higher algebra, solid geometry, and preparatory English, and who enter in the fall quarter. For those entering at other quarters, certain adjustments in sequence of courses will be made. Consult Professor Roy Jones of the School of Architecture.

FRESHMAN YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Engl. 4	Composition	3	3	.....	.....
M.&M. 11	College Algebra	5	5	.....	.....
Phys. 1	Introduction to Physical Sciences	3	3	.....	.....
Arch. 4-5-6	Graphic Representation	5	.....	.....	15
Arch. DP-I	Drawing and Painting, Grade I	2	.....	.....	4

Second Quarter

Engl. 5	Composition	3	3	.....	.....
M.&M. 12	Trigonometry	5	5	.....	.....
Phys. 2	Introduction to Physical Sciences	3	3	.....	.....
Arch. AD*	Architectural Design	5	.....	.....	15
Arch. DP-I	Drawing and Painting, Grade I	2	.....	.....	4

Third Quarter

Engl. 6	Composition	3	3	.....	.....
M.&M. 13	Analytic Geometry	5	5	.....	.....
Phys. 3	Introduction to Physical Sciences	3	3	.....	.....
Arch. AD*	Architectural Design	5	.....	.....	15
Arch. DP-I	Drawing and Painting, Grade I	2	.....	.....	4

SOPHOMORE YEAR

First Quarter

M.&M. 91	Calculus for Architects	4	4	.....	.....
Arch. 51	History of Architecture	3	.....	4	.....
Arch. 57-58	Building Materials and Methods	4	.....	4	.....
Arch. AD*	Architectural Design	5	.....	.....	15
Arch. DP-II	Drawing and Painting, Grade II	2	.....	.....	4

Second Quarter

M.&M. 92	Mechanics for Architects	4	4	.....	.....
Arch. 52	History of Architecture	3	.....	4	.....
Arch. 59-101	Building Materials and Methods	4	.....	4	.....
Arch. AD*	Architectural Design	5	.....	.....	15
Arch. DP-II	Drawing and Painting, Grade II	2	.....	.....	4

Third Quarter

M.&M. 93	Strength of Materials for Architects	4	4	.....	.....
Arch. 53	History of Architecture	3	.....	4	.....
Arch. 102-103	Building Materials and Methods	4	.....	4	.....
Arch. AD*	Architectural Design	5	.....	.....	15
Arch. DP-II	Drawing and Painting, Grade II	2	.....	.....	4

* Assignment to Grades I, II, III, or IV for each quarter of Architectural Design (AD) will be made for each student when he registers.

JUNIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
C.E. 38	Structural Design	3	.....	3	.....
Arch. 104§	City Planning	3	.....	3	.....
Arch. AD†	Architectural Design	5	.....	.....	15
Arch. DP-III	Drawing and Painting, Grade III	2	.....	.....	4
	Elective	3	.....	.....	.....

Second Quarter

C.E. 39	Structural Design	3	.....	3	.....
Arch. 71	Building Equipment	2	.....	2	.....
Arch. 105	Professional Practice	2	.....	2	.....
Arch. AD†	Architectural Design	5	.....	.....	15
Arch. DP-III	Drawing and Painting, Grade III	2	.....	.....	4
	Elective	3	.....	.....	.....

Third Quarter

C.E. 41	Structural Design	3	.....	3	.....
Arch. 72-73	Building Equipment	4	.....	4	.....
Arch. AD†	Architectural Design	5	.....	.....	15
Arch. DP-III	Drawing and Painting, Grade III	2	.....	4	.....

SENIOR YEAR

(For students not taking the accelerated program)

First Quarter

Arch. AD†	Architectural Design	15	.....	.....	45

Second Quarter

Arch. AD†	Architectural Design	15	.....	.....	45

Third Quarter

Arch. AD†	Architectural Design	15	.....	.....	45

ACCELERATED PROGRAM

For students electing the accelerated program.

Course No.	Title	Credits	Rec.	Lect.	Lab.
Arch. AD†	Architectural Design	15	.....	.....	45

Taken in each of three summer quarters.

Six-Year Course in Arts and Architecture

During the first four years of this course the student is registered in the College of Science, Literature, and the Arts and follows the plan of study prescribed for a bachelor of arts degree with a major in architecture.

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† Assignment to Grade I, II, III, or IV for each quarter of Architectural Design (AD) will be made for each student when he registers.

§ Arch. 106 may be substituted for Arch. 104. Students are recommended to take both courses.

The following courses should be completed during this period:

Required for the major sequence:

Course No.	Title	Credits
Arch. 4-5-6	Graphic Representation	6
Arch. 51-52-53	History of Architecture	9
Arch. 57-58-59	Building Materials and Methods	6
Arch. DP-I	Drawing and Painting, Grade I	6
Arch. DP-II	Drawing and Painting, Grade II	6
Arch. AD-I	Architectural Design, Grade I	15
Arch. AD-II	Architectural Design, Grade II	18

Additional requirements:

Math. 7-6-30	College Algebra, Trigonometry, Analytic Geometry	15
M.&M. 91-92-93	Calculus, Mechanics, Strength of Materials	12
C.E. 38-39-41	Structural Design	9
	Total	102

During the last two years of the course, or upon completion of the requirements for the bachelor of arts degree, the student is registered in the School of Architecture of the Institute of Technology to complete the requirements for a bachelor of architecture degree as prescribed for the five-year course.

See also the Junior and Senior College requirements as given in the Bulletin of the College of Science, Literature, and the Arts; and Architecture, in the Combined Class Schedule.

CHEMISTRY AND CHEMICAL ENGINEERING

FRESHMAN AND SOPHOMORE YEARS*

FRESHMAN YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 11	College Algebra	5	5	.....	.....
Inorg.Chem. 9	General Inorganic Chemistry	5	1	3	5
Engl. 4	Composition	3	3	.....	.....
Draw. 7	Drawing and Descriptive Geometry	3	.....	.....	8
or					
M.E. 15§	Survey of Manufacturing Processes	3	1	2	.....

Second Quarter

M.&M. 12	Trigonometry	5	5	.....	.....
Inorg.Chem. 10	General Inorganic Chemistry	5	1	3	5
Engl. 5	Composition	3	3	.....	.....
Draw. 7	Drawing and Descriptive Geometry	3	.....	.....	8
or					
M.E. 15§	Survey of Manufacturing Processes	3	1	2	.....

Third Quarter

M.&M. 13	Analytic Geometry	5	5	.....	.....
Inorg.Chem. 12	Semimicro Qualitative Analysis	5	2	1	6
Engl. 6	Composition	3	3	.....	.....
Draw. 8	Drawing and Descriptive Geometry	3	.....	.....	8
or					
M.E. 15§	Survey of Manufacturing Processes	3	1	2	.....
G.E. 13	Orientation	0	.....	1	.....

* See statement on page 15 for students entering without chemistry, higher algebra, or solid geometry and those required to take the course in Preparatory English.

§ Advanced standing students are permitted to substitute for M.E. 15 any other shop course or laboratory arts given in the Physics Department.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Inorg.Chem. 13	Semimicro Qualitative Analysis	5	1	2	8
Phys. 7	General Physics	5	1	4	2
German 24§	Chemical German	3	3	.....	.....

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Anal.Chem. 1	Quantitative Analysis	5	1	1	10
Phys. 8	General Physics	5	1	4	2
German 25§	Chemical German	3	3	.....	.....

Third Quarter

M.&M. 84	Technical Mechanics	5	5	.....	.....
Anal.Chem. 2	Quantitative Analysis	5	1	1	10
Phys. 9	General Physics	5	1	4	2
German 26§	Chemical German	3	3	.....	.....
Chem.E. 80¶	Chemical Engineering Materials	1	.....	2	.....

CHEMISTRY

Four-year course leading to the degree of bachelor of chemistry, B.Chem.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of at least 207 credits.

This professional course in Chemistry is designed to provide thoro training in the fundamentals of chemistry and related subjects. It serves as a basis for further specialization and a foundation for graduate work. Its graduates secure positions in practical chemistry, research, and teaching, in chemical industries, and government service, in colleges and laboratories, etc.

For freshman and sophomore years, see pages 25 and 26.

JUNIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Org.Chem. 54	Elementary Organic Chemistry	3	1	3	.....
Org.Chem. 57	Elementary Organic Chemistry Laboratory	2	.....	1	6
Phys.Chem. 101	Physical Chemistry	3	1	3	.....
Phys.Chem. 104	Physical Chemistry Laboratory	2	1	.....	5
	Electives*				

Second Quarter

Org.Chem. 55	Elementary Organic Chemistry	3	1	3	.....
Org.Chem. 58	Elementary Organic Chemistry Laboratory	2	.....	1	6
Phys.Chem. 102	Physical Chemistry	3	1	3	.....
Phys.Chem. 105	Physical Chemistry Laboratory	2	1	.....	5
	Electives*				

Third Quarter

Org.Chem. 156	Elementary Organic Chemistry	3	1	3	.....
Org.Chem. 159	Elementary Organic Chemistry Laboratory	2	.....	1	6
Phys.Chem. 103	Physical Chemistry	3	1	3	.....
Phys.Chem. 106	Physical Chemistry Laboratory	2	1	.....	5
Chem.E. 131	Industrial Inorganic Chemistry	4	1	4	.....
	Electives*				

* For list of elective courses in other colleges, see page 53.

§ Students who have had two years of high school German or one year of college German take Course 27-28-29.

¶ Required of chemical engineers only.

SENIOR YEAR¶

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Inorg.Chem. 103	Advanced Inorganic Chemistry	3	.....	3	.....
Anal.Chem. 131	Applications of Indicators	3	.....	2	5
Phys.Chem.§	Advanced Physical Chemistry	3	.....	.....	.....
Chem.E. 132	Industrial Organic Chemistry	4	.....	5	.....
German 41	Chemical German	2	2	.....	.....
	Electives*				

Second Quarter

Inorg.Chem. 104	Advanced Inorganic Chemistry	3	.....	3	.....
Anal.Chem. 132†	Electrometric Measurements and Titrations	3	.....	2	5
Phys.Chem.§	Advanced Physical Chemistry	3	.....	.....	.....
German 42	Chemical German	2	2	.....	.....
	Electives*				

Third Quarter

Inorg.Chem. 105	Advanced Inorganic Chemistry	3	.....	3	.....
German 43	Chemical German	2	2	.....	.....
	Electives*				

NOTE—Near the close of the junior year, each student will choose a major adviser from the list below. In consultation with the adviser he will plan a program of work for the entire senior year, based normally upon concentration of electives around a chosen field of chemistry.

LIST OF ADVISERS FOR SENIORS

Inorganic Chemistry: Professors Sneed, Barber, Cohen, Heisig, Pervier, Klug, Maynard.
Analytical Chemistry: Professors Kolthoff, Geiger, Sandell.
Organic Chemistry: Professors Smith, Lauer, Koelsch.
Physical Chemistry: Professors Lind, MacDougall, Reyerson, Livingston.
Chemical Engineering: Professors Mann, Montillon, Montonna, Stoppel, Pike.

SPECIALIZATION IN BACTERIOLOGY, BIOCHEMISTRY, AND GEOLOGY

For the benefit of students in chemistry who may desire to specialize in related fields, minor groups of electives have been arranged in bacteriology, biochemistry, and geology which may be taken in the junior and senior years in addition to the required courses of the regular chemistry curriculum shown above. The completion of one of these groups will qualify the chemistry graduate to enter upon graduate work towards the Ph.D. degree in that department, thus providing an exceptionally strong foundation in chemistry for specialization in the chosen field.

MINOR IN BACTERIOLOGY

JUNIOR YEAR

Four credits of botany or zoology are prerequisite to Bacteriology 53. Botany 1, 4 credits, or Zoology 14-15, 6 credits, should be taken in the junior year to satisfy this requirement. By special arrangement it may be possible to take Bacteriology 53, 5 credits, in the winter or spring quarter of the junior year, if desired.

* For list of elective courses in other colleges, see page 53.

† For permissible substitute, see page 54.

§ Three credits per quarter in physical chemistry courses to which Phys.Chem. 103 is a prerequisite.

¶ Students who are planning on taking graduate work are urged to take French as one of the electives in the senior year.

SENIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Bact. 53	General Bacteriology	5	.....	3	6
Bact. 121	Physiology of Bacteria	3	.....	3	.....

Second Quarter

Bact. 122	Physiology of Bacteria	3	.....	3	.....

Third Quarter

Bact. 123	Applied Bacteriology	3	.....	3	.....

Minor in Biochemistry

JUNIOR YEAR

First Quarter

Zool. 14†	General Zoology	3	.....	2	4

Second Quarter

Zool. 15†	General Zoology	3	.....	2	4

SENIOR YEAR

First Quarter

Ag.Biochem. 113	Biochemical Laboratory Methods	2	.....	.....	6
Ag.Biochem. 119	Colloids	3	.....	3	.....
Bact. 53	General Bacteriology	5	.....	3	6

Second Quarter

Ag.Biochem. 114	Biochemical Laboratory Methods	2	.....	.....	6

Third Quarter

Ag.Biochem. 115	Biochemical Laboratory Methods	2	.....	.....	6
Ag.Biochem. 123	Enzymes	3	.....	3	.....

Minor in Geology

JUNIOR YEAR

First Quarter

Min. 23	Elements of Mineralogy	4	1	2	4

Third Quarter

Min. 24	Elements of Mineralogy	4	1	2	4

SENIOR YEAR

First Quarter

Geol. 1	General Geology	3	.....	3	.....
Geol. A	General Geology Laboratory	2	.....	.....	4
Geol. 121	Crystallography	3	.....	3	2

Third Quarter

Geol. 3	General Geology (Dynamic and Economic)	3	.....	3	.....
Geol. C	General Geology Laboratory	2	.....	.....	4

† Nine credits in Botany may be substituted for Zoology 14-15.

CHEMICAL ENGINEERING

Four-year course leading to the degree of bachelor of chemical engineering, B.Ch.E.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of 218 credits.§

Chemical engineering deals with the unit operations, such as crushing, grinding, sifting, mixing, fluid flow and heat flow, filtration, evaporation, drying, distillation, extraction, absorption, crystallization, and the organic processes that are so vital in making any industry based on a chemical transformation of matter a commercial success. The chemist uses these operations in the laboratory, but in order to apply them to large-scale industrial processes he must have a thoro understanding of the fundamental physiochemical, chemical, and engineering principles on which they are based. The study of such principles constitutes that branch of engineering known as chemical engineering. For this purpose the chemical engineer must be thoroly trained in the various branches of chemistry, physics, and mathematics and have a good training in the fundamentals of mechanical, electrical, and chemical engineering so that he can design, construct, and successfully operate a plant using these unit operations.

The chemical engineer is primarily a producer. It is his province to develop a process from the laboratory stage through semi-works equipment to the production stage which uses engineering materials for the manufacture of unit process equipment in accordance with fundamental chemical engineering principles.

As many industries are based on some chemical operation, the chemical engineer is much in demand. He may be engaged in the manufacture of inorganic products—the mineral acids, alkalies, ammonia, paint pigments, fertilizers; in the organic industries—dyes, explosives, lacquers, solvents, medicinals; in the manufacture of gases—coal gas, carbureted blue gas, hydrogen, acetylene, helium; in the electrochemical industries such as the manufacture of graphite, calcium carbide, carborundum and other abrasives, wet and dry batteries, electroplating; in the metallurgical industries; and even in the food industries such as the manufacture of sugar, flour, salt, and starch. There are many others such as leather, paper, textiles, soaps, petroleum, glass, and cement.

In these industries the chemical engineer does investigational work, development work, design of equipment, and plant operation. Some enter the field of sales engineering and technical writing.

Students taking the five-year combined course in chemical engineering and business administration may substitute business courses for M.&M. 86.

For freshman and sophomore years, see pages 25 and 26.

JUNIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Chem.E. 101	Unit Operations	3	2	2	....
Chem.E. 105	Fuels and Combustion	4	2	2	4
Org.Chem. 54	Elementary Organic Chemistry	3	1	3	.....
Org.Chem. 57	Elementary Organic Chemistry Laboratory	2	...	1	6
M.&M. 86†	Hydraulics with Laboratory	3	2	....	2
Phys.Chem. 101	Physical Chemistry	3	1	3	.....

Second Quarter

Chem.E. 102	Unit Operations	6	4	2	4
Org.Chem. 55	Elementary Organic Chemistry	3	1	3	....
Org.Chem. 58	Elementary Organic Chemistry Laboratory	2	.....	1	6
Phys.Chem. 102	Physical Chemistry	3	1	3	....
M.E. 38	Heat Engines	3	1	2	....
M.E. 39	Heat Engines Laboratory	1	.....	.....	3

† For permissible substitute, see page 54.

§ Students who are planning to take graduate work are urged to take French as one of the electives in the senior year.

Third Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Chem.E. 103	Unit Operations	6	4	2	4
Org.Chem. 156	Elementary Organic Chemistry	3	1	3	.....
Org.Chem. 159	Elementary Organic Chemistry Laboratory	2	.....	1	6
Phys.Chem. 103	Physical Chemistry	3	1	3	.....
Chem.E. 131	Industrial Inorganic Chemistry	4	1	4	.....

Summer Session

Summer practice consisting of Chem.E. 151-152, Chemical Manufacture, 6 cred. will be taken by students in Chemical Engineering in the regular Summer Session between their junior and senior years. It is required for the degree of bachelor of chemical engineering.

SENIOR YEAR

First Quarter

Phys.Chem. 104	Physical Chemistry Laboratory	2	1	.....	5
E.E. 43	Electric Power	3	.....	2	2
Chem.E. 121	Chemical Engineering Economics	3	.....	3	.....
Chem.E. 132	Industrial Organic Chemistry	3	1	4	.....
M.&M. 85†	Strength of Materials	3	3	.....	.....
M.&M. 87†	Materials Laboratory	1	.....	.....	2
Met. 160§	Metallography	3	.....	2	3
	Electives*				

Second Quarter

Phys.Chem. 105	Physical Chemistry Laboratory	2	1	.....	5
E.E. 44	Electric Power	3	.....	2	2
Chem.E. 117	Chemical Engineering Equipment Design	3	2	1	4
Met. 160§	Metallography	3	.....	2	3
	Electives*				

Third Quarter

Phys.Chem. 106	Physical Chemistry Laboratory	2	1	.....	5
E.E. 45	Electric Power	3	.....	2	2
Chem.E. 118	Chemical Engineering Equipment Design	3	2	1	4
Chem.E. 187	Chemical Engineering Trip (spring vacation)	2	.....	.....	.....
	Electives*				

CIVIL ENGINEERING

Two four-year courses are offered: Civil Engineering I and Civil Enginering II (Sanitary Engineering).

Civil Engineering I

In addition to the prescribed courses, sufficient electives must be taken to complete a total of at least 207 credits for graduation. This is an average of about 17 credits per quarter.

The principal aim of the curriculum in civil engineering is to present to the student an opportunity to become familiar with the methods of science, so that in his attack upon any professional problem he may employ his abilities with economy and secure dependable conclusions. A secondary but important object of the course is to train the student in technique, so that at graduation he may be an economic asset to his employer.

The technique of surveying and platting, drawing, and certain laboratory procedures is taught throughout the course. Typical problems of railroad, highway, hydraulic, structural, and municipal engineering occupy the greater part of the last two years. In the junior year, there is a course of lectures and conferences on the relations of engineering

* For list of elective courses in other colleges, see page 53.

† For permissible substitute, see page 54.

§ Met. 160 may be taken first or second quarter.

projects to business and to public affairs. Elective courses are available in each of the three upper years; these offer a wide range of choice to the student who desires to extend his range of interests to those fields of knowledge and action related to civil engineering, but not strictly included therein.

For freshman year, see page 16.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5		
Phys. 7	General Physics	5	1	4	2
Draw. 21	Drafting	2			6
C.E. 11	Surveying	3	1		7
	Electives*				

Second Quarter

M.&M. 25	Calculus II: Integral	5	5		
Phys. 8	General Physics	5	1	4	2
Draw. 22	Structural Detailing	2			6
C.E. 12	Surveying	3	1		7
	Electives*				

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5		
Phys. 9	General Physics	5	1	4	2
Draw. 23	Structural Detailing	2			6
C.E. 13	Surveying	3	1		7
	Electives*				

JUNIOR YEAR

First Quarter

M.&M. 128	Strength of Materials	5	5		
M.&M. 141	Materials Laboratory	2		1	2
C.E. 14	Surveying	3		1	7
C.E. 31	Stresses in Structures	2		2	2
C.E. 51	Highways and Pavement	3		2	3
	Electives*				

Second Quarter

M.&M. 129	Hydraulics	4	3	1	
M.&M. 143	Hydraulics Laboratory	1			2
C.E. 15	Surveying	2		4	
C.E. 21	Railway Engineering	2	1		4
C.E. 32	Stresses in Structures	3		2	4
C.E. 52	Highways and Pavement	3	1	1	4
	Electives*				

Third Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5		
C.E. 16	Surveying	2		2	4
C.E. 22	Railway Engineering	2	1		4
C.E. 33	Elementary Structural Design	4		2	6
C.E. 53	Civil Engineering Practice	3	1	2	
	Electives*				

Summer Camp

Will not be offered during war emergency.

C.E. 23	Summer camp is held in the vacation preceding the senior year for 4 weeks beginning the last of August. Required of all students taking the courses in Civil Engineering. Fee, $25	9
	Health Service fee, $1.	

* For list of elective courses in other colleges, see page 53.

SENIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
C.E. 121	Railway Engineering	3	.....	1	6
C.E. 130	Statically Indeterminate Structures	3	.....	2	2
C.E. 141	Reinforced Concrete	3	.....	2	2
C.E. 161	Power	4	.....	2	6
C.E. 146	Plain Concrete	3	.....	2	4
or					
G.E. 101	Contracts and Specifications	3	.....	3	.....
	Electives*				

Second Quarter

C.E. 131	Analysis of Bridges and Buildings	2	.....	1	3
C.E. 142	Reinforced Concrete Design	3	.....	2	2
C.E. 162	Water Supply	3	.....	2	4
C.E. 109	Cadastral Surveying	2	.....	2	.....
or					
C.E. 124	Transportation	3	3	.....	.....
or					
C.E. 147	Foundations	2	.....	2	.....
or					
C.E. 156	Highway Transport	3	.....	3	.....
M.E. 42	Power	4	2	2	.....
C.E. 137†	Structural Laboratory	2	.....	1	3
or					
G.E. 101	Contracts and Specifications	3	...	3	.....
	Electives*				

Third Quarter

C.E. 132	Design of Bridges and Buildings	2	.....	1	3
C.E. 163	Sewerage and Sewage Treatment	3	...	2	4
C.E. 146	Plain Concrete	3	.....	2	4
or					
C.E. 137†	Structural Laboratory	2	.....	1	3
E.E. 42	Power	3	3	.....	.....
	Electives*				

CIVIL ENGINEERING II (Sanitary Engineering Option)

This curriculum is presented in recognition of the necessity for specialized training in sanitary engineering for those students desiring to enter the service of federal, state, local, or private agencies in this expanding field. It is intended to offer broader experience in allied fields as preparation for immediate service, and for future study without sacrificing the fundamentals of a civil engineering education. Many opportunities for employment in water supply, sewerage, public health and municipal engineering are available for the properly equipped graduate. This curriculum offers the essentials of the preparation toward that field.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics	5	1	4	2
C.E. 11	Surveying	3	1	.....	7
Draw. 21	Drafting	2	.....	.....	6
Org.Chem. 54	Elementary Organic Chemistry	3	1	3	.....

* For list of elective courses in other colleges, see page 53.

† C.E. 137 limited to 20 students.

Second Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics	5	1	4	2
C.E. 12	Surveying	3	1	.....	7
Draw. 22	Structural Detailing	2	.....	.....	6
Org.Chem. 55	Elementary Organic Chemistry	3	1	3	.....

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics	5	1	4	2
C.E. 13	Surveying	3	1	.....	7
Draw. 23	Structural Detailing	2	.....	.....	6
Anal.Chem. 9	Qualitative Analysis	3	1	1	6

JUNIOR YEAR§

First Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	2	.....	1	2
C.E. 14	Surveying	2	.....	1	7
C.E. 31	Stresses in Structures	2	.....	2	2
C.E. 51	Highways and Pavement	3	.....	2	3
Geol. 5	Engineering Geology	3	.....	3	.....

Second Quarter

M.&M. 129	Hydraulics	4	4	.....	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
C.E. 32	Stresses in Structures	3	.....	2	2
C.E. 52	Highways and Pavement	3	1	1	4
C.E. 61	Sanitary Engineering Practice	3	.....	2	3
	Electives*				

Third Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Bact. 53	General Bacteriology	5	.....	.....	9
C.E. 33	Elementary Structural Design	4	.....	2	6
C.E. 124	Transportation	3	3	.....	.....

SENIOR YEAR

First Quarter

C.E. 141	Reinforced Concrete	3	.....	2	2
C.E. 146	Plain Concrete	3	.....	2	4
C.E. 161	Power	4	.....	2	5
C.E. 191	Sanitary Engineering Seminar	1	1	.....	.....
G.E. 101	Contracts and Specifications	3	.....	3	.....
P.H. 53	Elements of Preventive Medicine and Public Health	5	2	3	.....

Second Quarter

C.E. 162	Water Supply	3	.....	2	4
C.E. 163	Sewerage and Sewage Treatment	3	.....	2	4
C.E. 140	Structural Problems in Sanitary Engineering	2	.....	2	.....
C.E. 179	Sewage Sanitary Laboratory	3	.....	.....	8
C.E. 192	Sanitary Engineering Seminar	1	1	.....	.....
M.E. 42	Power	4	2	2	.....
P.H. 102	Environmental Sanitation	3	.....	3	.....

* For list of elective courses in other colleges, see page 53.

§ Attendance at Senior Seminar in Sanitary Engineering desirable.

Third Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
C.E. 165	Public Health Engineering	3			
C.E. 169	Hydraulic Problems (Sanitary Engineering)	3		3	
C.E. 173	Sanitary Engineering Problems (Water)	3			
C.E. 174	Sanitary Engineering Problems (Sewage and Industrial Waste)	3			
C.E. 193	Sanitary Engineering Seminar	1	1		
E.E. 42	Power	3	3		
	Electives*				

RECOMMENDED ELECTIVES FOR SANITARY ENGINEERING CURRICULUM

Course No.	Title	Credits
B.A. 58	Elements of Public Finance	3
C.E. 264	Sanitary Engineering Unit Operation	3
C.E. 275	Industrial Waste Disposal	3
D.H. 51	Market Milk	3
Econ. 8-9	General Economics	per qtr. 3
M.E. 160	Heating, Ventilation and Air Conditioning	3
M.E. 169	Heating and Ventilation Laboratory	2
Phys.Chem. 107,108	Elementary Physical Chemistry	per qtr. 4
P.H. 104	Epidemiology	3
P.H. 106	Public Health Administration	3
P.H. 117	Sanitary Biology	3
Pol.Sci. 1,2,3	American Government and Politics	per qtr. 3
Soc. 1	Introduction to Sociology	3
Sp. 1	Fundamentals of Speech	3

ELECTRICAL ENGINEERING

Four-year course leading to the degree of bachelor of electrical engineering, B.E.E.

In addition to the prescribed courses, sufficient electives must be taken to complete a total of at least 207 credits for graduation.

The course in Electrical Engineering is designed to fit the student for a position of responsibility in the electrical field. This work is based upon the principles of electricity and magnetism contained in the prescribed courses in general physics and upon the principles of mathematics. In the senior year, specialized courses may be selected in the field of electric power generation, transmission, and utilization, in telephone and radio communication or in illumination.

The main laboratory of the department is well equipped for preliminary training in the operation of electrical machinery and for advanced research problems in this field. The communication laboratories contain, besides the general equipment for the study of circuits, special apparatus for the study of radio and electro-acoustical problems.

Graduate courses in this department, as well as in physics and mathematics, are available for those with exceptional ability who desire training beyond the usual four-year undergraduate curriculum.

Students taking the five-year combined course with business administration may substitute business courses for Draw. 26, M.&M. 141, M.E. 13, 17, and 26, Phys. 144, and E.E. 132, 134, and 136. In addition they are required to take courses E.E. 141, 142, and 143.

For freshman year, see page 16.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5		
Phys. 7	General Physics	5	1	4	2
M.E. 13	Forging, Welding and Heat Treating	2		2	3
E.E. 11	Elements of Electrical Engineering	3	2	1	
	Electives*				

* For list of elective courses in other colleges, see page 53.

Second Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics	5	1	4	2
Draw. 26¶	Drafting	2	.....	.....	6
E.E. 13	Elements of Electrical Engineering	3	2	1	.....
E.E. 14	Elements of Electrical Engineering Laboratory	1	.....	.....	2
	Electives*				

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics	5	1	4	2
E.E. 15	Elements of Electrical Engineering	3	2	1	.....
E.E. 16	Elements of Electrical Engineering Laboratory	1	.....	.....	2
M.E. 17	Machine Shop Practice	2	.....	2	3
	Electives*				

JUNIOR YEAR§

First Quarter

M.&M. 129	Hydraulics	4	3	1	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
E.E. 111	Electrical Engineering	5	5	.....	.....
E.E. 112	Electrical Engineering Laboratory	2	.....	.....	4
Phys. 144	Electrical Measurements	3	1	1	4
	Electives*				

Second Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
E.E. 113	Electrical Engineering	3	3	.....	.....
E.E. 114	Electrical Engineering Laboratory	1	.....	.....	2
E..E 117	Engineering Electronics	3	2	.....	2
M.E. 26	Mechanism and Kinematics	3	3	.....	.....
	Electives*				

Third Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	2	.....	1	2
E.E. 115	Electrical Engineering	3	3	.....	.....
E.E. 116	Electrical Engineering Laboratory	1	.....	.....	2
E.E. 119	Engineering Electronics	3	2	.....	2
	Electives*				

SENIOR YEAR

POWER OPTION

First Quarter

E.E. 121	Eleetrical Engineering	3	3	.....	.....
E.E. 122	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 132†	Electrical Design	2	2	.....	.....
M.E. 40†	Heat Engines	3	2	.....	3
	Electives*				

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* For list of elective courses in other colleges, see page 53.

† Students specializing in chemistry, mathematics, or physics may substitute electives in that department for courses E.E. 132, 134, 136 and M.E. 40, 41, and 55. Such specialization requires at least 18 credits of elective work in chemistry, physics, or mathematcis.

§ Students expecting to elect the communication option in the senior year must take E.E. 64-65-66, Elements of Communication, in the junior year.

¶ For permissible substitute, see page 54.

Second Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
E.E. 123	Electrical Engineering	3	3	.....	.....
E.E. 124	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 134†	Electrical Design	2	2	.....	.....
M.E. 41†	Heat Engines	3	2	.....	3
	Electives*				

Third Quarter

E.E. 100	Inspection Trip (spring vacation)	2	.....	.....	.....
E.E. 125	Electrical Engineering	3	3	.....	.....
E.E. 126	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 136†¶	Electrical Design	2	2	.....	.....
M.E. 55†	Internal Combustion Engines	3	2	.....	3
	Electives*				

COMMUNICATION OPTION§

First Quarter

E.E. 121	Electrical Engineering	3	3	.....	.....
E.E. 122	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 161	Radio Communication	3	.....	2	3
E.E. 164	Electrical Communication	4	.....	2	4
	Electives*				

Second Quarter

E.E. 123	Electrical Engineering	3	3	.....	.....
E.E. 124	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 162	Radio Communication	3	.....	2	3
E.E. 165	Electrical Communication	4	.....	2	4
	Electives*				

Third Quarter

E.E. 100	Inspection Trip (spring vacation)	2	.....	.....	.....
E.E. 125	Electrical Engineering	3	3	.....	.....
E.E. 126	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 163	Radio Communication	3	.....	2	3
E.E. 166	Electrical Communication	4	.....	2	4
	Electives*				

SPECIALIZED COURSES IN ELECTRICAL ENGINEERING

The number of electives in the electrical engineering course makes it practicable to obtain either a broad or a specialized education. Further to facilitate such election, certain courses in the senior year may be replaced by substitutes in chemistry, mathematics, or physics, subject to the approval of the head of the department and the Students' Work Committee. By properly choosing prerequisite subjects during the sophomore or junior year, a far-seeing student may prepare for advanced specialized courses in the following undergraduate and graduate years. As examples, one may specialize in business, chemistry, communication, illumination, manufacturing, military science and tactics, naval science and tactics, physics, power generation and distribution, public utilities, railway engineering, or other chosen line. Students are advised to consult with their classifiers, or with the head of the department, concerning desirable sequences of general or special courses.

* For list of elective courses in other colleges, see page 53.

† Students specializing in chemistry, mathematics, or physics may substitute electives in that department for courses E.E. 132, 134, 136 and M.E. 40, 41, and 55. Such specialization requires at least 18 credits of elective work in chemistry, physics, or mathematcis.

§ Students expecting to elect the communication option in the senior year must take E.E. 64-65-66, Elements of Communication, in the junior year.

¶ Students specializing in business may substitute an approved elective in that department for Course E.E. 136.

ENGINEERING AND BUSINESS ADMINISTRATION

For many years engineers have recognized the importance of a knowledge of the principles of economics in connection with their profession. Engineering students are encouraged to elect courses of various kinds in the fields of economics and administration when it is possible for them to find time to do so. This is true in all of the branches of engineering.

With the vast expansion which has taken place in the manufacturing industries in the United States, there has arisen a need for engineers having more training in economics and administration than is usually possible in the four-year engineering courses. To meet this need special groups of elective courses have been arranged. The recent economic stress has further emphasized the importance of a combination of engineering and business training in preparation for the industrial problems of the future.

The *Engineering Prebusiness course* described on page 38 provides a four-year combined curriculum in business administration with a background of the fundamental mathematics, chemistry, English, physics, and drawing, of the engineering courses.

As a further step to provide adequate training in engineering or chemistry, combined with business administration, a plan of *five-year courses leading to two degrees* has been arranged for the capable student who wishes to enter upon comprehensive professional training in this combined field.

FIVE-YEAR COMBINED COURSES WITH BUSINESS ADMINISTRATION

The new plan of five-year combined courses in Engineering, Architecture (six years), or Chemistry with Business Administration enables the student to complete the requirements for the Bachelor's degrees in both fields, as, for example, bachelor of electrical engineering and bachelor of business administration. Five years will usually be necessary for the completion of the combined course, but a longer time may be required if suitable programs cannot be arranged for the five-year period. This will depend upon the particular curriculum with which the combination with business administration is made.

For this purpose the School of Business Administration will accept the 74 credits in business subjects shown in the following list in conjunction with one of the regular curricula in engineering, architecture, or chemistry, as satisfying the requirements for the degree of bachelor of business administration. The student receives his engineering degree upon the completion of his regular course, altho this may not be until the end of the fifth year. He is not eligible for the degree in business administration on this 74-credit basis unless *the work is taken in conjunction with one of the regular curricula in this college.* The honor point ratio must be maintained at the completion of the 74 credits, otherwise the business administration degree will be given only upon the completion of the regular School of Business Administration requirements.

The business courses are intended to be spread over four years, beginning the business sequence in the sophomore year by taking economics and business law, 3 credits per quarter, as electives, in addition to the usual engineering program.

Normally, some of the required technical work of the senior year will be postponed to the fifth year to make room for business courses, in order to secure a desirable distribution of the latter rather than to concentrate them in the fifth year. Not more than 28 credits of business should be left for the fifth year.

In certain curricula, special concessions are made to students taking this five-year combined course by permitting them to omit certain required courses or to substitute business courses for them. (See Aeronautical, Agricultural, Chemical, and Electrical Engineering.)

Under this plan the student will be registered in the Institute of Technology and in the School of Business Administration for the entire combined program. His registration

for each quarter beginning with the school year is subject to *approval by the adviser representing the School of Business Administration* as well as by the regular classifier.

No student is considered officially registered in the five-year business engineering combination unless he has the approval of the Five-Year Student Work Committee.

The following order and distribution by years are suggested. With the approval of the adviser in the School of Business Administration both may be varied, however, so as to accommodate individual programs.

SECOND YEAR

Course No.	Title	Credits F	W	S
Econ. 8-9	General Economics	3	3	
Econ. 28	Business Law (8, 9)			3

THIRD YEAR

B.A. 54-55*	Elementary Accounting: Combined Course	4	4	
B.A. 77	Survey in Marketing			3

FOURTH YEAR

B.A. 58	Elements of Public Finance (8, 9)		3	
B.A. 70	Statistics Survey (8, 9)	3		
B.A. 71	Transportation: Services and Charges I (8, 9)			3
B.A. 89§	Production Management (8, 9)			3
B.A. 112	Business Statistics (70)		3	
B.A. 130	Cost Accounting Survey (26, 29 or 55)			3
B.A. 142	Advanced Money and Banking (8, 9)	3		
B.A. 167	Personnel Administration (161)		3	
Econ. 161	Labor Problems and Trade Unionism (8, 9)	3		

FIFTH YEAR

B.A. 155	Corporation Finance (8, 9)	3		
B.A. 101-102	Advanced General Economics (8, 9)	3	3	
B.A. 180-181-182G	Senior Topics: Production Management (89, 130)	3	3	3
Econ. 149	Business Cycles (142)		3	
Econ. 175	Government Regulation of Business (8, 9)			3
One of the following:				
B.A. 133	Standard Costs			3
B.A. 139	Advanced General Accounting (26)			3
B.A. 170-171	Production Standards		3	3
B.A. 180-181C	Senior Topics: Marketing	3	3	
B.A. 180-181-182D	Senior Topics: Personnel Management	3	3	3
Psy. 130	Vocational and Occupational Psychology		3	
	Total credits			74

ENGINEERING PREBUSINESS

(Four-year course in Engineering and Business Administration)

This course has been arranged for students who wish to prepare for positions in industry for which basic technical training is necessary, with instruction in business administration. Such positions are found in fields of purchasing, sales and sales promotion, cost accounting, employment and rate setting, and production control.

Upon the completion of two years of prescribed work in the Institute of Technology the student transfers to the School of Business Administration, where the third and fourth years are taken. Students in this program *must* transfer their enrolment to the School of

* If Econ. 54-55 cannot be scheduled, Econ. 20, 25, and 26 may be substituted.

§ Mechanical engineering students substitute M.E. 171 for B.A. 89 and replace the latter with an approved business course, preferably B.A. 180C. Credit will not be given for both M.E. 171 and B.A. 89.

Business Administration at the *beginning* of their junior year. The combined course leads to the degree of bachelor of business administration.

For freshman year, see page 16.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 91†	Calculus	4	4		
Phys. 7	General Physics	5	1	4	2
Econ. 8	General Economics	3		3	
M.E. 17	Machine Shop Practice	2		2	3
M.E. 70	Mechanical Technology	1		2	
	Electives*				

Second Quarter

Econ. 3	Elements of Money and Banking	5	3	2	
Econ. 9	General Economics	3	3		
Econ. 20¶	Elements of Accounting	3	3		
Phys. 8	General Physics	5	1	4	2
	Electives*				

Third Quarter

M.&M. 84†	Technical Mechanics	5	5		
Phys. 9	General Physics	5	1	4	2
Econ. 5	Elements of Statistics	5	5		
Econ. 25	Principles of Accounting	3	3		

JUNIOR YEAR§

(In the School of Business Administration)

	Credits
Strength of Materials (M.&M. 85)†	3
Materials Testing Laboratory (M.&M. 87)†	1
Principles of Accounting (Econ. 26)	3
Business Law (Bus.Adm. 51-52-53)	3
Business Statistics (Bus.Adm. 112)	3
Corporation Finance (Bus.Adm. 155)	3
Advanced Money and Banking (Bus.Adm. 142)	3
Transportation: Services and Charges I (Bus.Adm. 71)	3
Survey in Marketing (Bus.Adm. 77)	3
Production Management (Bus.Adm. 89)	3
Advanced General Accounting (Bus.Adm 139)	3
Tabulating Equipment Laboratory (Bus.Adm. 91)	1
Electives (See list, page 40)	4

SENIOR YEAR§

(In the School of Business Administration)

Transportation: Services and Charges II (Bus.Adm. 72)	3
Cost Accounting Survey (Bus.Adm. 130)	3
Advanced General Economics (Bus.Adm. 101-102)	6
Business Cycles (Econ. 149)	3
Labor Problems and Trade Unionism (Econ. 161)	3
Personnel Administration (Bus.Adm. 167)	3
Elements of Public Finance (Bus.Adm. 58)	3
Government Regulation of Business (Econ. 175)	3
Senior Topics: Production Management (Bus.Adm. 180-181-182G)	9
Electives (See page 40)	12

* For list of eleective courses in other colleges, see page 53.

† For permissible substitute, see page 54.

§ In addition to the required courses in the junior and senior years, the student must earn approximately 10 credits per year.

¶ Students who have had a high school course or experience in bookkeeping may be exempt from this course and admitted to Econ. 25 by passing a placement test.

RECOMMENDED ELECTIVES

	Hours
Economic History (Hist. 80-81-82)	9
Finance Management (Bus.Adm. 156)	3
Theory of Statistics (Econ. 121-122-123)	9
Geography of Commercial Production (Geog. 41)	5
Fire and Marine Insurance (Bus.Adm. 60)	3
Casualty Insurance (Bus.Adm. 61)	3
Senior Topics: Marketing (Bus.Adm. 180C)	3
Contracts and Specifications (G.E. 101)	3
General Psychology (Psy. 1-2)	6
Vocational Psychology (Psy. 130)	3
Senior Topics: Personnel Management (B.A. 180-181-182D)	9

GEOPHYSICS

The institute has established a curriculum for students interested in geophysics.

It is suggested that any student who desires to enter such a curriculum arrange his programs to include the following courses:

English
Drawing
Chemistry
Mathematics
- Algebra, Trigonometry, and Analytics
- Differential and Integral Calculus
- Differential Equations
- Advanced Calculus
- Technical Mechanics (Statics and Dynamics)

Geology
- General and Historical 1-2, A-B
- Mineralogy 23-24
- Sedimentation 101
- Rock Study 105
- Geology of Petroleum 112
- Structural Geology 125
- Map Interpretation 144-145
- Field Work 85

Elective topics in Mathematical Analysis 144-145-146

Physics
- General Physics 7-8-9
- Intermediate Physics 100-102-104
- Theoretical Physics 101-103-105
- Modern Experimental Physics 110-112 (individual work)
- Experimental Optics 134

Geophysics
- Principles of Geophysical Prospecting 161-162

Elective
- Paleontology 51
- Economic Geology 110
- Ore Deposits 111
- Advanced General Geology 151-152-153
- Field Work 85

Mining
- Mining 131

Civil Engineering
- Surveying 11-12-13

MECHANICAL ENGINEERING

Four-year course leading to the degree of bachelor of mechanical engineering, B.M.E.

In addition to the prescribed courses, sufficient electives must be taken to complete a total of at least 207 credits for graduation.

The field of mechanical engineering is very broad. Graduates hold positions in technical or nontechnical work in almost every kind of industry.

The profession includes the following major divisions: design of machinery and apparatus for all purposes; production and manufacturing methods; operation of industrial plants; steam power generation, internal combustion engines; heating, ventilation, refrigeration, and air conditioning; mechanical research and development; sales engineering; and the general field of management.

The course is planned to give broad training rather than highly specialized work. A reasonable amount of time is allowed for nontechnical subjects. A course in speech is required.

It is recommended that students in Mechanical Engineering spend their summer vacations in industry if possible.

For freshman year, see page 16.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5		
Phys. 7	General Physics	5	1	4	2
Ch.E. 31	Chemistry of Engineering Materials	2		3	
M.E. 9	Industrial Laboratory (Foundry Practice)	2		2	3
M.E. 20§	Elementary Machine Design	2			6
or					
Engl. 37†	Technical Discussion	3	3		
M.E. 70	Mechanical Technology	1		2	

Second Quarter

M.&M. 25	Calculus II: Integral	5	5		
Phys. 8	General Physics	5	1	4	2
M.E. 80	Industrial Materials	2		2	
M.E. 5	Industrial Laboratory (Pattern Practice)	2		2	3
Engl. 37†	Technical Discussion	3	3		
or					
M.E. 50§	Auto and Airplane Engines	3	3		
M.E. 20§	Elementary Machine Design	2			6
or					
M.E. 21§	Kinematics	2			6

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5		
Phys. 9	General Physics	5	1	4	2
M.E. 81	Industrial Materials	2		2	
M.E. 13	Industrial Laboratory (Forging, Welding, and Heat Treating)	2		2	3
Engl. 37†	Technical Discussion	3	3		
or					
M.E. 50§	Auto and Airplane Engines	3	3		
or					
M.E. 21§	Kinematics	2			6

JUNIOR YEAR

First Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5		
M.E. 22	Mechanism	3	3		
M.E. 33	Elementary Mechanical Laboratory	2		1	3
M.E. 71	Machine Shop Practice	2		2	3
M.E. 131	Thermodynamics	3	3		2
	Electives*				

Second Quarter

M.&M. 128	Strength of Materials	5	5		
M.&M. 141	Materials Laboratory	2		1	2
M.E. 23	Dynamics of Machine Design	3		1	6
M.E. 34	Mechanical Laboratory	2		1	3
M.E. 72	Machine Shop Practice	2		2	3
M.E. 132	Thermodynamics	3	3		
	Electives*				

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* For list of elective courses in other colleges, see page 53.

† Engl. 37 is offered each quarter. This course must be completed during the sophomore year. Enrolment is limited to 25 students.

§ M.E. 20, M.E. 21, and M.E. 50 are each offered two quarters. All courses must be completed during the sophomore year.

Third Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 129	Hydraulics	4	3	1	.....
M.&M. 143	Hydraulics Laboratory	1	...	.....	2
M.E. 24	Elements of Machine Design	3	2	...	3
M.E. 35	Elementary Steam and Power Laboratory	2	...	1	3
M.E. 141	Heat-Power Engineering	3	3	...	.....
	Electives*				

SENIOR YEAR

First Quarter

M.E. 121	General Engineering Design	2	.....	.....	6
M.E. 142§	Heat-Power Engineering	3	3	.....	.....
M.E. 150§	Internal Combustion Engines	3	3	.....	.....
M.E. 171§	Production Control	3	3	.....	.....
M.E. 180§	Refrigeration	3	3	.....	.....
	Senior Laboratory†	2	.....	.....	4
M.E. 160	Heating and Ventilation	3	2	1	.....
M.E. 190	Seminar	1	1	.....	.....
E.E. 36	Electric Power	3	2	.....	2
	Electives*				

Second Quarter

M.E. 142§	Heat-Power Engineering	3	3	.....	.....
M.E. 150§	Internal Combustion Engines	3	3	.....	.....
M.E. 171§	Production Control	3	3	.....	.....
M.E. 180§	Refrigeration	3	3	.....	.....
	Senior Laboratory†	2	.....	.....	4
M.E. 191	Seminar	1	1	.....	.....
	Engineering Design¶	2	.....	.....	6
E.E. 37	Electric Power	3	2	.....	2
	Electives*				

Third Quarter

M.E. 192	Seminar	1	.....	1	1
	Engineering Design¶	2	.....	.....	6
M.E. 195	Inspection Trip (spring vacation)	1	.....	.....	.....
E.E. 38	Electric Power	3	2	.....	2
G.E. 193	Engineering Practice	2	.....	2	.....
	Senior Laboratory†	2	.....	.....	4
	Electives*				

In addition to the regular four-year course in Mechanical Engineering, those who are qualified are urged to take a fifth year, that is, a year of graduate study. This year's work may lead to the Master's degree in mechanical engineering and also satisfy the requirement of graduate study towards the professional degree of mechanical engineer. (For detailed information as to procedure consult the Graduate School Bulletin.)

* For list of elective courses in other colleges, see page 53.

† Three of the four laboratory courses, M.E. 149, 159, 169, 174, must be taken in the three quarters and not more than two in any one quarter.

§ Courses M.E. 142, 150, 171, 180 must be taken in the first and second quarters. Each course is offered both quarters.

¶ The following courses are accepted for this requirement: M.E. 122-123, Mechanical Engineering Design; M.E. 147, Design of Steam Machinery; M.E. 148, Design of Power Plant Units; M.E. 156, 157, Design of Internal Combustion Engines; M.E. 161,162, Heating and Ventilation Design; M.E. 170, Tool Design and Construction; M.E. 172, Industrial Plant Design; C.E. 37, Structural Engineering.

GEOLOGICAL MINING, AND PETROLEUM ENGINEERING

Candidates for either of these degrees need not choose the field of specialization until the beginning of the junior year.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Geol. 11	Geology, General and Historical	5	.....	5	1
M.&M. 32	Calculus	4	4	...	.....
Met. 1	Assaying	2	.....	3	...
Met. 3	Assaying Laboratory	1	.....	.	4
Min. 11	Surveying	3	1	3	. ...
Phys. 7	General Physics	5	1	4	2

Second Quarter

Anal.Chem. 9	Quantitative Analysis	3	1	1	6
Geol. 23	Mineralogy	4	1	3	4
M.&M. 33	Calculus	5	5	...	...
Min. 12	Surveying	3	1	3	.....
Phys. 8	General Physics	5	1	4	2

Third Quarter

Geol. 24	Mineralogy	4	1	3	4
Min. 13	Mine Surveying	2	1	2	.....
Min. 14	Surveying Field Work	5	.....	.....	20
Min. 120	First Aid (1 week, 3 hours per day)	0	.....	.	.....
Phys. 9	General Physics	5	1	4	2

Summer Field Trips

Min. 15	Field work in surveying on the iron ranges of Minnesota	8
Geol. 100	Field work in geology on the iron ranges of Minnesota	3

GEOLOGICAL ENGINEERING

Four-year course leading to the degree of bachelor of geological engineering, B.Geol.E.

Requirements for graduation cover all prescribed courses including summer field trips and electives, making a total of 231 credits.

The course in Geological Engineering is designed to prepare students for responsible positions in geological departments of exploration, oil, or mining companies, or to engage in consulting geological practice.

There are in existence many ore deposits which are economically of no particular value at the present time, either because the cost of mining is excessive or because there is no known method of separating minerals in the mineral aggregate forming the ore at a cost which will result in a profit for the operator. In addition to thoro courses in geology, the mining geologist must be familiar with the various methods of mining and know something of the possibilities of ore dressing to recover the valuable minerals. A knowledge of the fundamental principles of the smelting and refining of metals is a decided asset in his work.

The basic training must, therefore, include thoro courses in mathematics, drafting, chemistry, and physics. It must also include plane and mine surveying, mapping, both topographic and geological, assaying, ore dressing, and the principles of metallurgy. The technical work in mining includes exploration, development, and mining methods together with the courses in mine administration, economics of mining, and mining law. The general course in geology is given in the freshman year. Then follow the courses in miner-

alogy, rock study, and petrography. These are followed by advanced general geology, structural and metamorphic geology, index fossils and paleontology, mineralography, sedimentation, ore deposits, oil geology. Advanced courses in petrology and petrography, blowpipe analysis, and map interpretation are also available.

The Department of Geology is well supplied with working collections of minerals, crystal models, rocks, thin sections, ores and economic minerals, fossils, and other illustrative material used in connection with the courses in paleontology, stratigraphy, and historical geology. The department has large, well-lighted, and fully equipped laboratories for the basic courses of mineralogy, rock study, and petrology. Special equipment is available for studies in sedimentation, rock analysis, and X-ray studies of minerals. Courses in geology and mineralogy extend throughout the four years.

JUNIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Geol. 105	Rock Study	2	.....	2	2
Geol. 144	Interpretation of Geologic Maps	4	.....	.....	8
Geol. 151	Advanced General Geology	3	.....	3	.....
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Min. 106	Mine Mapping	2	.....	.....	8
Min. 111	Exploration	3	.....	4	.....

Second Quarter

Geol. 106	Petrography	2	.....	2	2
Geol. 124	Metamorphic Geology	3	.....	3	.....
Geol. 131	Advanced Petrology	4	1	3	4
Geol. 145	Interpretation of Geologic Maps	2	.....	.....	4
Geol. 152	Advanced General Geology	3	.....	3	.....
Min. 112	Exploration and Development	3	.....	4	.....
	Electives*				

Third Quarter

Geol. 125	Structural Geology	3	.....	3	.....
Geol. 132	Advanced Petrology	4	1	3	4
Geol. 153	Advanced General Geology	3	.....	3	.....
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Min. 113	Development and Exploitation	3	.....	4	.....

Summer Field Trip

Geol. 150	Field Geology. Detailed systematic work conforming with standards of official surveys. Preparation of geologic maps, structure sections, reports; paragenesis of ores and their relations to geologic structures. Field, Black Hills, South Dakota	6

SENIOR YEAR

First Quarter

Geol. 61	Blowpipe Analysis	3	.....	2	4
Geol. 91	Index Fossils of North America	3	.....	1	4
Geol. 101	Sedimentation	3	.....	3	.....
Geol. 110	Economic Geology	3	.....	3	.....
Met. 106	Base Metals	2	.....	3	.....
Met. 110	Ore Dressing	2	.....	3	.....
Min. 141	Reports and Administration	3	.....	4	.....

* For list of elective courses in other colleges, see page 53.

Second Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Geol. 92	Index Fossils of North America	3	.....	1	4
Geol. 111	Ore Deposits	3	.....	3	.....
Geol. 140	Applied Petrography	3	.....	1	4
Geol. 166	Mineralography	3	.....	.....	6
Met. 107	Base Metals	2	.....	2	.....
Met. 112	Ore Dressing	2	.....	3	.....
Min. 142	Coal Mining	3	.....	4	.....

Third Quarter

Geol. 93	Index Fossils of North America	3	.....	1	4
Geol. 112	Geology of Petroleum	3	.....	3	.....
Geol. 141	Applied Petrography	3	.....	1	4
Geol. 167	Mineralography	3	.....	.....	6
Met. 108	Precious Metals	2	.....	3	.....
Met. 116	Ore Dressing Laboratory	1	.....	.....	4
Min. 143	Mining Law, Quarries, and Placers	3	.....	4	.....

Mining Engineering

Four-year course leading to the degree of bachelor of mining engineering, B.Min.E. Requirements for graduation cover all prescribed courses including summer field trips and electives, making a total of 233 credits.

The course in Mining is designed to prepare the student for responsible positions in the field of mining. In such positions a mining engineer, in addition to meeting the technical problems involved in the development and operation of a mine, must be able to pass upon proposals and specifications for structures and for mechanical and electrical equipment. In addition he must be familiar with the fundamental principles of ore dressing and ore testing, as in the early stages of development he must be able to determine whether or not separation of the minerals in the mineral aggregate forming the ore may be made at a cost which will leave a profit to the company.

The basic training must, therefore, include thoro courses in mathematics, drafting, chemistry, physics, and geology including the identification of minerals and rocks. It must also include plane and mine surveying, mapping, assaying, ore dressing, and ore testing. The mechanical and electrical features of the various types of machinery used in the industry must be understood. Tho it is not necessary for the mining engineer to concern himself with problems of the design of individual machines, he must be familiar with the essential characteristics in order to consider intelligently proposals and specifications. Essential to his training is a thoro knowledge of mine exploration and development, mining methods as influenced by the type of deposits, as well as the applications of economics to mining. He must have a reasonable familiarity with the basic mining laws of the various states and the laws governing corporations, etc.

The Department of Mining is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, safety and safety regulations, and the necessary allied subjects. The courses in mining extend through the sophomore, junior, and senior years.

JUNIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Geol. 105	Rock Study	2	.....	2	2
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Met. 106	Base Metals	2	.....	3	.....
Met. 110	Ore Dressing	2	.....	3	.....
Min. 106	Mine Mapping	2	.....	.....	8
Min. 111	Exploration	3	.....	4	.....
Min. 121	Mine Plant	3	.....	5	.....

Second Quarter

Geol. 106	Petrography	2	.....	2	2
M.&M. 128	Strength of Materials	5	5	.....	.....
Met. 107	Base Metals	2	.....	3	.....
Met. 112	Ore Dressing	2	.....	3	.....
Min. 112	Exploration and Development	3	.....	4	.....
Min. 122	Mine Plant	3	.....	5	.....
	Electives*	2			

Third Quarter

E.E. 41	Electric Power	3	.....	2	3
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Met. 108	Precious Metals	2	.....	3	.....
Met. 116	Ore Dressing Laboratory	1	.....	.....	4
Min. 113	Development and Exploitation	3	.....	4	.....
Min. 123	Mine Plant	3	.....	5	.....
Min. 130	Mine Rescue (1 week, 3 hours per day)	0	.....	.....	.....
	Electives*	2			

Summer Field Trip

Min. 139	Study of mining operations, mine plants, and metallurgical plants in one or more western mining camps	6

SENIOR YEAR

First Quarter

Geol. 110	Economic Geology	3	.....	3	.....
M.E. 9	Foundry Practice	2	.....	2	3
Met. 121	Ore Testing	2	.....	1	3
Min. 124	Mining Hydraulics	4	.....	5	.....
Min. 126	Engineering Construction	3	.....	.....	8
Min. 141	Reports and Administration	3	.....	4	.....
	Electives*	2			

Second Quarter

Geol. 111	Ore deposits	3	.....	3	.....
M.E. 13	Forging, Welding and Heat Treating	2	.....	2	3
M.E. 138	General Laboratory	2	.....	.....	4
Met. 156	Metallography	3	.....	2	3
Min. 127	Engineering Construction	3	.....	.....	8
Min. 142	Coal Mining	3	.....	4	.....
Min. 144	Advanced Mining	3	.....	.....	8

Third Quarter

Geol. 112	Petroleum Geology	3	.....	3	.....
Geol. 125	Structural Geology	3	.....	3	.....
M.E. 16	Machine Shop Practice	2	.....	2	3
Met. 126	Special Problems in Metallurgy	3	2	.....	4
Min. 143	Mining Law, Quarries, and Placers	3	.....	4	.....
Min. 145	Advanced Mining	3	.....	.....	8
	Electives*	2			

* For list of elective courses in other colleges, see page 53.

Petroleum Engineering

Four-year course leading to the degree of bachelor of petroleum engineering, B.Pet.E. Requirements for graduation cover all prescribed courses, including summer field trips, and electives, making a total of 233 credits.

The course in Petroleum Engineering is designed to prepare the student for responsible positions in the field of petroleum production. In such a position the petroleum engineer must be familiar with geology and in particular with oil geology. This involves a knowledge of the various geological ages during which oil was formed, of the geological conditions under which the oil was collected in pools, and the methods of interpreting geological data to determine whether or not a given locality may contain such pools. He must know the methods of drilling and the difficulties which must be overcome in this work. He must know the principles of pumping, with both gas lift and mechanical pumps, and the methods of gasoline recovery to be used in connection with these methods. He must know the causes of the formation of emulsions and methods of breaking them when formed. He must be familiar with the laws of flow of viscous fluids and be able to design pipe lines, pumping stations, and storage basins. In addition, he should know the essential economic principles involved in the industry, and be familiar with the forms, contracts, and other documents used in the industry.

The basic training must, therefore, include thoro courses in mathematics, drafting, chemistry, physics, and geology, including in particular, a thoro familiarity with sedimentary deposits. It must also include surveying and mapping. The mechanical and electrical features of the various types of machinery used in the industry must be understood. A course in pipe lines gives the necessary preparation in flow formulas, soil, corrosion, and methods of prevention. Thoro courses are included in prospecting, oil field mapping, production technology, and petroleum economics. Due emphasis is also placed on problems of administration, including reports, leases, contracts, and specifications.

The department is well supplied with samples of the smaller oil field equipment, well logs, drill cores, models, maps, photographs, lantern slides, and samples of petroleum products. The lectures treat of location, prospecting, development, production, refining methods, distribution, administration, leasing, mineral laws, safety work and safety regulations, and allied subjects affecting oil and gas production. Laboratory work includes special problems in oil and gas production. The courses in petroleum engineering subjects extend through the junior and senior years.

JUNIOR YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Geol. 105	Rock Study	2	.....	2	2
Geol. 144	Interpretation of Geologic Maps	3	.....	.....	6
Geol. 151	Advanced General Geology	3	.....	3	.....
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Min. 121	Mine Plant	3	.....	5	.....
Pet.E. 111	Oil Field Development	3	.....	4	.....

Second Quarter

Geol. 106	Petrography	2	.....	2	2
Geol. 152	Advanced General Geology	3	.....	3	.....
M.&M. 128	Strength of Materials	5	5	.....	.....
Min. 107	Mine Maps	1	.....	.....	3
Min. 122	Mine Plant	3	.....	5	.....
Pet.E. 112	Oil Field Production	3	.....	4	.....
Pet.E. 131	Petroleum Refining	2	.....	2	.....

Third Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Geol. 112	Petroleum Geology	3	.....	3	.....
Geol. 125	Structural Geology	3	.....	3	.....
Geol. 131	Advanced Petrology	4	1	3	4
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Pet.E. 134	Petroleum Plant	2	.....	3	.....
Pet.E. 138	Oil Field Mapping	2	.....	.....	6
Min. 130	Mine Rescue (1 week, 3 hours per day)	0	.....	.....	.....

Summer Field Trip

Pet.E. 135	Study of oil well drilling and production methods and refining practice in one or more oil fields	6			

SENIOR YEAR

First Quarter

Geol. 101	Sedimentation	3	.....	3	.....
Geol. 110	Economic Geology	3	.....	3	.....
Min. 124	Mining Hydraulics	4	.....	5	.....
Min. 126	Engineering Construction	3	.....	.....	8
Min. 141	Reports and Administration	3	.....	4	.....
Pet.E. 152	Petroleum Production Technology	3	.....	1	6

Second Quarter

Geol. 111	Ore Deposits	3	.....	3	.....
M.E. 13	Forging, Welding and Heat Treating	2	.....	2	3
Met. 156	Metallography	3	.....	2	3
Min. 127	Engineering Construction	3	.....	.....	8
Pet.E. 144	Advanced Petroleum Engineering	5	.....	4	6
Pet.E. 153	Petroleum Production Technology	3	.....	1	6

Third Quarter

Geol. 153	Advanced General Geology	3	.....	3	.....
M.E. 16	Machine Shop Practice	2	.....	2	3
Pet.E. 145	Advanced Petroleum Engineering	5	.....	4	6
Pet.E. 154	Petroleum Production Technology	3	.....	1	6
	Electives*	6			

METALLURGICAL ENGINEERING

Four-year course leading to the degree of bachelor of metallurgical engineering, B.Met.E.

Requirements for graduation cover all prescribed courses including summer field trips and electives, making a total of 224 credits.

Courses in metallurgy are designed to prepare the student for responsible positions in metallurgical industries. The instruction deals with the production and uses of ferrous, nonferrous, and precious metals. Metallurgists are concerned with the preparation of raw materials for smelting, the design and operation of furnaces to convert ores into metals, and the structure and physical properties of metals and alloys.

Representative ores of all the important metals, models and drawings of furnaces, and samples of furnace products are available. Lectures cover the construction and operation of ore dressing and concentrating machinery, together with typical combinations of ore dressing machines. The sequence of physical and chemical changes occurring during smelting, furnace design, fuels, refractories, methods, and efficiency of heat application and control over quality of product are stressed in courses dealing with metallurgical processes.

* For list of elective courses in other colleges, see page 53.

Laboratories equipped with various types of furnaces are provided so that the students can become familiar with high temperature equipment and conduct experiments demonstrating important features of metallurgical processes.

Metallography is an important branch of metallurgy dealing with the application of metals and alloys. The work relates to internal structures, as studied by the microscope, and to the physical and chemical properties of metals and alloys. A knowledge of metallography is essential in the design and development of new machines and equipment fabricated from metals.

An elaborate and up-to-date file of references and abstracts is available. A large collection of specimens, photomicrographs, and lantern slides covering all types of steels, brasses, bronzes, aluminum alloys, and other industrial alloys is available for study and comparison.

Laboratory courses accompany lecture work. The metallographic laboratory is equipped with the most up-to-date microscopes and apparatus for heat treating and physical and mechanical testing. Practice is obtained in taking photomicrographs.

Two options are open to students in metallurgy. Option A is provided for students specializing in ore dressing and the refining and smelting of nonferrous metals. Option B is for students interested in the production of ferrous metals and the application of all metals.

Students will register for either Option A or Option B at the beginning of the junior year.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Geol. 11	Geology, Historical and General	5	.....	5	1
M.&M. 32	Calculus	4	4	.....	.....
Met. 1	Assaying	2	.....	3	.....
Met. 2	Assaying Laboratory	3	.....	.....	8
Phys. 7	General Physics	5	1	4	2

Second Quarter

Anal.Chem. 9	Quantitative Analysis	3	1	1	6
Geol. 23	Mineralogy	4	1	3	4
M.&M. 33	Calculus	5	5	.....	.....
Met. 11	Metallurgy of Pig Iron	3	1	3	.....
Phys. 8	General Physics	5	1	4	2

Third Quarter

Geol. 24	Mineralogy	4	1	3	4
Met. 12	Metallurgy of Steel	3	1	3	.....
Min. 120	First Aid	.....	.....	.....	.....
Phys. 9	General Physics	5	1	4	2
	Electives	5			

JUNIOR YEAR

(Students will register for either Option A or Option B.)

First Quarter

Option	Course No.	Title	Credits	Rec.	Lect.	Lab.
A&B	M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
A&B	Met. 106	Base Metals	2	.....	3	.....
A&B	Met. 110	Ore Dressing	2	.....	3	.....
A&B	Met. 111	Ore Dressing Laboratory	1	.....	.....	4
A&B	Min. 121	Mine Plant	3	.....	5	.....
A&B	Geol. 105	Rock Study	2	.....	2	2
A	Geol. 165	Ore Dressing Microscopy	1	.....	.....	3
A	Min. 111	Exploration	3	.....	4	.....
B	M.E. 9	Foundry Practice	2	.....	2	3
B	Met. 153	Metallography	4	.....	3	4

Second Quarter

Option	Course No.	Title	Credits	Rec.	Lect.	Lab.
A&B	M.&M. 128	Strength of Materials	5	5	.....	.....
A&B	Met. 107	Base Metals	2	.....	3	.....
A&B	Met. 133	Electrometallurgy	3	.....	3	3
A&B	Min. 122	Mine Plant	3	.....	5	.....
A	Met. 112	Ore Dressing	2	.....	3	.....
A	Met. 113	Ore Dressing Laboratory	1	.....	.....	4
A	Min. 112	Exploration and Development	3	.....	4	.....
A	Geol. 106	Petrography	2	.....	2	2
B	M.E. 13	Forging, Welding and Heat Treating	2	.....	2	3
B	Met. 154	Metallography	4	.....	3	4

Third Quarter

A&B	E.E. 41	Electric Power	3	.....	2	3
A&B	M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
A&B	Met. 108	Precious Metals	2	.....	3	.....
A&B		Electives	3			
A	Met. 114	Ore Dressing	2	.....	3	.....
A	Met. 115	Ore Dressing Laboratory	1	.....	.....	4
A	Min. 113	Development and Production	3	.....	4	.....
B	M.E. 16	Machine Shop Practice	2	.....	2	3
B	Met. 155	Metallography	4	.....	3	4

Summer Field Trips

A	Met. 139	Study of metallurgical and mining operations in western mining districts	6
B	Met. 175	Study of metallurgical operations in important iron and steel centers	6

SENIOR YEAR

First Quarter

A&B	Met. 121	Ore Testing	2	.....	1	3
A&B	Met. 134	Advanced Metallurgy	4	.....	3	4
A	Met. 153	Metallography	4	.....	3	4
A	Min. 125	Metallurgical Hydraulics	3	.....	3	.....
A		Electives	6			
B	Chem.E. 76	Applied Electrochemistry	3	.....	2	4
B	Met. 141	Problems in Ferrous Metallurgy	3	.....	.....	9
	or					
B	Met. 166	Advanced Metallography Laboratory	3	.....	.....	9
B	Met. 163	Advanced Metallography	3	.....	3	.....
B		Electives	4			

Second Quarter

A&B	Met. 135	Advanced Metallurgy	4	.....	3	4
A	Met. 122	Ore Testing	4	.....	2	8
A	Met. 137	Problems in Nonferrous Metallurgy	4	.....	2	8
A	Met. 154	Metallography	4	.....	3	4
A		Electives	3			
B	Chem.E. 77	Applied Electrochemistry	3	.....	2	4
B	Met. 142	Problems in Ferrous Metallurgy	3	.....	.....	9
	or					
B	Met. 167	Advanced Metallography Laboratory	3	.....	.....	9
B	Met. 164	Advanced Metallography	3	.....	3	.....
		Electives	6			

Third Quarter

Option	Course No.	Title	Credits	Rec.	Lect.	Lab.
A&B	Met. 136	Advanced Metallurgy	4	.....	3	4
A	Met. 123	Ore Testing	4	.....	2	8
A	Met. 138	Problems in Ferrous Metallurgy	4	.....	2	8
A	Met. 155	Metallography	4	.....	3	4
A		Electives	3			
B	Chem.E. 31	Chemistry of Engineering Materials	3	.....	3	.....
B	M.&M. 144	Materials Testing Laboratory	2	.....	.....	4
B	Met. 143	Problems in Ferrous Metallurgy	3	.....	.....	9
	or					
B	Met. 168	Advanced Metallography Laboratory	3	.....	.....	9
B	Met. 165	Advanced Metallography	3	.....	3	.....
B		Electives	4			

PHYSICS

Four-year course leading to the degree of bachelor of physics, B.Phys.

The sequence leading to the degree, bachelor of physics, is intended to be sufficiently broad to provide for the needs of those who desire to prepare for the industrial research field or for graduate work in physics as a major. The outline given is only suggestive and is not complete. A total of 207 credits is required.

A student entering this course may take the freshman program outlined for the first year in any of the curricula of the Institute of Technology except that for architecture. Those who maintain a satisfactory average (C or better) during the first year may register in this course.

It is clear that a student having the above objectives must attain an adequate background in mathematics and in chemistry. The work in physics is planned so as to give a greater or lesser contact with theoretical physics and experimental physics, depending upon the special aptitude of the applicant. Any special interest of the applicant may be met by a careful choice of elective courses which meets the approval of his adviser. The Department of Physics reserves the right to limit the registration in this course to those who have given evidence of being able to profit by it. Those who contemplate registering in the course should consult the chairman of the department.

General requirements for graduation—The student must fulfill the requirements in credits earned (207) and standards of work required for graduation by the Institute of Technology. The student must include as a minimum:

A major in physics of 51 stated credits.
A minor in mathematics of 34 stated credits.
A minor in chemistry of 39 stated credits.

The following is the prescribed curriculum for the physics course. The student should consult his adviser in the choice of electives.

SOPHOMORE YEAR

First Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Anal.Chem. 7	Quantitative Analysis	4	1	1	8
E.E. 11	Elements of Electrical Engineering	3	2	1	.....
Phys. 7	General Physics	5	1	4	2

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Org.Chem. 1	Elementary Organic Chemistry	4	2	3	4
E.E. 13	Elements of Electrical Engineering	3	2	1	.....
E.E. 14	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Phys. 8	General Physics	5	1	4	2

Third Quarter

Course No.	Title	Credits	Rec.	Lect.	Lab.
Org.Chem. 2	Elementary Organic Chemistry	4	2	3	4
E.E. 15	Elements of Electrical Engineering	3	2	1	.....
E.E. 16	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Phys. 9	General Physics	5	1	4	2
Engl. 8	Explorations in Literature	3	.....	3	.....

JUNIOR YEAR

First Quarter

M.&M. 151	Differential Equations	3	3	.....	.....
Phys.Chem. 101	Physical Chemistry	3	1	3	.....
Phys.Chem. 104	Physical Chemistry Laboratory	2	1	.....	5
Phys. 100	Intermediate Physics	3	3	.....	.....
Phys. 107	Modern Physics	3	.....	3	.....
Phys. 144	Electrical Measurements	3	1	1	4

Second Quarter

M.&M. 152	Calculus III: Special Topics in Advanced Calculus	3	3	.....	.....
Phys.Chem. 102	Physical Chemistry	3	1	3	.....
Phys.Chem. 105	Physical Chemistry Laboratory	2	1	.....	5
Phys. 102	Intermediate Physics	3	3	.....	.....
Phys. 109	Modern Physics	3	.....	3	.....
	Electives*				

Third Quarter

M.&M. 153	Calculus IV: Special Topics in Advanced Calculus	3	3	.....	.....
Phys.Chem. 103	Physical Chemistry	3	1	3	.....
Phys.Chem. 106	Physical Chemistry Laboratory	2	1	.....	5
Phys. 104	Intermediate Physics	3	3	.....	.....
Phys. 111	Modern Physics	3	.....	3	.....
	Electives*				

SENIOR YEAR

First Quarter

Phys. 101	Theoretical Physics	5	5	.....	.....
Phys. 134	Experimental Optics	4	.....	.....	8
German 24	Chemical German	3	4	.....	.....
	Electives*				

Second Quarter

Phys. 103	Theoretical Physics	5	5	.....	.....
Phys. 110	Modern Experimental Physics	4	.....	.....	8
Phys. 136	Spectrum Analysis	4	.....	.....	8
German 25	Chemical German	3	4	.....	.....
	Electives*				

Third Quarter

Phys. 105	Theoretical Physics	5	5	.....	.....
Phys. 112	Modern Experimental Physics	4	.....	.....	8
or					
Elective					
German 26	Chemical German	3	4	.....	.....
	Electives*				

* For list of elective courses in other colleges, see page 53.

Recommended Electives for Physics Curriculum

Course No.	Title	Credits
Chem.E. 31	Chemistry of Engineering Materials	3
Econ. 3	Elements of Money and Banking	5
Econ. 8-9	General Economics, per quarter	3
Econ. 28	Business Law	3
E.E. 111	Junior Electrical Engineering	5
E.E. 113-115	Junior Electrical Engineering, per quarter	3
Engl. 21-22-23	Introduction to Literature, per quarter	5
Engl. 37-38-39	Twentieth-Century Literature, per quarter	3
Engl. 52-53	The English Novel, per quarter	3
Geol. 1-2	General Geology	6
Geol. A-B	General Geology Laboratory	4
Geol. 8	Introductory Geology	5
Hist. 1-2	European Civilization, per quarter	5
Hist. 4-5-6	English History	9
M.&M. 84	Technical Mechanics	5
M.&M. 154	Vector Analysis	3
M.&M. 155	Vector Analysis and Dyadics	3
M.&M. 156	Elements of Tensor Analysis	3
M.E. 5,9,13	Shop Practice, per quarter	2
Orient. 1-2-3	Man in Nature and Society, per quarter	3
Phil. 1	Problems of Philosophy	5
Phil. 2	Logic	5
Phil. 3	Ethics	5
Phil. 50-51-52	General History of Philosophy, per quarter	3
Phil. 154	Logic of Science	3
Phys. 52	Laboratory Arts	3
Phys. 61	Introduction to Geophysical Prospecting	3
Phys. 113	Intermediate Acoustics	3
Phys. 114-116-118	Elementary Physical Investigation, per quarter	3
Phys. 124	Pyrometry	3
Phys. 126	Advanced Heat	3
Phys. 134	Experimental Optics	3
Phys. 136	Spectrum Analysis	3
Phys. 146	Physics of Vacuum Tubes, Thermionics	3
Phys. 152	X Rays	3
Phys. 154	X-Ray Spectroscopy	3
Phys. 161-162	Principles of Geophysical Prospecting, per quarter	3
Phys.Chem. 116-117-118	Advanced Physical Chemistry, per quarter	3
Psy. 1-2	General Psychology, per quarter	3
Psy. 3	Psychology Applied to Daily Life	3
Zool. 1-2-3	General Zoology	10

ADDITIONAL ELECTIVE COURSES

For detailed schedules of classes see the programs of the respective departments in the Combined Class Schedule.

Course No.	Title	Credits	Prerequisites
Ast. 11	Descriptive Astronomy	5	None
French 1-2	Beginning French	10	None
French 3-4	Intermediate French	10	None
Geog. 11	Human Geography	5	3rd qtr. fr., soph., jr., sr.; none
Geog. 41	Geography of Commercial Production	5	Soph., jr., sr.; none
German 1	Beginning German A	5	None
German 2	Beginning German B	5	Ger. 1 or one year high school German
German 3	Beginning German C	5	Ger. 2 or two years high school German
German 4	Intermediate German	5	Ger. 3 or three years high school German

Course No.	Title	Credits	Prerequisites
Hist. 1-2-3	European Civilization	12	None
Hist. 4-5-6	English History	9	None
Hist 11-12-13	Medieval History	9	None (arch. only)
Hist. 20-21-22	American History	9	Soph., jr., sr.; none
Italian 1-2	Beginning Italian	10	None
Jour. 5	The American Newspaper	3	None
Lib.Meth. 1	Use of Books and Libraries	2	None (fr. and soph. only)
Phil. 2	Logic	5	Soph., jr., sr.; none
Phil. 153	Philosophy of Science	3	Phil. 2
Phil. 154	Logic of Science	3	Phil. 153
Pol.Sci. 1-2-3	American Government and Politics	9	None
P.H. 3	Personal Health	2	Fr., soph.; none
Psy. 1-2	General Psychology	6	None
Psy. 160	Psychology in Personnel Work	3	Psy. 1-2, Econ 8-9
Soc. 1	Introduction to Sociology	5	None
Span. 1-2	Beginning Spanish	10	None
Span. 3-4	Intermediate Spanish	10	Spanish 1-2 or two years high school Spanish
Sp. 1,2,3	Fundamentals of Speech	9	Engl 6
Sp. 5,6	Fundamentals of Speech	10	Engl 6
Study 1	How To Study	2	Permission of instructor

SUBSTITUTIONS

In order that students whose course of study is irregular may avoid delays on account of program conflicts or other difficulties, the following substitutions will be approved by petition. Additional credits thus earned may be applied as elective credits.

Course	Credits	Substitute Course	Credits
Aero.E. 115	3	M.&M. 180	3
Arch. 104	3	Arch. 106	3
Draw. 7	3	Draw. 1 and 2	6
8	3	3	3
21	2	28	2
26	2	28	2
28	2	26	2
M.&M. 84	5	M.&M. 26 and 127	10
85	3	128	5
86	3	129 and 143	5
87	1	141	2
91	4	24 and 25	10
92	4	26 or 84	5
93	4	85 or 128	4 or 5
Anal.Chem. 132	3	Anal.Chem. 105	3

DESCRIPTION OF COURSES

AERONAUTICAL ENGINEERING

Aeronautical Engineering laboratory fee (required of sophomores, juniors, and seniors in Aeronautical Engineering.) $3.00 per quarter.

1—Aeronautics. History. Nomenclature. Resistance of simple bodies. Theory of flight. The airplane and its parts. Constructional details. Performance. 3 cred.; prereq., M.&M. 24; 3 rec. hrs. per week.

2—Aircraft and Auto Engines. Principles and types. Electrical systems. Lubrication and cooling. Carburetors. Accessories. (Open only to aeronautical engineers or by petition.) 3 cred.; soph.; 2 lect., 1 quiz., and 2 lab. hrs. per week.

3—Aeronautics. Instruments. Meteorology. Avigation. 3 cred.; prereq., M.&M. 13; 3 rec. hrs. per week.

10-11—Pilot's and Navigator's Ground School. Elementary ground school course covering material necessary for the Civil Aeronautics Administration written examinations for private pilots. Civil Air Regulations, aerial navigation, aircraft instruments, meteorology, theory of flight, and general service and operation of aircraft. 3 cred. per qtr.; no prereq.; 3 lect. hrs. per week.

12—Pilot's and Navigator's Ground School. Survey of the requirements for the Civil Aeronautics Administration written examinations for the commercial pilot's certificate and the instrument rating. Includes aircraft engines, theory of flight, aeronautical meteorology, radio navigation, instrument flying, and Civil Air Regulations pertaining to instrument flight. 3 cred.; prereq., 10 and 11 or equiv.; 3 lect. hrs. per week.

83—Stresses in Simple Structures. Statically determinate trusses and beams. Graphic statics. Combined stresses. Airplane wing bracing. Short and long struts. 3 cred.; prereq., M.&M. 128; 3 rec. hrs. per week.

100-101-102—Aerodynamics. Atmospheric properties. Fluid mechanics. Stream functions and velocity potential. Motion of body in liquids in three dimensions. Prandtl's wing theory. Dynamic loads, stability, maneuverability, controllability. 3 cred. per qtr.; prereq., 1 and M.&M. 25; 3 rec. hrs. per week. Messrs. Boehnlein and Cronk.

103-104-105—Advanced Aerodynamics. 3 cred. per qtr.; prereq., 102 or special permission; 3 rec. hrs. per week. Mr. Boehnlein.

115—Airplane Stresses. Deflection of structures. Theory of statically indeterminate structures. 3 cred.; prereq., 83; 2 rec. and 2 lab. hrs. per week.

116—Advanced Airplane Stresses. Frames, space frameworks, secondary stresses, beams, columns, curved beams, rings, multispar and unit wing construction, monocoque fuselages. 3 cred.; prereq., 115 or M.&M. 180; 2 rec. and 2 lab. hrs. per week.

120-121-122—Airplane Design. Stress analysis of wings, fuselage, chassis, control surfaces, etc. Specifications. Performance and design calculations. Propellers. 120, 3 cred.; 121, 4 cred.; 122, 3 cred.; prereq., 83, 102, M.&M. 128; 1 lect. and 3 lab. hrs. per week for 120; 2 lect. and 6 lab. hrs. per week for 121; and 1 lect. and 6 lab. hrs. per week for 122.

123*-124*-125*—Advanced Airplane Design. Problems in airplane design or development. 2 to 5 cred. per qtr.; prereq., 121. Messrs. Akerman and Von Eschen.

126*—Propeller Design. Graphical and analytical methods of investigation. 3 cred.; prereq., 120. Mr. Akerman.

127*-128*—Advanced Problems in Airscrew Design. 2 to 5 cred. per qtr.; prereq., 126. Mr. Akerman.

140—Aeronautical Laboratory. Study of airplane parts and their construction. Fittings. Rigging. Inspection and accessories. 2 cred.; prereq., 102; 6 lab. hrs. per week. Messrs. Peilen and Ruszaj.

141—Aerodynamics Laboratory. Measurement of air flow. Calibration of Pitot tubes and anemometers. Distribution of air pressure on surfaces. Wind tunnel tests of wings, propellers, and airplane models. 3 cred.; prereq., 101 or registration in 101; 1 lect. and 6 lab. hrs. per week. Messrs. Boehnlein, Peilen, Ruszaj, and Cronk.

155—Aeronautical Calculations. 2 cred.; prereq., sr.; 2 rec. hrs. per week.

158—Physics of the Atmosphere. Study of physical properties of the air. Laws of pressure, temperature, density. Composition, structure, circulation of atmosphere. Troposphere and stratosphere. Basic effects on functioning of the human body, performance of aircraft. 2 cred.; prereq., jr. standing; 2 lect. and 1 rec. hr. per week. Mr. Piccard.

* Enrolment in these courses requires the approval of the professors from whom the courses are to be taken.

159—Inspection Trip. Various aircraft and aircraft engine manufacturing plants are visited during the spring vacation period. Written report covering this trip will be submitted. Required of seniors in Aeronautical Engineering. 1 cred. (Subject to cancellation.)

160—Lighter-Than-Air Craft. Theory and design. Rigid and non-rigid types. Stresses. Performance. 3 cred.; prereq., 83, 102, M.&M. 128; 2 lect. and 3 lab. hrs. per week. Mr. Piccard.

164—Problems Relating to the Stratosphere. 3 cred.; prereq., 102; 3 rec. hrs. per week. Mr. Piccard.

165*—Advanced Aeronautical Laboratory. Research problems in aeronautical engineering requiring laboratory or field research facilities. 2-4 cred.; prereq., 140 or 141; 1 lect. and 3 lab. hrs. per week. Messrs. Akerman and Piccard.

170—Air Transport. Economics. Airports and airways and their equipment. Air commerce rules and regulations. Communications. 2 cred.; prereq., open to jr. and sr. in Aero.E.; 2 rec. hrs. per week. (Cancelled for duration.)

173—Introductory Meteorology. Physics of the air especially as related to meteorological phenomena. Problems of pressure, temperature, and general circulation of the atmosphere. Laboratory work consists of practical applied problems concerning meteorological phenomena. 3 cred.; prereq., jr. or sr.; 2 lect. and 3 lab. hrs. per week. Messrs. Piccard and Hamilton.

174—Airways Meteorology. Study of air mass analysis. Application of the air mass analysis methods and polar front theory to construction and interpretation of synoptic charts for forecasting purposes. Use of thermodynamic diagrams and vertical cross sections. Preparation and analysis of synoptic maps; preparation of working forecasts. Organization and operation of airways meteorological service. Work in observatory for both ground and upper air observations. 4 cred.; prereq., 173; 1 lect. and 6 lab. hrs. per week.

175—Advanced Meteorology. Use of the thermodynamic charts. Construction and use of isentropic charts. Isobaric analysis and weather forecasting procedure based on Pettersen's theory of mathematical forecasting. Special application of forecasting to airline operations; general consideration to long range forecasting; continuous map analysis and forecasting work. 4 cred.; prereq., 174; 2 lect. and 6 lab. hrs. per week.

190-191-192—Seminar. Readings, reports, conferences, and discussions. 1 cred. per qtr.; prereq., 101; 1 rec. hr. per week. Messrs. Akerman and Piccard.

193*-194*-195*—Advanced Problems in Aeronautical Engineering. 2 to 5 cred. per qtr.; prereq., sr. or grad. in Aero. E. Messrs. Akerman, Piccard, Robertson, Boehnlein, and Von Eschen.

201*-202*-203*—Advanced Problems in Aerodynamics. 3 cred. per qtr.; prereq., 102 or special permission. Mr. Boehnlein.

260*—Advanced Airship Stresses. Coplanar and space rigid frameworks. Secondary stresses. Buckling and elastic instability. Framework of dirigibles, gondolas, and cabins. 3 cred.; prereq., 115.

272*-273*-274*—Research in Aeronautical Engineering. 2 to 5 cred. per qtr. Messrs. Akerman, Piccard, Robertson, and Boehnlein.

275*-276*-277*—Advanced Aircraft Engines. Advanced study of aircraft engines and auxiliary equipment, analysis of current developments, new accessories and installations. Theoretical analysis of their effects upon the performance of modern aircraft. 2 to 5 cred. Messrs. Akerman and Robertson.

For additional courses available to aeronautical engineers in:

Internal Combustion Engines, see Mechanical Engineering 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 250, 254.

Aeronautical Communication and Electric Power, see Electrical Engineering 46-47-48.

Advanced Strength of Materials, see Mathematics and Mechanics 180, 181, 182, 184, 185, 186, 294, 295, and 296.

AGRICULTURAL BIOCHEMISTRY

103‡—Dairy Chemistry. The physical, colloidal, and chemical properties of milk and dairy products, the chemistry of the various constituents of milk and the chemical

* Enrolment in these courses requires the approval of the professors from whom the courses are to be taken.

‡ A laboratory fee of $5 is required for each quarter of this course. The $5 card purchased from the cashier's office, University Farm, must be presented before laboratory space will be assigned; a $5 breakage card against which breakage can be charged must be purchased also.

technology of the manufacture of dairy products. 5 cred.; prereq., Anal. Chem. 1, 2, Org. Chem. 54, 55; 3 lect. and 9 lab. hrs. per week. Mr. Palmer.

108—Chemistry of Wheat and Wheat Products. Lecture course, with collateral library reference work, on chemical technology of the production and milling of wheat and its conversion into food. 3 cred.; prereq., Org. Chem. 54-55; 3 rec. hrs. per week. Mr. Geddes.

110‡—Flour Laboratory Methods. Analysis of wheat and its products. Designed to train students for the cereal industry. 3 cred.; prereq., 101-102 or food analysis; 12 lab. hrs. per week. Mr. Geddes.

113‡-114‡-115‡—Biochemical Laboratory Methods. Course paralleling the lectures in 119-123. 2 cred. per qtr.; prereq., quantitative analysis, reg. in 119-123; 6 lab. hrs. per week. Mr. Sandstrom.

119—Colloids. The colloidal state of matter, the preparation and properties of colloidal systems, and the relation of these to biochemical processes. 3 cred.; prereq., Org. Chem. 54 and one year of either zoology or botany; 3 rec. hrs. per week. Mr. Briggs.

120—Proteins. The composition, structure, chemical and physical properties, and the functions of proteins and amino acids. 3 cred.; prereq., 119; 3 rec. hrs. per week. Mr. Sandstrom.

121—Carbohydrates. The composition, structure, chemical and physical properties, and the functions of the carbohydrates. 3 cred.; prereq., 119; 3 rec. hrs. per week. Mr. Geddes.

122—The Lipids and Fats. The composition, structure, chemical and physical properties, and the functions of the fats and fat-like compounds. 3 cred.; prereq., 119; 3 rec. hrs. per week. Mr. Briggs.

123—Enzymes. Enzyme action, including the methods of preparation and investigation of enzymes and their function in biological and industrial processes. 3 cred.; prereq., 119; 3 rec. hrs. per week. Mr. Sandstrom.

AGRICULTURAL ECONOMICS

102—Farm Management: Organization. Characteristics of farming as a business; factors determining type of farming; farm tenure and selection; farm layout and improvements; factors affecting the selection of crops and livestock for a particular farm. 3 cred.; jr., sr.; prereq., 2 or Econ. 8, 9; 3 rec. hrs. per week. Mr. Pond.

103—Farm Management: Operation. Farm budgeting; personal and business factors affecting farm financial success; utilization of labor, power, and equipment; research methods and services. Special problem in farm planning. Field visit to well-managed farms. 3 cred.; jr., sr.; prereq., 102; 3 rec. hrs. per week. Mr. Pond.

AGRICULTURAL ENGINEERING

FARM STRUCTURES

5—Farm Structures Laboratory. Laboratory practice and study of farm building construction with different types of materials. (For professional agricultural engineers only.) 3 cred.; no prereq.; 2 lect. and 4 lab. hrs. per week. Mr. Christopherson.

37—Rural Sanitation and Water Supply. Wells, pumps, and water supply. Methods of securing sanitary water systems for farmsteads and rural institutions. Sanitary sewage disposal methods for homes, creameries, etc. 3 cred.; prereq., M.&M. 129; 3 lect. hrs. per week. Mr. Tyler.

44—Advanced Drawing. Plans and pictorial drawings, including perspective, charts, graphs, and co-ordinate plotting on various scales. Mapping. Illustrations for publication. 2 cred.; prereq., Draw. 2 or equiv.; 1 lect. and 4 lab. hrs. per week. Mr. Otis.

53—Farm Structures. Planning and economics of farm structures. 3 cred.; prereq., 5, Draw. 3 or equiv.; 2 lect. and 4 lab. hrs. per week. Mr. White.

67—Advanced Farm Structures Design. Planning, estimating, and designing of farm structures. Study of materials and equipment commonly used. 3 cred.; prereq., 5, 53, M.&M. 128; 1 lect., 1 rec., and 4 lab. hrs. per week. Messrs. White and Otis.

111-112-113—Farm Building Problems. Investigations in building materials, special designs, methods of construction, costs, and efficiency of farm buildings. 2 to 6 cred. per qtr.; sr.; prereq., 67; ar.; 305En(UF). Messrs. White, Christopherson, and Otis.

211-212-213—Farm Structures Research. Studies in farm structures as related to other factors in the farm business. 2 to 6 cred. per qtr.; prereq., 111; ar. Mr. White.

‡ A laboratory fee of $5 is required for each quarter of this course. The $5 card purchased from the cashier's office, University Farm, must be presented before laboratory space will be assigned; a $5 breakage card against which breakage can be charged must be purchased also.

FARM POWER AND MACHINERY

18—Agricultural Automotives. Principles of internal combustion engines and tractors including ignition, lubrication, carburetion, cooling, real gas cycles, transmission systems, and drive members. 4 cred.; prereq., Phys. 7; 2 lect. and 6 lab. hrs. per week. Messrs. Torrance and Strait.

43—Mechanical Laboratory. Instruction and laboratory practice in mechanical work, embracing rope work, belt lacing, and pulleys; cement work; soldering; welding; pipe fitting; electric wiring. 3 cred.; no prereq.; 1 lect. and 5 lab. hrs. per week. Mr. Dent.

52—Elements of Farm Machinery. Principles of development, construction, and use of agricultural machines. Drawbar power. 3 cred.; prereq., M.&M. 26; 1 lect., 1 rec., and 3 lab. hrs. per week. Mr. Schwantes.

71—Design and Economics of Agricultural Machinery. Machine and power costs of farm operations; operating principles and design problems. 3 cred.; prereq., 18, 52, M.E. 27; 1 lect. and 4 lab. hrs. per week. Messrs. Schwantes and Strait.

72—Applied Electricity. Lectures and laboratory work on topics important in the application of electric power to agriculture, including circuit theory, instruments, farmstead wiring, lighting, motors and controls, and storage batteries. (Offered only in alternate years, 1944-45. Alternate with Ag.E. 73.) 3 cred.; jr., sr.; prereq., Phys. 9; 2 lect. and 4 lab. hrs. per week. Mr. Hustrulid.

73—Steam Boilers and Heat Engines. Steam boilers and heat engines in their applications to agriculture. (Offered only in alternate years, 1945-46, etc. Alternate with Ag.E. 72.) 3 cred.; prereq., M.E. 131 and Ag.E. 18; 1 lect., 1 rec., and 4 lab. hrs. per week. Mr. Strait.

121-122-123—Farm Power and Machinery Problems. Special studies of farm machinery and mechanical power for the farm. Tests, design, and adaptability. 2 to 6 cred. per qtr.; prereq., 126; ar. Messrs. Schwantes and Hustrulid.

126—Selection and Management of Agricultural Machinery. Special problems in economical power and machine combinations and their application to the farm. 3 cred.; prereq., 18, 71, Ag.Econ. 102; 2 lect. and 3 lab. hrs. per week. Mr. Schwantes.

221-222-223—Farm Power and Machinery Research. Studies involving the design or utilization of power machinery used in connection with farm operation. 2 to 6 cred. per qtr.; prereq., 121; ar. Messrs. Schwantes and Hustrulid.

SOIL MOISTURE RELATIONS

21—Elements of Surveying. Use of tape, level, transit, traverse board in differential and profile leveling, cross sectioning, running tangents, and simple curves, topographic and agricultural surveys. Mapping, calculation of earth-work, and adjustments of instruments. 5 cred.; prereq., Draw. 3, M.&M. 12; 1 lect. and 12 lab hrs. per week. Messrs. Manson and Park.

51—Soil Moisture Relations. Principles and practices of irrigation, land drainage, and soil erosion control in relation to plant growth, farm operation, land development, and community interest. (Offered only in alternate years, 1945-46, etc. Alternate with Soils 108.) 5 cred.; prereq., 21 or reg. in 21, Soils 9, M.&M. 129 and 143 or reg. in M.&M. 129 and 143; 4 lect. and 1 rec. hr. per week. Messrs. Manson and Park.

101-102-103—Advanced Problems in Soil Moisture Regulation. Special problems in surface run-off, soil permeability, relation of soil and crop type to soil moisture, shape and regulation of water table in relation to root growth, etc. 2 to 6 cred. per qtr.; prereq., 51. Messrs. Manson and Park.

201-202-203—Research in Soil Moisture Relations. Studies of design and functioning of soil moisture control works with special reference to soil types and soil water conditions. 2 to 6 cred. per qtr.; prereq., 101, 102, or 103 and one qtr. Statistics; ar. Mr. Manson.

AGRONOMY AND PLANT GENETICS

1—Farm Crops. Important field crops of the United States with emphasis upon those of local importance, distribution, economic importance, agricultural classification, cultural methods, and principles of improvement and seed selection. 3 cred.; no prereq.; 3 rec. hrs. per week. Mr. Wilson.

ANIMAL AND POULTRY HUSBANDRY

1—Livestock Production. Opportunities and problems in livestock production. Survey of practices followed in the production of beef cattle, sheep, swine, and horses. Lectures and laboratory practice in classifying and appraising livestock. 3 cred.; jr., sr.; no prereq.; 3 lect. and 3 lab. hrs. per week. Mr. Harvey.

ARCHITECTURE

HISTORY AND THEORY

1-2-3—Introduction to Architecture. Discussions and problems to inform prospective students regarding the nature of architecture as an art and a profession. 1 cred. per qtr.; no prereq.; open only to students in architecture and students majoring in architecture; 1 rec. hr. per week. Mr. Roy Jones.

4-5-6—Graphic Representation. Projections, shades and shadows, perspective and other processes involved in architectural drawing. 5 cred.; no prereq.; 3 lect. and 12 lab. hrs. per week. Mr. Robertson.

51-52-53—History of Architecture. Same as F.A. 51-52-53. Significant architecture of the past, with particular reference to the geographic, social, and technical influences which produced it. 3 cred. per qtr.; prereq., soph. standing; 3 lect. hrs. per week. Mr. Robertson.

57-58-59—Building Materials and Methods. Principles, methods, and materials involved in the standard types of building construction. 6 cred.; no prereq.; 6 lect. hrs. per week. Mr. Robert Jones.

61-62-63—Tutorial Work in History of Architecture. Same as F.A. 61-62-63. 2 cred. per qtr.; prereq., 53; ar. Mr. Robertson.

67-68-69—Theory of Design. Basic principles of creative composition in space, color, and materials as applied to architectural, industrial, and interior design. 2 cred. per qtr.; prereq., consent of instructor; 2 lect. hrs. per week.

71-72-73—Building Equipment. Mechanical, electrical, and sanitary equipment of buildings. 6 cred.; prereq., soph. standing. Messrs. Robert Jones, Cerny, and Heath.

101-102-103—Building Materials and Methods (continued). 6 cred.; prereq., 59; 6 lect. hrs. per week. Mr. Robert Jones.

104—City Planning. Same as Econ. 111, Pol. Sci. 124, and Soc. 104. Social, economic, political, and technical phases of modern city planning. Intended for mature students in the College of Science, Literature, and the Arts and the Institute of Technology. 3 cred.; prereq., sr. or grad. standing; 3 lect. hrs. per week. Messrs. Robert Jones, Anderson, Chapin, Filipetti, and Vaile.

105—Professional Practice. Relations of the architect to client, contractor, and fellow-practitioners. Procedures of architectural practice. 2 cred.; prereq., sr. standing; 2 lect. hrs. per week. Mr. Roy Jones.

106—City Planning. Technical phases of modern city planning with special reference to the architects' functions therein. 3 cred.; prereq., sr. standing; 3 lect. hrs. per week. Mr. Robert Jones.

110—Architectural Acoustics. Principles, methods, and materials involved in the acoustical treatment of buildings. 2 cred.; no prereq.

For special courses for architects in structural engineering see Mathematics and Mechanics 91, 92, 93 and Civil Engineering 38, 39, 41.

DESIGN

Completion of these courses is dependent upon achievement, rather than time. Students will continue their registration until the course is completed and a mark is reported. An acceptable quality of work normally allows a rate of progress as indicated for each course.

Architectural

The object of the courses in architectural design is to develop the individual student's skill in creative effort as applied to the production of architecture. They provide opportunity for the student to exercise himself in all necessary phases of that creative effort, including especially research, composition, construction, and representation as four essential and interrelated parts of one unified process.

The courses consist of a series of problems, classified into three stages of advancement called grades, and culminating in a thesis whose satisfactory completion is a prerequisite for the degree in architecture. Most problems are done under criticism in which critics representing the several phases involved will collaborate. Certain problems are done entirely without criticism, in order to develop and test more fully the student's own power of independent achievement.

Work in all these courses is carried on simultaneously and continuously. A student may enter or leave them at any time he is judged ready to do so. They are administered by a design committee consisting of the major and consulting critics and Mr. Roy Jones, chairman. See also Statement Concerning Courses in Architectural Design issued by the School of Architecture.

AD-I‡—Architectural Design, Grade I. 10 cred.; prereq., 4, 5, 6; 10 lab. hrs. per week. Major critic, Mr. Cerny; consulting critic, Mr. Robert Jones (Construction).

AD-II‡—Architectural Design, Grade II. 15 cred.; prereq., AD-I; 15 lab. hrs. per week. Major critic, Mr. Cerny; consulting critic, Mr. Robert Jones (Construction).

AD-III‡—Architectural Design, Grade III. 45 cred. (normally 5 or 15 cred. per qtr.); prereq., AD-II. Major critic, Mr. Arnal; consulting critics, Mr. Robert Jones (Construction and Community Planning), Mr. Graves (Structural Engineering).

AD-IV‡‡—Architectural Thesis. 15 cred.; prereq., AD-III. Major critic, Mr. Roy Jones; consulting critics, Mr. Arnal (Composition), Mr. Robert Jones (Construction).

Interior

Problems dealing with the composition, decoration, and furnishing of interiors.

Arch. ID-I‡—Interior Design. 24 cred. (normally 8 cred. per qtr.); prereq., AD-II.

Stage

Problems dealing with the design of settings and costumes for dramatic productions.

Arch. SD-I—Stage Design. 4 cred. (normally 2 cred. per qtr.); no prereq. Mr. Burton.

DRAWING, PAINTING, AND MODELING

Completion of these courses is dependent on achievement rather than time. Students will continue their registration until the course is completed and a mark is reported. An acceptable quality of work normally allows a rate of progress for each course.

The object of these courses is to develop student's skill in esthetic expression through the medium of form and color. They consist of studio exercises divided into successive stages of advancement called grades. Work in most of the grades is carried on continuously. A student may enter or leave them at any quarterly interval he is judged ready to do so.

DP-I‡‡‡—Drawing and Painting, Grade I. Studies in graphic expression dealing with simpler composition in form and color. 6 cred. (normally 2 cred. per qtr.); no prereq.; 4 lab. hrs. per week. Mr. Young.

DP-II‡‡‡—Drawing and Painting, Grade II. Studies in graphic expression dealing especially with composition in color. 6 cred. (normally 2 cred. per qtr.); prereq., DP-I; 4 lab. hrs. per week. Mr. Young.

DP-III‡‡‡—Drawing and Painting, Grade III. Studies in graphic expression dealing especially with composition based on the human figure. 6 cred. (normally 2 cred. per qtr.); prereq., DP-II; 4 lab. hrs. per week. Mr. Burton.

DP-IV‡‡‡—Drawing and Painting, Grade IV. Studies in graphic expression dealing especially with advanced figure composition and mural decoration. 6 cred. (normally 2 cred. per qtr.); prereq., DP-III; 6 lab. hrs. per week. Mr. Burton.

DP-V—Drawing and Painting, Grade V. For graduate students only. Continuation of DP-IV. 6 cred. (normally 2 cred. per qtr.); prereq., DP-IV or equivalent. Mr. Burton.

M-I‡‡‡—Modeling, Grade I. Studies in plastic expression dealing with simpler compositions. 6 cred. (normally 2 cred. per qtr.); no prereq.; 6 lab. hrs. per week. Mr. Burton.

M-Ia—Modeling for Architects. Studies in plastic expression as applied to architectural composition. 2 cred.; prereq., reg. in Arch. Design; 4 lab. hrs. per week. Mr. Burton.

‡ A fee of $2 per quarter is charged for this course.

‡‡ A fee of $5 is charged for this course.

‡‡‡ A fee of $1 per quarter is charged for this course.

M-II‡—Modeling, Grade II. Studies in plastic expression dealing especially with the human figure. 6 cred. (normally 2 cred. per qtr.); prereq., M-I; 6 lab. hrs. per week. Mr. Burton.

M-III—Modeling, Grade III. For graduate students only. Continuation of M-II. 6 cred. (normally 2 cred. per qtr.); prereq., M-II or equivalent. Mr. Burton.

IHP-I—Illustration. Studies in graphic expression as applied to illustration. 2 cred.; prereq., DP-I or equivalent; 6 lab. hrs. per week. Mr. Young.

IHP-II—Hand Print Processes. Studies in graphic expression as applied to engraving, etching, drypoint, and lithograph. 4 cred. (normally 2 cred. per qtr.); prereq., DP-I or equivalent; 6 lab. hrs. per week. Mr. Young.

ASTRONOMY

51—General Astronomy. Fundamental facts and principles of astronomy. 3 cred.; prereq., M.&M. 12; 3 rec. hrs. per week. Mr. Luyten.

101*—Celestial Mechanics. 3 cred.; prereq., M.&M. 25; 3 rec. hrs. per week, ar. Mr. Luyten.

140*—Method of Least Squares. Combination and adjustment of observations and the discussion of their precision as applied to engineering, physics, astronomy, and psychology. 3 cred.; prereq., 51 or 11 and M.&M. 24; ar. Mr. Luyten.

BACTERIOLOGY AND IMMUNOLOGY

53‡‡—General Bacteriology. Principles and technique of general bacteriology; studies in the morphologic and biologic characters of the common bacteria; culture media; principles of sterilization and disinfection; examination of air, water, milk, food; relation of bacteriology to the industries. Lectures and laboratory. 5 cred.; prereq., 4 cred. of zoology or botany and Inorg. Chem. 10; 9 lab. hrs. per week.

103—Soil Microbiology. Studies of the microscopic inhabitants of the soil. Prereq., 53, and 15 cred. in chemistry; 9 hrs.; 5 cred.; 9 lab. hrs. per week. Dr. Skinner.

104—Sanitary Bacteriology. Standard and other methods for the bacteriological products. Preparation of standard culture media, technique and evaluating of results. Primarily for major in bacteriology. Limited to 15 students. 4 cred.; prereq., 53 and 15 cred. in chemistry; 6 lab. hrs. per week. Dr. Skinner.

114—Molds, Yeasts, and Actinomycetes. 4 cred.; prereq., Bact. 53; 6 hrs.; 6 lab. hrs. per week. MH. Dr. Henrici.

121-122§—Physiology of Bacteria. Effect of environment on growth; enzymes; food requirements; carbohydrates, protein, and fat metabolism; products of growth; dormancy; death. 6 cred.; prereq., 53 and 8 cred. of organic chemistry or biochemistry; 3 lect. hrs. per week. Dr. Halvorson.

123—Applied Bacteriology. Industrial fermentations; bacteriology of water and sewage; interpretation of bacteriological data. 3 cred.; prereq., 121-122; 3 lect. hrs. per week. Dr. Halvorson.

203—Seminar in Bacteriology. 1 hr.; 1 cred.; 1 rec. hr. per week. Staff.

BOTANY

1‡-2‡-3‡—General Botany. A survey lecture and laboratory course on plants and their human interest; fundamental facts of growth, structure, and reproduction of plants; principles underlying inheritance, variation, organic evolution, and relations to environment. 10 cred.; no prereq.; 2 lect. and 4 lab. hrs. per week. Messrs. Abbe, Huff, and Sharsmith.

4‡-5‡—General Botany. (See 1-2-3.) 3 lect. and 6 lab. hrs. per week.

10—Minnesota Plant Life. A study of our native wild flowers, trees, shrubs, ferns, liverworts, mosses, lichens, and mushrooms. A course for teachers, camp and scout leaders, and others who would know our native plants. Lectures, laboratory, and field work. 3 cred.; no prereq.; 3 lect. and 2 lab. hrs. per week. Mr. Huff.

12—Plants Useful to Man. A survey of the world's more important economic plants including sources of rubbers, oils, fibers, edible products, etc., with special attention to those of current strategic importance. Lectures, demonstration, and reference reading. 3 cred.; no prereq.; 3 lect. hrs. per week. Mr. Sharsmith.

* Courses 101 and 140 are usually offered in alternate years, and only one will be given in each year, depending on the demand.

‡ A fee of $1 per quarter is charged for this course.

‡‡ Microscope required. Students (except medical) may obtain use of microscope by purchasing $1.50 microscope card from bursar.

§ To receive credit for any part of this course, a student must complete both quarters.

154‡‡‡—Spectroscopy and Photochemistry Applied to Biology. Principles of absorption and emission spectroscopy, light measurements and photochemistry. Practice in the use of these methods for investigation of light effects in biological materials, and for the determination of pigments and enzymes. 3 to 5 cred.; prereq., 20 cred. in chemistry or biochemistry; 1 lect. and 3 to 5 lab. hrs. per week, Mr. French.

CHEMISTRY

INORGANIC CHEMISTRY*

1‡-2‡—General Inorganic Chemistry. (Agr., arch., predent, premed.) Study of the general laws of chemistry and of the nonmetals and metals and their compounds. 4 cred. per qtr.; no prereq.; 4 lect., 1 quiz, and 3 lab. hrs. per week for 1; 3 lect., 1 quiz, and 3 lab. hrs. per week for 2. Messrs. Barber and Pervier.

3‡—Semimicro Qualitative Analysis. (Agr.) Laboratory work in systematic qualitative analysis with lectures on solutions, ionization, chemical and physical equilibria, oxidation and reduction, etc. 4 cred.; prereq., 2; 3 lect. and 4 lab. hrs. per week. Mr. Barber.

4‡-5‡—General Inorganic Chemistry. Study of the general laws of chemistry and of the nonmetals and their compounds. More intensive than Course 1-2. 4 cred. per qtr.; prereq., high school chemistry; 3 lect., 1 quiz, and 3 lab. hrs. per week. Students doing unsatisfactory work in this course will be required to take two additional hours per week. Messrs. Reyerson, Heisig, and Maynard.

6‡-7‡—General Inorganic Chemistry. Study of the general laws of chemistry and of nonmetals, metals, and their compounds. 5 cred. per qtr.; no prereq.; 4 lect. and 5 lab. hrs. per week. Miss Cohen.

9*‡-10‡—General Inorganic Chemistry. Course 9: Study of general laws of chemistry and of nonmetals and their compounds. More intensive than Courses 6 and 7. Course 10: The metals and their compounds. 5 cred. per qtr.; prereq., one year of high school chemistry; 3 lect. and 6 lab. hrs. per week. Mr. Sneed, Miss Cohen, and Messrs. Klug and Taylor.

11‡‡§—Semimicro Qualitative Analysis. Laboratory work in systematic qualitative analysis with lectures on solutions, ionization, chemical and physical equilibria, oxidation and reduction, etc. 4 cred.; prereq., 2, 5, 7, 10, or 15; 3 lect. and 4 lab. hrs. per week. Mr. Reyerson, Miss Cohen, and Mr. Pervier.

12‡‡§-13‡‡—Semimicro Qualitative Analysis. Laboratory work in systematic qualitative analysis with lectures on solutions, ionization, chemical and physical equilibria, oxidation and reduction, etc. 5 cred. per qtr.; prereq., 7 or 10; 3 lect. and 6 lab. hrs. per week for 12; 2 lect., 1 quiz, and 8 lab. hrs. per week for 13. Mr. Sneed, Miss Cohen, and Messrs. Heisig and Taylor.

14‡-15‡—General Inorganic Chemistry. (Engrs. and miners without high school chem.) General laws of chemistry; the nonmetals, the metals, and their compounds. 4 cred. per qtr.; no prereq.; 3 lect., 1 quiz, and 5 lab. hrs. per week. Mr. Maynard.

16‡‡—Semimicro Qualitative Analysis. (Engrs. and miners.) Laboratory work in systematic qualitative analysis with lectures on solutions, ionization, chemical and physical equilibria, oxidation and reduction, and other subjects pertinent to qualitative analysis. 5 cred.; prereq., 5 or 15; 3 lect. and 6 lab. hrs. per week. Messrs. Heisig and Maynard.

96-97-98‡—Senior Thesis. 5 cred. per qtr.; sr.

101—History of Chemistry. Historical development of the theories of chemistry from the period of the ancients to the present time is covered by this course, particular emphasis being given to modern theories and laws. 2 cred.; prereq., Org. Chem. 52 or permission of instructor; 2 lect. hrs. per week. Miss Cohen.

* Students who have failed in 1, 4, 6, 9, or 14 may register for this course without further prerequisite.

‡ A fee of $2 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2 course fee, laboratory material, and breakage will be charged against the deposit.

‡‡ A fee of $2.40 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2.40 course fee, laboratory material, and breakage will be charged against the deposit.

‡‡‡ A fee of $3 is charged for this course.

§ In place of 16, Course 11 or 12 may be taken by students registered in the College of Engineering and Architecture and the School of Mines and Metallurgy.

102‡‡—Semimicro Qualitative Analysis. A course designed to acquaint the student with the universally applicable method and underlying principles in the identification of the more common cations by use of drop reactions on spot plate and filter paper, and separation by use of the centrifuge. 3 cred.; prereq., Anal. Chem. 1, 2. Mr. Barber.

103-104-105—Advanced Inorganic Chemistry. A discussion of selected topics in theoretical inorganic chemistry. Fall—The Chemistry of the Solid State. Winter—Atomic Structure and the Chemical Bond. Spring—Co-ordination Compounds. 3 cred. per qtr.; prereq., Anal. Chem. 1, 2, Org. Chem. 52; 3 lect. hrs. per week. Messrs. Klug, Maynard, and Taylor.

109‡-110‡—Synthetic Inorganic Chemistry. Methods of preparation and purification of inorganic compounds of special interest. Current literature. 3 to 5 cred. per qtr.; prereq., Org. Chem. 51; 2 lect., with lab.; ar. Mr. Heisig.

115‡—Commercial Products and Their Analysis. Study of current commercial products, their composition and methods of analysis. 5 cred.; prereq., Anal. Chem. 1 and 2; lect. and lab. Mr. Barber.

117‡—Glassblowing. Exercises in the more important operations in building chemical apparatus. 1 cred.; jr., sr., grad.; no prereq.; ar.

120—Crystal Analysis. Discussion of the theory and methods of crystal analysis. Crystal geometry; nature and production of X rays; interaction of X rays and crystals; methods of crystal analysis. 3 cred.; prereq., Phys. Chem. 103; 3 lect. hrs. per week. Mr. Klug.

121-122—Crystal Chemistry. Discussion of the relation between crystal structure and the chemical and physical properties of solids. The elements; alloys, solid solutions, intermetallic compounds; inorganic compounds, hydrates, ammoniates, silicates, glasses; ionic and atomic radii; the chemical bond in crystals; lattice energies; molecular rotation in crystals; fiber structure; applications to qualitative and quantitative analysis and to colloidal phenomena. 3 cred. per qtr.; prereq., 120; 3 lect. hrs. per week. Mr. Klug.

134-135-136—Seminar: Modern Problems in Inorganic Chemistry. 1 cred.; prereq., Anal. Chem. 1 and 2 and Phys. Chem. 103. Mr. Sneed.

301-302-303—Research in Inorganic Chemistry. Cred. ar. Messrs. Sneed, Reyerson, Barber, Miss Cohen, and Messrs. Heisig, Klug, Maynard, and Taylor.

ANALYTICAL CHEMISTRY

Credits obtained in Courses 144, Applied Spectroscopy in Biology, and 145, Advanced Spectroscopy in Biology, offered in the Department of Botany, are accepted for a major and a minor in analytical chemistry.

1‡-2‡—Quanitative Analysis. Introductory courses covering the general principles and methods of quantitative analysis. Typical problems are assigned and attention given to proper laboratory practice. Course 1, Gravimetric Analysis. Course 2, Volumetric Analysis. 5 cred. per qtr.; prereq., Inorg. Chem. 13; 1 lect., 1 rec., 1 quiz, and 9 lab. hrs. per week. Mr. Geiger.

7‡—Quantitative Analysis. (Premed.) Introductory courses covering the general principles and methods of quantitative analysis, both gravimetric and volumetric. Typical problems are assigned and attention is given to proper laboratory practice. 4 cred.; prereq., Inorg. Chem. 11, 12, or 16; 1 lect., 1 rec., 1 quiz, and 8 lab. hrs. per week. Messrs. Geiger and Meehan.

9‡—Quantitative Analysis. (Dentists, engineers, miners.) Short introductory course covering general principles of quantitative analysis, both gravimetric and volumetric. Typical problems are assigned and attention given to proper laboratory practice. 3 cred.; prereq., Inorg. Chem. 11, 12, or 16; 1 lect., 1 rec., and 6 lab. hrs. per week. Mr. Meehan.

96‡-97‡-98‡—Senior Topics. 5 cred. per qtr.; sr. Messrs. Kolthoff, Geiger, Sandell, and Meehan.

‡A fee of $2 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2 course fee, laboratory material, and breakage will be charged against the deposit.

‡‡A fee of $2.40 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2.40 course fee, laboratory material, and breakage will be charged against the deposit.

101‡-102‡—Quantitative Analysis. General principles, methods, and procedure of quantitative analysis, both gravimetric and volumetric. Typical problems assigned and attention given to proper laboratory practice. 5 cred. per qtr.; prereq., Inorg. Chem. 13; 12 lab. hrs. per week. Mr. Geiger.

103‡—Quantitative Inorganic Microanalysis. Representative methods of micro- and semimicrogravimetric, volumetric, and colorimetric analysis. 3 cred.; prereq., 1, 2; 1 lect., 6 hrs. of lab. ar. Class limited to 16 students. Mr. Sandell.

104‡—Qualitative Microchemistry. Use of microscope. Technique of handling small amounts of materials, inorganic qualitative analysis by means of crystal reactions and modern spot reactions. 3 cred.; prereq., 1, 2; 1 lect., 6 hrs. of lab. ar. Mr. Sandell.

105‡—Polarizing Microscope. Its use and application to chemistry. Identification of substances. 3 cred.; prereq., Phys. Chem. 101; 1 lect. hr. and lab. ar. per week. Mr. Sandell.

106‡-107‡-108‡—General Technical Analysis. Analysis of commercially important materials such as iron, steel, paper, and glass, also analysis of food materials. Use of microscope in technical problems. Quantitative analysis of heterogeneous mixtures, particle size determinations. 2 or 3 cred.; prereq., 1, 2; 1 lect. and 1 lab. hr. per week ar. Mr. Sandell.

109‡§—Rock Analysis. Laboratory course covering the technique of rock analysis. 3 cred.; prereq., 1, 2; 2 lab. hrs. ar. Mr. Ellestad.

122‡—Advanced Analytical Chemistry. Condensed review of modern fundamentals of gravimetric and volumetric analysis. 1 to 2 cred.; 1 lect., 1 rec., and 3 to 6 lab. hrs. ar. Mr. Geiger.

123‡—Advanced Analytical Chemistry. Analysis of complex materials by modern methods. 3 cred.; prereq., 1, 2, or by permission; 1 lect. ar., 6 lab. hrs. per week. Mr. Meehan.

127‡—Optical Methods in Analytical Chemistry. 2 to 3 cred.; prereq., Phys. Chem. 103; 2 lect. and lab. hrs. per week. Mr. Meehan.

131‡—Applications of Indicators in Neutralization Reactions and *p*H Determinations. 3 cred.; prereq., 1, 2, and Phys. Chem. 103; 2 lect. with lab. hrs. ar. per week. Mr. Kolthoff.

132*‡—Electrometric Measurements and Titrations. Application of potentiometric and conductometric methods in analytical work. 3 cred.; prereq., 1, 2, and Phys. Chem. 103; 2 lect. with lab. hrs. ar. per week. Mr. Kolthoff.

133‡—Voltammetry and Amperometric Titrations. A discussion of the use of the dropping mercury electrode (polarograph) and the platinum microelectrode in pure and applied chemistry. 2 to 4 cred.; prereq., Phys. Chem. 103; 2 lect. and lab. hrs. per week. Mr. Kolthoff.

134-135-136—Seminar: Modern Problems in Analytical Chemistry. 1 cred. per qtr.; prereq., 1, 2, and Phys. Chem. 103; 1 rec. hr. per week. Mr. Kolthoff.

137‡—Advanced Volumetric Analysis. 3 cred.; prereq., 131; 2 lect. with lab. hrs. ar. per week. Mr. Kolthoff.

140‡—Water Analysis. Analysis of potable water with interpretation of results. 2 cred.; prereq., 1, 2. Mr. Sandell.

201-202-203—Selected Topics in Analytical Chemistry. 3 cred. per qtr.; prereq., 1, 2, and 123. Mr. Kolthoff.

301-302-303—Research in Quantitative Analysis. Cred. ar. Messrs. Kolthoff, Geiger, Sandell, and Meehan.

ORGANIC CHEMISTRY

1‡-2†‡—Elementary Organic Chemistry. (Premed., predent., pharm.) Discussion of important classes of organic compounds, both aliphatic and aromatic. Laboratory work includes the preparation of typical substances. 4 cred. per qtr.; prereq., Inorg. Chem. 11; 3 lect., 1 lab. conference, 1 quiz, and 4 lab. hrs. per week. Messrs. Koelsch and Arnold.

54-55†-156—Elementary Organic Chemistry, Lecture Course. Jr., sr., first, second, and third qtrs. (All except premed., predent., and pharm.) Discussion of important classes of organic compounds, both aliphatic and aromatic, together with some heterocyclic

* For permissible substitute, see page 54.

† To receive credit for any part of this course a student must complete the parts preceding the dagger.

‡ A fee of $2 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2 course fee, laboratory material, and breakage will be charged against the deposit.

§ Registration limited. Permission of instructor must be obtained.

compounds. Courses 156 and 159 are prerequisite to all other advanced courses in organic chemistry. 3 cred. per qtr.; prereq., 15 cred. Chem.; 3 lect. and 1 quiz hr. per week. Messrs. Smith and Lauer.

57‡-58†‡-159‡—Elementary Organic Chemistry, Laboratory Course. To accompany Course 54-55-156. Preparation of typical substances; some original work. Must be accompanied or preceded by the corresponding quarter of 54-55-156. 2 cred. per qtr.; 1 lect. and 6 hrs. lab. work weekly. Courses 54-57; 55-58; and 156-159 take the place of Course 51-52-153. Messrs. Smith, Lauer, and Arnold.

96‡-97‡-98‡—Senior Thesis. 5 cred. per qtr.; sr. May be taken with any member of the staff of the Division of Organic Chemistry.

105-106-107—Advanced Organic Chemistry. Advanced descriptive course covering the field of organic chemistry, together with an introduction to the literature of organic chemistry. Lectures and outside reading. Ability to read German is assumed. 3 cred. per qtr.; prereq., 156 and 159 or equiv.; 3 lect. hrs. per week. Mr. Smith.

110‡‡—Organic Qualitative Analysis. Reactions of typical functional groups, identification of pure organic compounds, separation and identification of constituents of mixtures. 5 cred.; prereq., 156 and 159 or equiv.; 2 lect. and 9 lab. hrs. per week. Mr. Arnold.

130‡—Organic Quantitative Analysis. Methods of proximate and ultimate analysis of organic compounds, with special attention to semimicro methods. 2 or 3 cred.; prereq., 156 and 159 and Anal. Chem. 1 and 2; ar.; 1 lect. and 3 or 6 lab. hrs. per week. Mr. Lauer.

139‡—Advanced Organic Chemistry Laboratory Work. Selected laboratory problems of an advanced nature, including some original work. Ability to read German is assumed. Students are advised to take this course during the winter quarter. Permission of instructor is required to take it at any other time. 2 to 5 cred.; prereq., 156 and 159. Mr. Arnold.

140—Aromatic Compounds. Discussion of the chemistry of typical aromatic compounds, including derivatives of benzene, naphthalene, anthracene, phenanthrene, and other polynuclear hydrocarbons, together with a consideration of certain heterocyclic compounds which show aromatic character. The properties of these compounds will be illustrated by examples chosen from the sterols and the alkaloids. 3 cred.; prereq., 156 and 159; 3 lect. hrs. per week. Mr. Koelsch.

141—Reagents in Organic Chemistry. Discussion of typical reagents used in organic reactions; their limits of applicability, methods of use, and types of substances with which they react. 3 cred.; prereq., 156 and 159; 3 lect. hrs. per week. Mr. Koelsch.

142-143—The Chemistry of Natural Products. Discussion of the organic chemistry of important classes of natural products. 3 cred. per qtr.; prereq., 156 and 159; 3 lect. hrs. per week. Messrs. Lauer and Arnold.

156—See 54-55-156.

159—See 57-58-159.

201-202-203—Organic Chemistry Seminar. 1 hr. per week; 1 cred. per qtr. Required of all graduate students taking major work in Organic Chemistry. Messrs. Smith, Koelsch, Lauer, and Arnold.

205-206—Theoretical Organic Chemistry. Structure, reaction mechanisms, relation of physical properties to constitution, and other topics of a theoretical nature. 3 cred. per qtr.; prereq., 107. Mr. Lauer.

212—Physico-Organic Chemistry. Contributions made to organic chemistry by kinetic and equilibrium studies of organic reactions, including mechanisms of catalytic and ionotropic reactions; and an introduction to the current electronic formulations of organic reactions. Lectures, outside reading, and a term paper are required. 4 cred.; prereq., 107, Phys. Chem. 103, and calculus, or permission of instructor. Mr. Arnold.

301-302-303—Research in Organic Chemistry. Cred. ar.; prereq., 110. Messrs. Smith, Lauer, Koelsch, and Arnold.

† To receive credit for any part of this course a student must complete the parts preceding the dagger.

‡ A fee of $2 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2 course fee, laboratory material, and breakage will be charged against the deposit.

‡‡ A charge of $10 is made to cover special chemicals in this course.

PHYSICAL CHEMISTRY

96‡-97‡-98‡—Senior Thesis. 5 cred. per qtr.; ar.

101-102-103*—Physical Chemistry. General survey of the subject. 3 cred. per qtr.; prereq., two years of college chem., one year of college phys., differential and integral calculus. 3 lect. and 1 rec. hr. per week. Messrs. MacDougall and Allen.

104‡-105‡-106*‡—Physical Chemistry Laboratory. 1 or 2 cred. per qtr. To accompany or follow 101-102-103; 1 lab. conf. and 5 lab. hrs. per week. Mr. Allen.

107‡—Elementary Physical Chemistry. (Premed.) 6 cred. per qtr.; prereq., two years of college chem., one year of college phys.; 4 lect., 1 rec., and 6 lab. hrs. per week. Mr. Crawford.

113—Fundamentals of Reaction Kinetics. Order of reaction, collision theory, activation, chain reactions especially in gaseous systems. 3 cred.; prereq., 103. Mr. Livingston.

114—Kinetics of Reactions in Liquid Solutions and in Heterogeneous Systems. Effect of solvents and electrolytes on reaction velocity. Homogeneous and heterogeneous catalysis. 3 cred.; prereq., 113. Mr. Livingston.

116—Advanced Physical Chemistry. Thermodynamics. Designed to cover the fundamentals and the applications to chemical problems. 3 cred.; prereq., 103 and calculus. Mr. Crawford.

117—Advanced Physical Chemistry. Quantum theory and statistical mechanics, with emphasis on the applications to thermodynamic calculations and to reaction rates. 3 cred.; prereq., 103 and calculus. Mr. Crawford.

118—Advanced Physical Chemistry. Molecular structure and the nature of the chemical bond. 3 cred.; prereq., 117 or equivalent. Mr. Crawford.

128-129-130—Colloid Chemistry. General survey of surface chemistry, adsorption, catalysis, electrokinetic phenomena, lyophilic and lyophobic colloids. 2 cred. per qtr.; prereq., 103; twice a week.

131‡-132‡-133‡—Colloid Chemistry Laboratory. Cred. and hrs. ar. Must be preceded or accompanied by 128, 129, or 130.

175—Photochemistry. General survey, including a discussion of spectroscopy, with particular reference to the visible and ultraviolet absorption spectra of molecular gases. 3 cred.; prereq., 103 and Phys. 9. Mr. Livingston.

201-202-203—Thermodynamics and Chemistry. A detailed study of the principles of thermodynamics and their application to physical and chemical phenomena. 4 cred. per qtr.; prereq., 103 and calculus.

204-205-206—Kinetic Theory and Atomistics. Kinetic theory of gases and liquids, crystal structure of atom, quantum theory. 4 cred. per qtr.; prereq., 103 and calculus. Mr. MacDougall.

207—Modern Theories of Acidity and Basicity. 2 cred.; prereq., 103. Mr. Kolthoff.

211-212-213—Advanced Physical Chemistry Laboratory. To accompany or follow any of the advanced courses in physical chemistry. Cred. ar.; prereq., 103. Mr. MacDougall and staff.

221-222-223—Colloid Seminar. 1 cred. per qtr. Mr. Reyerson.

251-252-253—Physical Chemistry Seminar. Seminars in one or more special fields will be announced each year in September. Cred. and hrs. ar. Members of the staff.

264—Radioactivity Laboratory. Use and standardization of electroscopes, radioactive measurements, and quantitative determination of radium in ores, minerals, waters, and plant products. 1 or 2 cred. Must be preceded or accompanied by 161.

301-302-303—Research in Physical Chemistry, including work in electrochemistry, photo- and radio-chemistry, colloids, and crystal structure. Cred. ar. Messrs. MacDougall, Kolthoff, Lind, Reyerson, Crawford, and Klug.

A colloquium for graduate students in Physical, Analytical, and Inorganic Chemistry, carrying no credit, is held weekly. Mr. Livingston.

CHEMICAL ENGINEERING

31—Chemistry of Engineering Materials. Application of general chemistry in engineering practice. Technology and properties of wood, alloys, fuels, water, lubricants, cements, coating materials, plastics, etc. 2 cred.; prereq., Inorg. Chem. 16; 3 lect. hrs. per week. (Not open to chem. engrs.) Mr. Montonna.

* Physical Chemistry 101-102-103, 104-105-106, 107, will be acceptable in partial or complete fulfillment of the course requirements for a minor in physical chemistry, for students who are not majoring in chemistry.

‡ A fee of $2 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2 course fee, laboratory material, and breakage will be charged against the deposit.

76‡-77‡—Applied Electrochemistry. Application of the electric current to chemical processes. Laws and phenomena of electrochemistry, batteries, electroplating, electric furnace construction and operation, and electrochemical products. Engineers with one year of chem. and one year of phys. 3 cred. per qtr.; 2 lect. and 4 lab. hrs. per week.

80—Chemical Engineering Materials. The technology, physical and chemical properties, and economic considerations of materials used in the construction of chemical engineering equipment and plants. Metals and alloys; woods, cements, ceramic and plastic materials; textiles; rubber; protective materials, etc. 1 cred.; prereq., Inorg. Chem. 13; 2 lect. hrs. per week.

101—Unit Operations. Unit operations, and materials of construction, performance, and uses of equipment. Crushing, grinding, size separation, fluid flow, and problems in chemical stoichiometry. 3 cred.; prereq., 80, Anal. Chem. 1, 2; 2 lect. and 2 rec. hrs. per week. Messrs. Mann, Stoppel, and Pike.

102‡—Unit Operations. Continuation of 101 with discussions on filtration, heat transfer, evaporation, humidification, and air conditioning and drying. Their applications including economic balance and the solution of problems. 6 cred.; prereq., 101; 3 lect., 3 rec., and 4 lab. hrs. per week. Messrs. Mann, Stoppel, and Pike.

103‡—Unit Operations. Continuation of 101 and 102. Discussions and problems on distillation, absorption, extraction, and crystallization. 6 cred.; prereq., 102; 3 lect., 2 rec., and 4 lab. hrs. per week. Messrs. Mann, Piret, Stoppel, and Pike.

105*‡—Fuels and Combustion. The technology of solid, liquid, and gaseous fuels, analysis, combustion characteristics, specific uses, and furnaces. Calculation of heat and material balance. 4 cred.; prereq., Anal. Chem. 1, 2; 2 lect., 2 rec., and 4 lab. hrs. per week. Messrs. Stoppel and Pike.

106‡—Petroleum and Petroleum Products. Technology and testing of petroleum products, principally gasoline, lubricating oils, and fuel oils. Lectures and laboratory. 3 cred.; prereq., Org. Chem. 51, or by permission; 3 lect. and 4 lab. hrs. per week. Mr. Stoppel.

107—Petroleum Refinery Engineering. Unit operations and chemical engineering design principles and calculations involved in the manufacture of the principal petroleum products. Lectures and recitations. 3 cred.; prereq., 103 or permission of instructor; 3 lect. hrs. per week. Mr. Pike.

117-118—Chemical Engineering Equipment Design. Fundamental principles in the design of simple chemical engineering equipment. Recitation and drawing room. 3 cred.; prereq., 103; 3 rec. and 4 lab. hrs. per week. Mr. Montonna.

119-120—Chemical Engineering Thermodynamics. A study of the principles of the three fundamental laws of energy as applied to chemical engineering problems. Lectures and recitations. 3 cred.; prereq., 103; 3 rec. hrs. per week.

121—Chemical Engineering Economics. The economic and business considerations controlling chemical engineering industries and their statistical analysis. Economic factors affecting plant location, layout, and design. Unit operation costs. Principles of management, operation, and control. 3 cred.; prereq., 131; 3 lect. hrs. per week. Mr. Montonna.

131—Inorganic Technology. Applications of unit operations common to chemical industries, chemistry involved, equipment used, marketing of products, utilization of by-products, use of trade journals. Topics: industrial water, acids and alkalies, salts, chlorine, ammonia, glass, pigments, etc. Lectures and recitations. 4 cred.; prereq., (for chem. engrs.) 102; (for chem.) Anal. Chem. 1, 2; 4 lect. and 4 rec. hrs. per week. Mr. Mann.

132†—Organic Technology. Similar to 131 but covering organic field. Destructive distillation of coal and wood, petroleum, organic processes, synthetic products, plastics, cellulose products, etc. 3 cred.; prereq., (for chem. engrs.) 103 and 131; 4 cred. per qtr.; prereq., (for chem.) Org. Chem. 55; 4 lect. and 1 rec. hr. per week. Mr. Mann.

134—Intermediates and Dyestuffs. Their technical chemistry and manufacture. Processes, purification, uses, etc. Lectures and recitations. 3 cred.; prereq., Org. Chem. 153. (May be accompanied by laboratory work in 160.) 3 lect. hrs. per week. Mr. Montonna.

136—Chemistry and Technology of Cellulose. Processes and industries based on the use of cellulosic materials including the chemical and technological considerations. Pulp and paper, plastics, esters, rayon, etc. 3 cred.; prereq., Org. Chem. 156; 3 lect. hrs. per week. Mr. Montonna.

* Each laboratory section is limited to 16 students.

† Chemists receive 4 credits in Organic Technology as they do not take Unit Operations.

‡ A fee of $2 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2 course fee, laboratory material, and breakage will be charged against the deposit.

151*‡—Chemical Manufacture (Inorganic). Manufacture of technical products on a scale large enough to afford data for the determination of operating conditions and costs of manufacture. Use of semi-plant scale equipment. Technical trade journals used. Laboratory. 3 or more cred.; prereq., 103, 131.

152*‡—Chemical Manufacture (Organic). Similar to 151 but covering the unit organic processes. Laboratory. 3 or more cred.; prereq., 103, 131.

153‡-154‡-155‡-156‡—Special Problems. Investigations in chemical engineering. Library or laboratory research. 3 or more cred. per qtr.; 1 conference hr. and 2 lab. periods ar. Chemical Engineering staff.

160‡—Intermediates and Dyestuffs Laboratory. Manufacture of intermediates and dyestuffs using semi-works equipment. Operations on sulphonation, hydroxylation, nitration, reduction, alkylation, diazotization, coupling, etc. Laboratory. 3 or more cred.; prereq., 131, 152, and preceded or accompanied by 134. Mr. Montonna.

176‡-177‡—Applied Electrochemistry. Application of the electric current to chemical processes. Laws and phenomena of electrochemistry, batteries, electroplating, electric furnace construction and operation, and electrochemical products. 4 cred. per qtr.; prereq., Phys. Chem. 103, or by permission; 3 lect. and 4 lab. hrs. per week.

179‡—Applied Electro-Organic Chemistry. Theory and practice of the electrochemistry of organic compounds. 3 cred.; prereq., 176-177 or by permission; 3 lect. hrs. per week. Mr. Mann.

201-202-203—Seminar. Presentation and discussion of papers concerning the newer developments in chemical engineering. 1 cred. per qtr. Mr. Mann.

205-206-207—Advanced Problems in Unit Operations. A study of new developments in the unit operations. Theory and practical applications to equipment and plant process design including economic balance problems. 3 cred. per qtr.; prereq., 103. Mr. Piret.

211-212-213—Chemical Engineering Plant Design. Planning of plants and design of equipment based on collected data for the same. Classroom and drawing room work. 3 cred. per qtr.; prereq., 103; ar. Mr. Piret.

301-302-303—Research in Chemical Engineering. Unit operations, applied electrochemistry and electric furnace work, and chemical manufacture. Cred. ar. Messrs. Mann, Montonna, Piret, and Stoppel.

CIVIL ENGINEERING

SURVEYING

11—Surveying. Lectures and field problems; use of steel tape and transit. Computation and platting of field notes, determination of areas. 3 cred.; prereq. M.&M. 12, Dr. 2; 1 lect. and 7 lab. hrs. per week.

12—Surveying. Lectures and drafting room. Platting of profiles and mass diagrams, computation of earthwork volume and overhaul. Public land survey. Mapping and conventional signs. 3 cred.; prereq., 11; 1 lect. and 7 lab. hrs. per week.

13—Surveying. Lectures and field problems; differential and profile leveling; cross sections, circular curves, and adjustment of instruments. 3 cred.; prereq., 12; 1 lect. and 7 lab. hrs. per week.

14—Surveying. Complete topographical survey, stadia method, is made and platted. 3 cred.; prereq., 13; 1 lect. and 7 lab. hrs. per week.

15—Surveying. Purpose and theory of triangulation, meridian determination, base line measurements, computations. Theory and use of the sextant. Hydrographic surveying. Aerial mapping. Applied problems. 2 cred.; prereq., 14; 4 lect. hrs. per week. Mr. Zelmer.

16—Surveying. Classroom and field. Field problems with the sextant. Triangulation reading and computations. Plane table theory. Various field solutions of the "three point" problem. Plane table survey based on triangulation control. Topographic map. 2 cred.; prereq., 15; 2 lect. and 4 lab. hrs. per week.

17—Surveying. Short course including problems in chaining, transit and tape surveys; differential, trigonometric and profile leveling, computations and platting of notes, etc. Open to students other than civil engineers. 3 cred.; prereq., M.&M. 12; 8 lab. hrs. per week.

23—Summer Camp. Six weeks immediately preceding the beginning of the senior year. Not given during war emergency. A portion of the work of the summer camp session

* Required of undergraduate chemical engineers during Summer Session. Open only to graduate students fall and winter.

‡ A fee of $2 per quarter is charged for this course. The student should purchase a $5 chemistry deposit card from the bursar, in the Administration Building. No student will be assigned a desk in the laboratory until he presents this card. The $2 course fee, laboratory material, and breakage will be charged against the deposit.

may be given at the campus during the University Summer Session. 3 to 5 cred.; prereq., 16, 22.

109—Cadastral Surveying. Study of the newer methods of accurate surveys of property with geodetic control and with co-ordinates of property monuments. 2 cred.; prereq., 16; 2 lect. hrs. per week.

110—Errors in Surveying. Study of the sources, importance, and reduction of errors in surveying. 2 cred.; prereq., 23; 2 lect. hrs. per week.

111—Methods of Computation. Study of the methods used in various problems in precise and geodetic surveys and distribution of errors. 2 cred.; prereq., 110; ar.

RAILWAY ENGINEERING

21—Railway Engineering. General survey of the problems of railway location, including grades, curvature, rise and fall, etc. 2 cred.; prereq., 13; 1 lect. and 4 lab. hrs. per week.

22—Railway Engineering. Study of the construction and maintenance of railway track and structures. Simple, compound, and spiral curves, and turnouts. 2 cred.; prereq., 21; 1 lect. and 3 lab. hrs. per week.

121—Railway Engineering. Train resistance, ruling and momentum grades, curvature, distance, rise and fall as factors in the revision and operation of railroads. Train loading, acceleration, retardation; locomotives and equipment. Operating costs governing grade revision. 3 cred.; prereq., 22; 1 lect. and 6 lab. hrs. per week.

122—Railway Engineering. Lectures, office work, and field inspection. Design and operation of various types of yards and terminals, and terminal facilities, including the hump, engine house, coal and water station. 3 cred.; prereq., 22.

123—Railway Engineering. Design and construction of railroad buildings and structures; culverts, wooden trestles, switches, crossovers, crossing frogs, etc. 3 cred.; prereq., 22.

124—Transportation. Development of railway and inland waterway transport, railway regulation and control with special reference to the 1920 Railway Transportation Act, and its later amendment, geographical, financial, and rate grouping of railways. Interstate Commerce Commission method of accounting and organization. 3 cred.; prereq., 21; 3 lect. hrs. per week.

221-222-223—Railway Administration. Analysis of railway organization and methods of management and operation. Special problems. 3 cred. per qtr.; prereq., 122.

224—Railway Terminals and Yards. Continuation of Course 123. 3 cred.; prereq., 122.

STRUCTURAL ENGINEERING

31—Stresses in Structures. Analytical and graphic analysis of various types of bridge roof trusses and portals for fixed and moving loads. 2 cred.; prereq., M.&M. 26; 2 lect. and 2 lab. hrs. per week.

32—Stresses in Structures. Analysis of simple span bridge trusses. Standard engine loadings, highway truck loadings, and equivalent uniform loads. 3 cred.; prereq., 31; 2 lect. and 2 lab. hrs. per week.

33—Elementary Structural Design. Designing principles and methods. Complete designs and detail drawings of typical simple structures. 4 cred.; prereq., 32, M.&M. 128, Dr. 23; 2 lect. and 6 lab. hrs. per week.

37—Structural Engineering. (Ag.E., M.E., E.E.) Elementary structural analysis and design in wood, steel, and reinforced concrete. 3 cred.; prereq., M.&M. 26 or 84; 1 lect. and 3 lab. hrs. per week.

38-39-41—Structural Design (Arch.). General principles of structural design. Roof trusses. Structural steel, timber, and reinforced concrete as applied to building construction. 3 cred. per qtr.; prereq., M.&M. 93; 3 lect. hrs. per week.

130—Statically Indeterminate Structures. Theory of deflections and statically indeterminate stresses and their application to redundant members and reactions, continuous beams, and frames. 3 cred.; prereq., 33, M.&M. 128; 2 lect. and 2 lab. hrs. per week.

131—Analysis of Bridges and Buildings. Analysis of bridges and buildings, with special emphasis on continuity. 2 cred.; prereq., 130; 1 lect. and 3 lab. hrs. per week.

132—Design of Bridges and Buildings. 2 cred.; prereq., 131; 1 lect. and 3 lab. hrs. per week.

135—Advanced Structural Design (Arch.). Analysis of structures as rigid frames. Wind stress analysis. Effect of temperature, and settlement of foundations. Applications to steel and concrete frames. 3 cred.; prereq., 41.

137—Structural Laboratory. Theoretical and experimental analysis of structural members and models. 2 cred.; prereq., 130, 141; 1 lect. and 3 lab. hrs. per week. (Limited to 16 students each section.)

141—Reinforced Concrete. Principles of reinforced concrete. Theory of beams, slabs, and columns, and the application to ordinary structures. 3 cred.; prereq., 33; 2 lect. and 2 lab. hrs. per week.

142—Reinforced Concrete Design. Continuation of 141 with special emphasis on the practical features of the design of buildings, bridges, retaining walls, footings, etc. 3 cred.; prereq., 130, 141; 2 lect. and 2 lab. hrs. per week.

143—Reinforced Concrete Arches. Analysis and design of reinforced concrete arches and rigid frame bridges. 3 cred.; prereq., 130, 142.

146—Plain Concrete. Design and control of concrete mixtures. Practice in control tests of concrete and concrete materials. Lectures and laboratory work. 3 cred.; prereq., M.&M. 141; 2 lect. and 4 lab. hrs. per week. (Limited to 16 students per qtr.)

147—Foundations. Design and construction of footings, cofferdams, and caissons for bridges and buildings. Piers, abutments, and sheet piling. Exploration and testing of foundation sites. Excavation and removal of materials from foundation site. 2 cred.; prereq., 33, 141; 2 lect. hrs. per week.

148-149-150—Advanced Concrete. Short research problems in concrete. 2 cred. per qtr.; prereq., 146; ar.

180-181-182—Advanced Structural Laboratory. Special problems. 3 to 5 cred. per qtr.; prereq., 137.

234-235—Advanced Theory of Structures. Application of the theory of indeterminate stresses to the more complex problems of structural analysis. Continuous and swing bridges, simple and multiple arch and suspension systems, wind stresses in tall building frames, secondary stresses. 3 to 5 cred. per qtr.; prereq., 132, 142.

236—Advanced Structural Design. Effect of shrinkage and plastic flow. Eccentrically loaded concrete sections. Nonsymmetrical bending. Lateral earth pressure theories. Design of sheet piling, bearing piles, and cofferdams. 3 to 5 cred.; prereq., 131, 147.

245-246-247—Seminar. Special topics in the theory of structures. 3 to 6 cred. per qtr.; prereq., 131, 142.

HIGHWAY ENGINEERING

51-52—Highways and Pavements. Elementary course with field inspection, relating to the economics, location, construction, and maintenance of highways and pavements. 3 cred. per qtr.; prereq., 12; 2 lect. and 3 lab. hrs. per week for 51; 1 lect., 1 rec., and 4 lab. hrs. per week for 52. (Lab. sec. limited to 12 students.)

151—Advanced Highway Laboratory. Special experimental studies of highway materials. 3 to 5 cred.; prereq., 52.

152—Highway Design. Preparing of a plan and specifications for short sections of highways and city streets, also making estimates of materials and cost. 3 to 5 cred.; prereq., 52.

153—Engineering Properties of Soils. Origin and composition, characteristics, structural properties, and practical design and construction. 3 cred.; prereq., jr. or sr.; 3 lect. hrs. per week.

154—Soils Laboratory. Laboratory study of properties of soils which pertain to their stability. 1 cred.; prereq., jr. or sr.; ar.

155—Field Soil Studies. Soil classification and mapping, analysis of soil conditions where road failures have occurred. 2 cred.; prereq., 52.

156—Traffic Engineering. Co-ordination of elements of transportation system for the movement of traffic. Studies of roads, street layouts, intersections and bottlenecks; mechanical means for regulating traffic; operating characteristics of vehicles, driver behavior. Methods of prevention of accidents and traffic congestion. 2 cred.; prereq., jr. or sr.

157—Highway Economics. Annual highway costs, effect of highway location and design on motor vehicle operating costs. Economical significance of highway accidents. Allocation highway costs to motor vehicle owners and general public. Economics of highway administration, finance, and taxation. 2 cred.; prereq., jr. or sr.

158—Airport Design. Field layout, drainage, and studies of sub-bases, bases, and surfaces for aprons, runways, and taxiways. 3 to 5 cred.; prereq. 52.

HYDRAULIC ENGINEERING

160—Hydrology. A study of the fundamental aspects of hydrology as the natural basis for hydraulic engineering work. Laws, influences, variations in hydrological phenomena and their relation to engineering. Studies of the atmosphere, wind and storm movement, hydrography, precipitation, evaporation, water storage, and stream run-off. Geology, flood flows. 3 cred.; prereq., M.&M. 129; 3 lect. and 3 lab. hrs. per week.

161—Power. Elementary hydrology; precipitation, evaporation, transportation, run-off, storage, and lake levels, types of water power development; dams, waterways, penstock, turbines, and accessory equipment. 4 cred.; prereq., M.&M. 129; 2 lect. and 5 lab. hrs. per week.

164—Water Conservation. Weather variations and cycles, variable stream flow and water levels with respect to control in problems of public water supply, sewage disposal, water power, navigation, floods, and low water. National and state water conservation policies with discussion of typical problems. 3 cred.; prereq., 160, 161, or equiv., or by permission; hrs. ar.

166—Water Power. Stream flow and water power estimates. Storage problems. Analysis, design and selection of water power structures and equipment. Types and purposes of dams. Turbine analysis. Transmission lines. Cost and value of water power. Typical problems, inspection trips. 3 cred.; prereq., 160 or 161; 2 lect. and 3 lab. hrs. per week. Recommended for seniors in Sanitary Engineering. See C.E. 160. C.E. 160 and 166 may be substituted for required course, C.E. 161.

168—Irrigation and Drainage Applications of Hydrology to the Irrigation of Arid and Semi-Arid Regions. Water duty, diversion, storage, controlling, and transmission works. Cost estimates. Hydrology of drainage. Legal rights. Surface and ground water, survey problems in interception and diversion, storage, channels, ditches, miscellaneous structures. Pumping. Relations to public health and water conservation. Typical problems. 3 cred.; prereq., 160 or 161; 2 lect. and 3 lab. hrs. per week.

263—Advanced Hydraulic Engineering Problems. Special hydraulic problems in laboratory, drafting room, and field. 3 to 5 cred.; prereq., 164.

SANITARY ENGINEERING

61—Sanitary Engineering Practice. Introduction to sanitary engineering. Inspection of sanitary engineering works, lectures, field work, and laboratory work designed to correlate previous studies in surveying, hydraulics, chemistry, and bacteriology to the field of sanitary engineering. 3 cred.; prereq., jr.; 2 lect. and 3 lab. hrs. per week.

140—Structural Problems in Sanitary Engineering. Earth pressures; retaining walls; reservoirs and tanks of steel and reinforced concrete; filters and settling basins, pipes and culverts; footings and raft foundations; shells, arches, and domes. 2 cred.; prereq., sr.; 2 lect. hrs. per week.

162—Water Supply. Sources of water supply; characteristics of water; quantities and rates; quality of water, collection, distribution, and water purification; test methods; selection of equipment. Laboratory problems in analysis and design. Inspection trips. 3 cred.; prereq., 161, M.&M. 129; 2 lect. and 4 lab. hrs. per week.

163—Sewerage and Sewage Treatment. Sources and quantities of sewage; sanitary, storm, and combined sewer systems; materials and methods of construction; sewer appurtenances; pumping equipment, physical, chemical, and biological characteristics of sewage. Disposal by dilution, domestic and industrial waste treatment. Laboratory problems in analysis and design. Inspection trips. 3 cred.; prereq., 162; 2 lect. and 4 lab. hrs. per week.

165—Public Health Engineering. Sanitary problems associated with the location, construction, and operation of water supplies, purification works, and distribution systems, with the treatment and disposal of sewage, excreta, and waste, and with the production, pasteurization, and distribution of milk. Public health engineering methods as applied to sanitary problems in urban and rural communities including schools, institutions, camps, bathing places, dwellings, etc. Lectures, field and laboratory demonstrations. 3 cred.; prereq., P.H. 50.

167—Industrial Hygiene Engineering. Field and laboratory methods used by the industrial hygiene engineer in the study and control of occupational health hazards. Lectures, field and laboratory demonstrations. 3 cred.; open to sr.

169—Hydraulic Problems (Sanitary Engineering). Advanced problems having special reference to the hydraulic features of sanitary works. Flow through pipes, open channel flow, backwater and drawdown computations. Pumps, mechanical and electrical equipment governing hydraulic installations. 3 cred.; prereq., sr.; 3 lect. hrs. per week.

171—Building Sanitation. Location and orientation of buildings; lighting, ventilation, water supply, plumbing, sewerage, and refuse disposal. 2 cred.; prereq., sr. arch. only; 2 lect. hrs. per week.

173—Sanitary Engineering Problems (Water). Investigations of problems in water supply to supplement C.E. 162. Collection, distribution, and purification. Economic studies. 3 cred.; prereq., 162; hrs. ar.

174—Sanitary Engineering Problems (Sewage and Industrial Wastes). Investigations of problems in sewage treatment and industrial wastes disposal to supplement C.E. 163. Stream pollution, stream standards, economic studies of various types and degrees of treatment. 3 cred.; prereq., 163; hrs. ar.

175—Industrial Waste Disposal. Investigation of quality of various types of industrial wastes and of methods of disposal. Economic studies. 3 cred.; prereq., 163; hrs. ar.

179—Sanitary Laboratory. The biological, bacteriological, physical, and chemical analyses of water, sewage, milk, shellfish, air, filter-science, coagulant chemicals, disinfectants, sewage sludge, etc. 3 cred.; prereq., sr.; 8 lab. hrs. per week.

191-192-193—Sanitary Engineering Seminar. Required of sr. and grad. students. Attendance desirable for juniors in the curriculum. Reports and discussion on assigned topics in the field of sanitary engineering with occasional talks by practicing sanitary engineers on subjects of interest. 1 cred.; prereq., sr.; 1 rec. hr. per week.

261-262—Water and Sewage Plant Design. Design of water purification and sewage disposal works. 3 to 5 cred. per qtr.; prereq., 163.

264—Sanitary Engineering Unit Operations. Lectures, laboratory studies, and plant-scale studies on screening, sedimentation, chemical coagulation, aeration, filtration, disinfection of water with chlorine, disinfection of air, heat transfer, pastuerization, handling of material, humidification and air conditioning, drying, incineration, and digestion. 3 cred.; prereq., grad.; 1 lect. and 6 lab. hrs. per week.

275—Industrial Waste Disposal. Investigation of quality and quantity of various types of industrial wastes, and of methods of disposal. Economic studies. 3 cred.; prereq., grad.

GENERAL

53—Civil Engineering Practice. Greater problems of engineering. Interrelations of various branches of engineering in practice. Legal, financial, and business functions of the engineer. Relations of the engineer to government and public affairs. 3 cred.; open to jr. and sr.; hrs. ar.

172—City Planning. Physical elements of the city; topography, drainage, geology. Public works and structures. Internal and external transportation. Zoning. Subsurface structures. Esthetic features of the city. 3 to 5 cred.; prereq., 52; hrs. ar.

176—Public Works Engineering. An introduction to the engineering phases and relationships of public works. Historical survey. Federal, state, and local administration problems. Present trends and practices. The need for adequate public planning design and construction. Responsibilities of the engineer. Typical problems. 3 cred.; prereq., 52; hrs. ar.

280-281-282—Civil Engineering Research. Original work in concrete, structural steel, hydraulics, municipal, or transportation problems. Investigations, reports, tests, designs. 5 cred. per qtr.; prereq., by permission.

DAIRY HUSBANDRY

1—Elements of Dairying. Lectures and demonstrations. History and development of the dairy industry. Characteristics of the dairy breeds of cattle. Milk, its composition, food value, chemical and physical properties, handling of milk, and the manufacture of milk products. 3 cred.; prereq., entrance cred. in chem. or Chem. 1, 4, or 9; 3 lect. hrs. per week. Mr. Combs.

DRAWING AND DESCRIPTIVE GEOMETRY

1—Engineering Drawing. Elements of drafting including an introductory course in methods of representation and constructive geometry. Sketching, lettering, working drawings, conventions, standards, tracing, and blue printing. 3 cred.; prereq., solid geometry; 8 lect. and lab. hrs. per week.

2—Engineering Drawing. A continuation of Course 1 including fastenings and auxiliary projections and emphasizing technique. 3 cred.; prereq., 1; 8 lect. and lab. hrs. per week.

3—Descriptive Geometry. Elementary course in the methods of representation, correlated in part with algebraic solutions, lectures, demonstrations, and drafting. 3 cred.; prereq.; 2, M.&M. 11; 8 lect. and lab. hrs. per week.

7—Engineering Drawing (Chem. and chem. engr.). Courses 7 and 8 cover, in an abbreviated form, the contents of Courses 1, 2, and 3. 3 cred.; prereq., solid geometry; 8 lect. and lab. hrs. per week.

8—Descriptive Geometry—(Chem. and chem. engr.). The graphic solution of space problems in this course emphasizes the auxiliary view method. 3 cred.; prereq., 7; 8 lect. and lab. hrs. per week.

10—Solid Geometry. Lines and planes in space, dihedral and polyhedral angles, polyhedrons, surfaces, cylinders, cones, and sphere. Numerical exercises in areas, volumes, weights. No cred.; no prereq.; 4 lect., rec., and quiz hrs. per week.

21—Drafting (C.E.). Application of descriptive geometry to drafting-room problems including working drawings. 2 cred.; prereq., 3; 6 lect. and lab. hrs. per week.

22—Structural Detailing (C.E.). Detail, assembly, and construction drawing of steel members and simple structures. Standards and conventions. 2 cred.; prereq., 21; 6 lect. and lab. hrs. per week.

23—Structural Detailing (C.E.). Drafting problems in general construction work including earthwork, wood, steel, and concrete. 2 cred.; prereq., 22 or reg. in 22; 6 lect. and lab. hrs. per week.

26—Drafting (E.E.). Applications of descriptive geometry to drafting-room problems. Working drawings and tracing. 2 cred.; prereq., 3; 6 lect. and lab. hrs. per week.

28—Drafting (Aero.E.). Applications of descriptive geometry to drafting-room problems. Working drawings and tracing. 2 cred.; prereq., 3; 6 lect. and lab. hrs. per week.

29—Drafting (Aero.E.). Detail, assembly, and layout drawings. Standard practices in the aircraft industry. Army and Navy standards and specifications; tolerances and allowances; graphical integration. 2 cred.; prereq., 28; 6 lect. and lab. hrs. per week.

34—Lettering. Study and analysis of single stroke lettering with particular emphasis on the application to engineering drawing. 1 cred.; prereq., 1; 1 lect. and rec. hr. per week.

37—Lettering for Engineers. Analysis of the alphabets. Exercises in roman and gothic lettering. Design and composition of the paragraph and title. 2 cred.; prereq., 2; 2 lect. and rec. hrs. per week.

38—Reading Drawings. Calculations and estimates of areas, volumes, and weights. Tabulation of quantities from working drawings. Problems concerned with fabrication, manufacture, and construction. 2 cred.; prereq., 2; 2 lect. and rec. hrs. per week.

41-42-43—Technical Drawing. (a) General course in the theory and practice of free-hand drawing. Principles of perspective, sketching, renderings, conventions, lettering, and industrial drawing. (b) Modification of the above of particular interest to dental, medical, and scientific students. Not an engineering or architecture elective. 2 cred. per qtr.; no prereq.; 6 lect. and lab. hrs. per week.

44—Lettering. Practical course in plain lettering. Not an engineering or architecture elective. 1 cred.; no prereq.; 1 lect. and rec. hr. per week.

45—Alphabets. Construction and analysis of classic and modern roman, italic, script, and gothic styles, including Old English. Exercises in composition. Reference work. Not an engineering or architecture elective. 2 cred.; soph., jr., sr.; prereq., 44; 2 lect. and rec. hrs. per week.

50—Diagrams and Charts. Elementary course dealing with the construction of simple diagrams and charts. 2 cred.; no prereq.; 2 lect. and rec. hrs. per week.

51—Graphic Representation and Computation. Types of charts and applications to the solution of problems and equations. 3 cred.; prereq., 2, M.&M. 12; 3 lect. and rec. hrs. per week.

52—Alignment Charts. Functional scales. Application of geometry to the development of straight line alignment charts for equations of three or more variables. 3 cred.; prereq., 2, M.&M. 12; 3 lect. and rec. hrs. per week.

64—Graphic Arts. Introduction. Field development and application in art and industry. Design and composition. Discussion of materials, style, and technique. 3 cred.; jr., sr.; prereq., 15 cred. in econ.; 3 lect. and rec. hrs. per week. Mr. Doseff.

65—Graphic Arts. Processes. Discussion of reproduction processes—letterpress, planography, intaglio, also engravings, inks, paper stock, bindings, and miscellaneous printing operations. 3 cred.; jr., sr.; prereq., consent of major adviser in the School of Journalism or in the School of Business Administration. 3 lect. and rec. hrs. per week. Mr. Barnhart.

81-82-83—Advanced Drawing. Principles of design—traditional and modern. Layouts, composition, and illustration. Black and white, and color. Scientific modeling. 3 cred. per qtr.; prereq., 43 or equiv.; 6 lect. and lab. hrs. per week. Mr. Doseff.

86-87—Anatomical Drawing. 3 cred. per qtr.; prereq., 43 or equiv.; 6 lect. and lab. hrs. per week. Mr. Doseff.

111-112-113—Advanced Descriptive Geometry. Parallel and central projections. Curves and surfaces. Intersections and tangencies. Shades and shadows. Warped surfaces. The figured plan. 3 cred. per qtr.; prereq. 3, M.&M. 25; 3 lect. and rec. hrs. per week.

115-116-117—Curve Fitting. Finite differences and their application to curve fitting; graduation of experimental data; interpolation; fitting of data to type form of curves. 3 cred. per qtr.; prereq., 3, M.&M. 25; 3 lect. and rec. hrs. per week.

118—Short Course in Curve Fitting. Derivation of formulae to fit experimental data. Combination of graphic and algebraic methods. 3 cred.; prereq., 3, M.&M. 25, or permission of instructor; 3 lect. and rec. hrs. per week.

152-153-154—Nomography. Application of geometry to the development of alignment charts involving curved and straight line scales. Networks, combination of networks, and alignment charts. Line co-ordinates. Use of determinants for the construction of alignment charts. Special rules. 3 cred. per qtr.; prereq., 52 or equiv., M.&M. 25; 3 lect. and rec. hrs. per week.

157-158-159—Graphical Mathematics. Graphical calculus. Polar diagram method of stress analysis. 2 cred. per qtr.; prereq., 3, M.&M. 26; 2 lect. and rec. hrs. per week.

194—Advanced Advertising Procedure. Advanced course conducted by means of laboratory work on problems and cases in (1) market research and (2) preparation of copy and layout. 3 cred.; sr., grad.; prereq., B.A. 88, Draw. 64-65, Journ. 55 or permission of instructor; 3 lect. and rec. hrs. per week. Mr. Vaile.

ECONOMICS AND BUSINESS ADMINISTRATION

ECONOMICS

3—Elements of Money and Banking. Basic principles of money and a description of the various types of financial institutions, their functions and relations to the whole economic organization. 5 cred.; no prereq.; 2 lect. and 3 rec. hrs. per week. Mr. Stehman and others.

5†—Elements of Statistics. Elementary concepts in statistical method; averages, ratios, errors, sampling, index numbers, graphic representation, collection of material. 5 cred.; no prereq.; 1 lect. and 4 rec. hrs. per week. Mr. Kozelka and others.

8-9—General Economics. (Engrs., arch., chem.) Principles of economics with special emphasis upon their application to current problems such as money, banking, conservation, insurance, international commerce, monopolies, transportation, labor, socialism and public ownership, and finance. 3 cred. per qtr.; no prereq.; 3 rec. hrs. per week. Mr. Filipetti and others.

20—Elements of Accounting. Fundamental principles underlying bookkeeping and accounting. Sufficient practice in technical processes will be given to serve as a background for more advanced work. Preparation and analysis of statements. Open only to engineering prebusiness students. Other engineering students register in 29 or B.A. 54. 3 cred.; no prereq.; 3 rec. hrs. per week. Mr. Heilman and others.

25-26—Principles of Accounting. Principles underlying the accounting statements, the accounts, principles of valuation, depreciation, preparation and analysis of statements. 3 cred. per qtr.; prereq., 20; 3 rec. hrs. per week. Mr. Heilman and others.

28—Business Law. Business law arranged for engineers, including the law of contracts, real estate agency, partnership, corporations, negotiable instruments. 3 cred.; 3rd qtr. soph., jr., sr.; 3 rec. hrs. per week. Mr. Palmer.

29—Principles of Accounting. (Engrs., arch., chem.) Purpose and principles of account classification; capital and revenue, accruals; valuation; depreciation; preparation and interpretation of balance sheets, income accounts, and other statements. 3 cred.; no prereq.; 3 rec. hrs. per week. Mr. Lund.

149—Business Cycles. Analysis of factors involved in business fluctuations. Comparison of theories of the cause of prosperity and depression. Introduction to the statistical data and methods of business forecasting. 3 cred.; sr., grad.; prereq., 141 or B.A. 142; 3 rec. hrs. per week. Mr. Myers.

161—Labor Problems and Trade Unionism. Discussion of employment; hours; wages; extent of strongholds of unionism; open and closed shops; collective bargaining; industrial unrest; government regulation of labor disputes. 3 cred.; prereq., 8, 9; 3 rec. hrs. per week. Mr. Yoder.

175—Government Regulation of Business. General course on the economic aspects of legislation affecting the pricing process and the distribution of the national income. Topics studied include economic origins of modern business limitations on free competition; regulation of public utilities, trusts and combinations, and "unfair competitive practices"; positive assistance to industrial groups. 3 cred.; jr., sr., grad.; prereq., 8, 9; 3 rec. hrs. per week. Mr. Garver.

†Not open to students who have received credit in Soc. 45 or B.A. 70.

BUSINESS ADMINISTRATION

51-52-53—Business Law.* 51. Contracts. 52. Agency, Partnership, Corporations. 53. Sales and Negotiable Instruments. 3 cred. per qtr.; jr., sr.; prereq., for 51, Econ. 8 and 9, for 52 and 53, B.A. 51; 3 rec. hrs. per week. Mr. Gray.

54-55—Elementary Accounting. Combined course. Covers the same material as Econ. 20, 25, and 26, or Econ. 29 and 26. 4 cred. per qtr.; recommended for five-year engineering business students; 4 rec. hrs. per week. Mr. Miller.

58§—Elements of Public Finance. Public expenditures, revenues, and debts. Special attention is given to tax principles, practices, and burdens. Condensed course given especially for business administration students. 3 cred.; jr., sr.; prereq., Econ. 8, 9; 3 rec. hrs. per week. Messrs. Blakey and Borak.

70†—Statistics Survey Course. Tools and devices which facilitate the use of business data. Statistical information is collected by questionnaires, consolidated into tables, summarized in averages, and illustrated by graphic devices. Current index numbers are compared in form and application. Interpretation and limitations of statistical data. 3 cred.; prereq., Econ. 8, 9; 3 rec. hrs. per week. Mr. Graves.

71—Transportation: Services and Charges I. Survey of rail, highway, and water transportation facilities, services, and rates. Current transportation problems. 3 cred.; prereq., Econ. 8, 9; 3 rec. hrs. per week. Mr. Nightingale.

72—Transportation: Services and Charges II. Principles, construction, interpretation, and use of rail, highway, and water classifications, rates, and tariffs for handling freight, express, and mail shipments. Audit of transportation charges. Adjustment of rates, rules, and regulations. 3 cred.; prereq., 71; 3 rec. hrs. per week. Mr. Nightingale.

77—Survey of Marketing. (An introductory course.) Principles of production economics and of price as illustrated in marketing. Commodity classifications, market functions, description of market organizations. 3 cred.; jr., sr.; prereq., Econ. 8, 9; 3 rec. hrs. per week. Messrs. Vaile, Chute, and Miss Canoyer.

89—Production Management. Analysis of the procedure and methods of production in industrial plants, the factors involved in production management, the means of effecting control. 3 cred.; prereq., 77; 3 rec. hrs. per week. Mr. Filipetti.

91—Tabulating Equipment Laboratory. Use of tabulating equipment in preparation of sales analyses and the laying out of production programs, in the keeping of perpetual inventory records and in making distributions of labor and overhead costs in cost accounting. 1 cred.; jr., sr.; prereq., Econ. 26 and either 5 or B.A. 70; 2 lab. hrs. per week. Ar.

101-102¶—Advanced General Economics. Study of some of the more important theoretical problems of economics; competitive and monoply prices; equilibrium prices and costs; theories of valuation of producers' goods; capital earnings and interest rates; profits. 3 cred. per qtr.; sr.; prereq., Econ. 8, 9; 3 rec. hrs. per week. Messrs. Garver and Stigler.

112‡—Business Statistics. Survey and criticism of methods used in analyzing time series, with special applications to the study of cyclical fluctuations of economic phenomena. 3 cred.; jr., sr., grad.; prereq., Econ. 5 or B.A. 70; 3 rec. hrs. per week. Mr. Kozelka.

130‡—Cost Accounting Survey. (General survey.) 3 cred.; prereq., Econ. 26, 29 or 55; 3 rec. hrs. per week. Mr. Ostlund.

133—Standard Costs. Establishment of standards and their results as reflected in the cost accounts. The application of standards in distribution. 3 cred.; jr., sr., grad.; prereq., B.A. 130 or 152, 153; 3 rec. hrs. per week. Mr. Ostlund.

139‡—Advanced General Accounting. Course intended for the general student of business. Interpretation of accounts and statements, statement preparation, and analysis. Utilization of the statements by the executive. The use of budgets in business. Accounting methods and statements in a number of business fields. 3 cred.; jr., sr., grad.; prereq., Econ. 25, 26; 3 rec. hrs. per week. Mr. Heilman.

142—Advanced Money and Banking. 3 cred.; jr., sr., grad.; prereq., Econ. 8, 9; 3 rec. hrs. per week. Mr. Myers.

155—Corporation Finance. 3 cred.; prereq., Econ. 8, 9; 3 rec. hrs. per week. Mr. Stehman.

* No credit will be given for 51, 52, or 53 until all three are completed.

† Not open to students who have received credit in Econ. 5.

‡ A fee of $1 per quarter is charged for this course.

§ Credit may not be received for both Econ. 191-192 and B.A. 58.

¶ The entire course must be completed before credit is received for any quarter.

167—Personnel Administration. Managerial policy for various types of organization of labor. Job analysis, employment, incentives, and regulation of employment. 3 cred.; prereq., Econ. 161 and B.A. 89; 3 rec. hrs. per week. Mr. Yoder.

180C-181C—Senior Topics: Marketing. Selected topics in industrial marketing industry. (1) Market research; (2) marketing of installations; (3) product design as an aid in marketing; (4) market prices and price policies. 3 cred. per qtr.; prereq., consent of adviser; two 1½ rec. hrs. per week. Mr. Vaile.

180G-181G§-182G—Senior Topics: Production Management. Selected problems in management; technique of executive control in manufacturing enterprises; field research and surveys in organization and management of Northwest industrial concerns. 9 cred.; prereq., B.A. 89, 130; 3 rec. hrs. per week. Mr. Filipetti.

184§—Scientific Management in Industry. 3 cred.; prereq., 8, 9; 3 rec. hrs. per week. Mr. Filipetti.

(For other courses see Combined Class Schedule, School of Business Administration section.)

ELECTRICAL ENGINEERING†

11-13-15—Elements of Electrical Engineering. Introduction to the development, principles, materials, safety, and general applications of electrical engineering. 3 cred. per qtr.; prereq., reg. in phys. and M.&M. 24 for 11; reg. in M.&M. 25 for 13; 3 rec. hrs. per week.

14-16—Elements of Electrical Engineering Laboratory. Taken with Course E.E. 13, 15. 1 cred.; prereq., for 14, 13 or reg. in 13; for 16, 14 and reg. in 15; 2 lab. hrs. per week.

111—Junior Electrical Engineering. Alternating current circuits and machinery. 5 cred.; prereq., 15, 16; 5 rec. hrs. per week.

112—Junior Electrical Engineering Laboratory. Taken with Course 111. Experimental study of alternating current circuits and machinery. 2 cred.; prereq., reg. in 111; 4 lab. hrs. per week.

113-115*—Junior Electrical Engineering. Alternating current circuits and machinery. 3 cred. per qtr.; prereq., 111, 112 for 113, and 113, 114 for 115; 3 rec. hrs. per week.

114-116—Junior Electrical Engineering Laboratory. Taken with Course 113-115. Experimental study of alternating current circuits and machinery. 1 cred. per qtr.; prereq., reg. in 113-115. Lab. given alternate weeks; 4 lab. hrs. per week.

117-119*—Engineering Electronics. Fundamental theory of electronic devices. 3 cred. per qtr.; prereq., 111, 112 for 117, and 117 for 119. Lab. given in alternate weeks; 2 rec. and 4 lab. hrs. per week.

121-123-125—Senior Electrical Engineering. Theory of alternating and direct current machinery. 3 cred. per qtr.; prereq., 115, 116, and 119; 3 rec. hrs. per week.

122-124-126—Senior Electrical Engineering Laboratory. Operating characteristics of alternating and direct current machinery. 2 cred. per qtr.; prereq., 116 and reg. in 121-123-125; 4 lab. hrs. per week.

127-128-129—Transient Electrical Phenomena. Mathematical study of electric circuits during sudden changes of conditions. Classical and operational methods of analysis applied to electric circuits and machines, and use of the oscillograph in the analysis of these problems. 3 cred. per qtr.; prereq., reg. in 121-123-125; 2 rec. and 3 lab. hrs. per week.

130—Electric Control. Study of methods of control and control devices for direct and alternating current motors and generators. Open to aero., chem., elec., and mech. engrs. 2 cred.; prereq., 37, 44, 46 or 123.

132-134-136—Electrical Design. Design of direct current generators and motors, alternating current transformers, generators, and synchronous motors. 2 cred. per qtr.; prereq., for 132, reg. in 121; 134, reg. in 123; 136, reg. in 125; 2 rec. hrs. per week.

197-198-199—Electrical Design. Special problems. 2 cred. per qtr.; prereq., 132-134-136.

227-228-229—Transients in Electrical Machinery and Transmission Lines. Theoretical and laboratory study of transients in electrical power machinery and of lightning surges and lightning protection. 3 cred. per qtr.; prereq., 127-128-129.

* Students registering in E.E. 113 and 117 and E.E. 115 and 119 must take both courses at the same hour of the day. The laboratory part of 117 and 119 must be taken on the same day that the student registers for E.E. 114 and 116 respectively. These laboratory courses are given in alternate weeks.

† In courses continuing through three quarters, the work of each quarter is prerequisite for the following quarters.

§ Credit may not be received for both B.A. 181G and B.A. 184.

255-256-257—Electrical Engineering Applications. Investigation of electrical engineering applications. Laboratory and library study, research both in residence and the field. Written reports with oral presentation and discussion. 1 to 3 cred. per qtr.; prereq., grad. only.

ELECTRIC POWER FOR NONELECTRICAL STUDENTS

36-37-38—Electric Power. Elementary study of the generation, distribution, measurement, and utilization of electric power. 3 cred. per qtr.; sr. M.E.; prereq., Phys. 9; 2 lect. and 2 lab. hrs. per week.

41—Electric Power. Elementary principles of continuous and alternating currents, generators, and motors; transmission and distribution. Measurement of power. 3 cred.; jr. mines; prereq., Phys. 8; 2 lect. and 3 lab. hrs. per week.

42—Electric Power. Similar to 41. 3 cred.; sr. C.E.; prereq. Phys. 8; 3 rec. hrs. per week.

43-44-45—Electric Power. Similar to 36-37-38. 3 cred. per qtr.; sr. Chem.E.; prereq., Phys. 9; 2 lect. and 2 lab. hrs. per week.

46-47—Electric Power and Aeronautic Radio. Fundamentals of direct current and alternating current circuits, tubes, direction finding, and blind landing. 3 cred. per qtr.; prereq., sr. AeroE., Phys. 9; 2 rec. and 2 lab. hrs. per week.

48—Aeronautic Radio Developments. Study of radio aids for the operation of aircraft. Direction finding, instrument landing systems, ultra-high-frequency applications, television, and radiosonde equipment. 2 cred.; prereq., 47 or by permission; 2 rec. hrs. per week.

POWER AND CENTRAL STATION ENGINEERING

138-139-140—Power Systems. Short-circuit currents in power networks; unbalanced loads in polyphase circuits, transformers and motors; harmonics; stability of power systems under steady state conditions. Application of relay, oil circuit breakers, and lightning arresters to power systems for protection of apparatus and service. 3 cred. per qtr.; prereq., reg. in 121, 123, or 125; 3 rec. hrs. per week.

141—Central Stations. Electric power generating stations and distributions systems. Economic considerations. Costs, load curves, plant location, selection of prime movers, station equipment. 3 cred.; prereq., reg. in 121; 3 rec. hrs. per week.

142—Electrical Transmission. Designing and building of transmission lines. Mechanical, electrical, and economic considerations. Lightning protection, underground lines, high-voltage direct current transmission. 3 cred.; prereq., reg. in 123; 3 rec. hrs. per week.

143—Valuation of Public Utilities Properties. Factors affecting value, depreciation, taxation, and regulation of public utilities properties. Elements of engineering economics; cost analysis, economic investigations, rate making. 3 cred.; sr. and grad. only; 3 rec. hrs. per week.

144—Power Transmission Line Design. Preparation of detailed plans and specifications for construction of high voltage transmission lines and distributing systems. 3 cred.; prereq., 134, 142. Ar.

145—Railway Electrical Engineering. Principles of mechanics applied to electric train movements. 2 cred.; prereq., 36 or 43 or 46 or 115; 2 rec. hrs. per week.

146—Railroad Electrification. Reasons for electrification. Study of European and American systems. Results of electrification. 2 cred.; prereq., 145; 2 rec. hrs. per week.

ILLUMINATING ENGINEERING

151—Illuminating Engineering. Nature of light. Laws of vision. Principles of illumination. Photometry. Sources of light and their characteristics. Lighting equipment. Illumination requirements and calculation for various fields of use. 2 cred.; prereq., Phys. 9; 2 rec. hrs. per week.

152—Photometric Laboratory. Photometer practice. Distribution curves of lamps and reflectors. Measurement of lighting installations. 1 cred.; prereq., reg. in 151; 2 lab. hrs. per week.

153-154—Illumination Problems. Illumination design and specifications applied to problems in street, residence, industrial, commercial, and other kinds of lighting. 1 to 3 cred. per qtr.; prereq., 151; ar.

251-253—Illuminating Engineering. Lectures and laboratory work. Methods of determining locations, kind and quality of lights for obtaining desired illumination. 2 cred. per qtr.; prereq., 151; ar.

TELEPHONE AND TELEGRAPH ENGINEERING

64-65-66—Elements of Communication. Theoretical and laboratory study of communication circuits and apparatus. Simplex, duplex, multiplex, telegraph systems. Speed of transmission. Magneto, common battery, manual, automatic telephone systems. 2 cred. per qtr.; prereq., reg. in 111-113-115; 1 lect. and 2 lab. hrs. per week.

164-165-166—Electric Communication. Telephone circuits at audio and carrier frequencies. Theoretical and laboratory study of circuits having distributed constants. Use of hyperbolic functions. Wave filters, balancing networks, equalizers, repeaters. 4 cred. per qtr.; prereq., 66; 2 lect. and 4 lab. hrs. per week.

RADIO ENGINEERING

161-162-163—Radio Communication. Theoretical and laboratory study of radio transmitting and receiving circuits and apparatus. Amplifiers, detectors, oscillators. Electromagnetic waves in free space and on antenna systems. 3 cred. per qtr.; prereq., reg. in 121-123-125; 2 lect. and 2 lab. hrs. per week.

167—Radio Transmission. Design and operation of modern transmitting equipment, with special emphasis on broadcast transmission. 3 cred.; prereq., reg. in 161; 2 lect. and 3 lab. hrs. per week.

168—Problems in Radio Receiver Design. Detailed study of the problems arising in broadcast receiver design. 3 cred. per qtr.; prereq., reg. in 162; 2 lect. and 3 lab. hrs. per week.

169—Television and U.H. Frequency Technique. Problems in television, U.H. frequency transmission and reception, micro-waves, wave guides, velocity modulation. Kylstrons and Magnetrons. 3 cred.; prereq., reg. in 163; 2 lect. and 3 lab. hrs. per week.

176-177-178—Electronics. Theoretical and laboratory study of the following subjects with aspects of their engineering applications. Electron emission from hot bodies, Richardson's equation, Langmuir-Child's equation, secondary electron emission, ionization and resonance potentials, external and internal photoelectric effect, positive ion emission, shot effect, discharge of electricity through gases, "getter" action, vacuum gages, vacuum technic, etc. 2 cred. per qtr.; grad. or sr. by permission; ar.

261-263-265—Advanced Radio Communication. Theoretical study of the transmission of electromagnetic waves. Design and testing of radio transmitting and receiving apparatus. Theory of electron tubes and their use in radio circuits. High frequency measurements. Taken with 262-264-266. 2 cred. per qtr.; reg. by permission; ar.

262-264-266—Advanced Radio Laboratory. Special problems in radio laboratory and station, usually taken in connection with Course 261-263-265. For students specializing in electrical communication. 1 or more cred. per qtr.; reg. by permission; ar.

RESEARCH

171-172—Undergraduate Thesis. Investigation of some approved problem in electrical engineering. 3 to 6 cred. per qtr.; prereq., 121; ar.

275-276-277—Electrical Engineering Research. Investigation of special problems in laboratory or library. 2 to 6 cred. per qtr.; grad.; ar.

MEASUREMENT

81—Electrical Engineering Measurements. Principles of electrical measuring instruments, construction, limitations, sources of error, methods of calibration. Methods of measuring voltage, current, watts, watt hours, resistance inductance, mutual inductance, capacity. 3 cred.; prereq., 111; 2 lect. and 2 lab. hrs. per week.

173-174-175—High Voltage Engineering. Study of insulation and generating equipment for high voltage; measurements of electrical quantities at high voltage; surges, and surge proof equipment. Lecture and laboratory. 2 or 3 cred.; sr. or grad.; ar.

181—Communication Frequency Measurements. Vector treatment of net work. Bridge circuits for measuring of resistance, inductance, and capacity of audio and radio frequencies. 2 cred.; prereq., 126; ar.

183-184-185—Special Electrical Laboratory. Efficiency tests and special problems. 1 to 3 cred. per qtr.; prereq., jr., sr., grad. by permission; ar.

187-188-189—Special Communication Laboratory. Special problems in electrical communication. Includes a weekly seminar meeting. 1 to 3 cred. per qtr.; jr., sr., grad. by permission; ar.

281-282—Advanced High Frequency Measurements. Vector treatment of circuit networks. Bridge circuits for the measurement of resistance, inductance, and capacity of audio and radio frequencies. 2 cred. per qtr.; prereq., 126; ar.

284-285-286—Precise Electrical Engineering Measurements. Measurements of resistance, voltage, current, energy, self-induction, and capacity; standardization of measuring instruments. 2 cred. per qtr.; prereq., 122; ar.

GENERAL

93—Seminar. Weekly discussion of current engineering periodicals and reports on assigned topics. 1 cred.; no prereq.; jr. E.E.; ar.

100—Inspection Trip. Inspection of selected industrial plants made in the spring vacation period. 2 cred.; required of senior E.E. (subject to cancellation).

156—Vacuum Tube and Control Devices. Two, three, four, and five electrode vacuum tubes. Thyratron, kenotron, grid glow, photoelectric tubes, etc. Theoretical study of apparatus and circuits with demonstrations. 2 cred.; sr. only; not open to students having credit in 161; 2 lect. hrs. per week.

191-192-193—Seminar. Weekly discussion of current electrical periodicals. 1 or 2 cred. per qtr.; prereq., 111; ar.

194-195-196—Vacuum Tube Applications. Study of commercial thermionic vacuum, vapor, and gas discharge tubes including an extensive survey and detailed study of their scientific and industrial applications. 3 cred. per qtr.; open to grad. and sr. in E.E. by permission of instructor; ar.

211-212-213—Advanced Circuit Analysis. Circuit analysis using Heaviside's *Operational Calculus*. 2 cred. per qtr.; grad.; prereq., M.&M. 151; ar.

291-292-293—Graduate Seminar. Discussion problems and results of research work. 1 cred. per qtr.; ar.

294-295-296—Vacuum Tube Circuit Analysis. Continuation of 196. Mathematical and experimental analysis of circuits associated commonly with vacuum tubes. 3 cred. per qtr.; grad. only; prereq., 196; ar.

ENGLISH (ENGINEERING)

4-5-6—Composition. Review of grammar; principles of composition; constant practice in elementary technical exposition, both written and spoken. Reading. 3 cred. per qtr.; prereq., placement test; 3 rec. hrs. per week. Messrs. Richardson and Guthrie.

7—Explorations in Literature. Epics and modern plays. 3 cred.; prereq., 6; 3 rec. hrs. per week. Mr. Richardson.

8—Explorations in Literature. Novels. Some individual selection permitted. 3 cred.; prereq., 6; 3 rec. hrs. per week. Mr. Richardson.

36—The Technical Article. Practice in writing. Typical problems in presenting scientific and engineering information to various classes of readers. 3 cred.; prereq., 6; 3 rec. hrs. per week.

37—Technical Discussions. (M.E.) Oral presentation of technical and nontechnical material for the purpose of developing speaking ability. Class criticism. Extemporaneous discussion. Limited to twenty-five students per section. 3 cred.; prereq., 6; 3 rec. hrs. per week. Mr. Richardson.

FORESTRY

10—Farm Woodlots and Windbreaks. Trees and their relation to the farm. Planning and planting farm windbreaks, shelter belts, and woodlots. Utilization and marketing of farm grove or woodlot products. 3 cred.; no prereq.; 3 rec. hrs. per week. Mr. Bensend.

GENERAL ENGINEERING

11—Orientation. Series of lectures designed to orient the student who has just begun his university course. No cred.; no prereq.; req. of all freshmen except arch., chem., and chem. engrs.; 1 lect. hr. per week. Mr. Zelner.

12—Orientation. Series of lectures given by the heads of departments and other selected speakers, covering the various branches of engineering. No cred.; no prereq.; req. of all freshmen except arch., chem., and chem. engrs.; 1 lect. hr. per week. Mr. Zelner.

13—Hygiene. Lectures on hygiene and first aid given by physicians and dentists on the university staff and others. No cred.; no prereq.; req. of all students except arch.; 1 lect. hr. per week. Mr. Zelner.

70—The Slide Rule. Computation practice and theory. Design of special scales. 1 cred.; prereq., M.&M. 12 or reg. in M.&M. 12; 1 rec. hr. per week. Mr. French.

101—Contracts and Specifications. Engineering contracts. Specification essentials; approved methods of handling construction projects; trade practices, workman compensation acts, unemployment compensation law, minimum wage and hour legislation. Powers and duties of engineer executive. 3 cred.; jr. and sr. only; 3 rec. hrs. per week. Mr. Fixen.

112-113-114—Rates for Public Utility Properties. Determination of the rate base and depreciation amount for transportation, gas, water, electric power, and telephone utilities operating expenses, the rate structure for particular utilities, service and discrimination. 3 cred. per qtr.; sr. and grad. in engineering, economics, and business administration; 3 rec. hrs. per week.

193—Engineering Practice. Engineering relations, personal and ethical; business relations, letters and employment; legal relations and interpretations; patents, rights of invention; engineering specifications and salesmanship. Engineering reports and discussions. 2 cred.; sr. only; 1 lect. and 1 rec. hr. per week.

GENERAL SCIENCE

50—Elementary Logic. 3 cred.; prereq., soph. standing; 3 rec. hrs. per week. Mr. Castell.

GEOLOGY AND MINERALOGY

1-2—General Geology (Dynamic and Historical). Synoptical treatment of the materials of the earth and of geologic processes, together with a study of the history of the earth and its inhabitants as recorded in the rocks. 3 cred. per qtr.; no prereq.; 3 lect. hrs. per week. Mr. Thiel.

A‡-B‡—General Geology Laboratory (General and Historical). 2 cred. per qtr.; no prereq.; 4 lab. hrs. per week.

5-6—Engineering Geology. Materials of the earth and geologic processes. Applications of geology to engineering problems. Brief survey of occurrence, properties, production, and uses of building stones, cements, clays, fuels, and road material. 3 cred. per qtr.; no prereq.; 3 lect hrs. per week. Mr. Schwartz.

8—Introductory Geology. Short introductory course. Principles of earth sculpture; topographic changes and their causative agents; dynamic, structural, and historic geology. 5 cred.; no prereq.; 5 lect. hrs. per week.

23‡-24‡—Elements of Mineralogy. Crystal systems; morphological, physical, and chemical characters of minerals; occurrence, genesis, and use of minerals; classification and description of common minerals, rock minerals, and common rocks. Determinative work in laboratory, blowpipe analysis, sight identification. 4 cred. per qtr.; prereq., Inorg. Chem. 10 or equiv.; 3 lect., 1 rec., and 4 lab. hrs. per week. Mr. Gruner.

61—Blowpipe Analysis. Determination of minerals by systematic blowpipe analysis. 3 cred.; prereq., 24; 3 lect. and 3 lab. hrs. per week. Mr. Gruner.

91-92-93—Index Fossils of North America. Study of fossil forms with special reference to those of geologic importance; faunas and their correlation. 3 cred. per qtr.; prereq., 2; 1 lect. and 4 lab. hrs. per week.

100—Field Work. About two weeks, approximately July 15 to 30, are spent in studying selected areas in the iron district of Minnesota. Involves preparation of geologic maps and written reports. 3 cred.; prereq., 105. Messrs. Gruner and Thiel.

101-102—Sedimentation. Origin and structure of sedimentary deposits; the interpretation of these in relation to paleogeography. Lectures, assigned readings, and laboratory work. 3 cred. per qtr.; prereq., 24; 3 lect. hrs. per week for 101, 1 lect. and 4 lab. hrs. per week for 102. Mr. Thiel.

103-104—Micropaleontology. Study and classification of Foraminifera, Ostracoda, and other small fossil organisms, and their use for purposes of correlation. 3 cred. per qtr.; prereq., 91; 6 lab. hrs. per week.

105—Rock Study. Occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. Classification and methods of identification and description of rocks. 2 cred.; prereq., 1 or 6 and 24; 2 lect. and 2 lab. hrs. per week. Mr. Grout.

106—Petrography. Identification and study of minerals and rocks by optical methods; study of igneous rocks, crystalline schists, and metamorphic rocks. Origin and classification of rocks. 2 cred.; prereq., 105; 4 lab. hrs. per week. Mr. Grout.

‡ A fee of $1 per quarter is charged for this course.

110—Economic Geology. Study of nonmetallic minerals of economic value and discussions of geologic guides to prospecting for these deposits. 3 cred.; prereq., 105; 3 lect. hrs. per week. Mr. Schwartz.

111—Ore Deposits. Nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; deformation and superficial alteration of ore deposits. 3 cred.; prereq., 105; 3 lect. hrs. per week.

112—Geology of Petroleum. Nature, origin, and accumulation of petroleum, discussion of the various oil fields of the world. 3 cred.; prereq., 105; 3 lect. hrs. per week.

114—Geology of Minnesota and Adjoining Areas. Geologic history, stratigraphy, and structure of Minnesota. 3 cred.; prereq., 105; 3 lect. hrs. per week. Mr. Thiel.

118*—Principles of Geomorphology. Principles of physiography of the lands, or geomorphology. Study of the form and structure of plains, plateaus, volcanoes, and the different types of mountains. Normal or fluvial, glacial, marine, and arid cycles of erosion and the resulting land forms. 3 cred.; prereq., 2.

119—Geomorphology of the United States. Regional study of the United States by geomorphic or physiographic units. Development of the surface features as affected by rock structure and geologic history. Discussion of the principal problems presented by each area. 3 cred.; prereq., 2.

120*—Glacial Geology. Nature and process of glacial action. Land forms resulting from alpine and continental glaciers. Character and distribution of pleistocene and earlier glacial deposits. 3 cred.; prereq., 2.

121—Crystallography. Study of crystal models and space groups. Crystal drawings and measurements. Projections and mathematical calculations. 3 cred.; prereq., M.&M. 12 and Inorg. Chem. 10 or equiv. Mr. Gruner.

124—Metamorphic Geology. Conditions, processes, and results of weathering and metamorphism. 3 cred.; prereq., 105; 3 lect. hrs. per week. Mr. Schwartz.

125—Structural Geology. Study of the principles and applications of geologic structures. 3 cred.; prereq., 105; 3 lect. hrs. per week. Mr. Schwartz.

131-132—Advanced Petrology. Advanced optical methods. Criteria for rapid identification of minerals and rocks. Uses of schedules and tables. Standard rock types. Regional and genetic studies. Petrographic reports. 4 cred. per qtr.; prereq., 106; 3 lect., 1 rec., and 4 lab. hrs. per week. Mr. Grout.

140-141—Applied Petrography. Determination of ores and gangue minerals. Microscopic studies of paragenesis of ores and other mineral associations. Practical problems in mining and geology settled by microscopic and optical examinations. 3 cred. per qtr.; prereq., 131; 1 lect. and 4 lab. hrs. per week. Mr. Grout.

144—Interpretation of Geologic Maps. Study and problems in construction and interpretation of various types of geologic maps. Recognition of structural and stratigraphic relations. 4 cred.; prereq., 105; 8 lect. hrs. per week.

144A—Interpretation of Geologic Maps. Same subject matter as 144. For petroleum engineers. 3 cred.; prereq., 105; 6 lab. hrs. per week.

145—Interpretation of Topographic Maps. Application of the principles of geomorphology to the interpretation of topographic maps. Practice in the recognition of land forms. Determination of underground structures and evolution of topography from surface contours. 2 cred.; prereq., 2 or 3 or 13; 4 lab. hrs. per week.

150—Field Geology. Detailed, systematic work conforming with standards of official surveys. Preparation of geologic maps, structure sections, reports; paragenesis of ores and their relation to geologic structures. Field, Black Hills, South Dakota. 6 cred.; prereq., 124. 4 weeks. First term, Summer Session. Approximately June 15 to July 15. Mr. Schwartz.

151-152-153—Advanced General Geology. Geologic processes and their results; development of the North American continent. 3 cred. per qtr.; prereq., 2 or 3 or 13; 3 lect. hrs. per week.

161—Crystal Structure. Study of point groups and space groups. Diffraction of X rays of crystals. Interpretation of powder and Laue diagrams. 3 cred.; prereq., 121, Phys. 7, 9, M.&M. 13. Mr. Gruner.

165—Ore Dressing Microscopy. Methods of studying opaque ore minerals and the application of metallurgical problems. 1 cred.; prereq., 106; 3 lab. hrs. per week. Mr. Schwartz.

166-167—Mineralography. Methods of studying opaque minerals and the application of the methods to problems in ore genesis and history. 3 cred. per qtr.; prereq., 111 or reg. in 111, 131; 6 lab. hrs. per week. Mr. Schwartz.

* Offered in alternate years.

170—Geologic Problems. Special problems adapted to the needs of the student. 3 cred.; ar.

GERMAN

24-25-26—Chemical German. Pronunciation, reading, sentence analysis, and translation. 3 cred. per qtr.; for students who have had no German previously; 3 rec. hrs. per week.
27-28-29—Chemical German. Representative chemical prose. 3 cred. per qtr.; prereq., two years high school German or one year college German; 3 rec. hrs. per week.
41-42-43—Chemical German. Readings from German chemical periodicals. 2 cred. per qtr.; prereq., German 26 or the equiv.; 2 rec. hrs. per week; ar.

HISTORY

84—History of Engineering and Industrial Technology. 3 cred.; jr., sr.; no prereq.; ar. Mr. Heaton.

HORTICULTURE

6—Fruit Growing. Fundamental principles of fruit growing. Sites, soils, nursery stock, planting and planting plans, tillage, fertilization, cover crops, pollination, frost avoidance, pruning and thinning. Lectures, references. 3 cred.; no prereq.; 3 rec. hrs. per week. Mr. Brierley.

MATHEMATICS AND MECHANICS

The Mathematics and Mechanics Department maintains a consultation period for freshman and sophomore mathematics students beginning the third week of the quarter, hrs. to be posted.

MATHEMATICS

9—Higher Algebra. (High School.) Fundamental rules, fractions, linear simultaneous equations, graphs, theory of exponents, surds, complex quantities, quadratic equations, numerical exercises. No cred.; no prereq.; 5 rec. hrs. per week.
11—College Algebra. Review of fundamental operations, factoring, fractions, linear simultaneous equations, exponents, surds, complex numbers, and quadratic equations. Theory of quadratic equations, ratio, proportion, variation, determinants, binomial theorem, progressions, theory of equations, higher numerical equations, partial fractions, and infinite series. 5 cred.; prereq., M.&M. 9 or equiv.; 5 rec. hrs. per week.
12—Trigonometry. Graphical representation of functions, computation by logarithms and slide rule. Trigonometric functions, plane right triangles, reduction formulas, fundamental relations, addition formulas, double angles, half angles, identities and equations, inverse functions, oblique triangles, de Moivre's theorem, spherical right triangles. 5 cred.; prereq., 11; 5 rec. hrs. per week.
13—Analytic Geometry. Rectangular co-ordinate systems, locus and equation, straight line, circle, parabola, ellipse, hyperbola. Transformation of co-ordinates and simplification of equations. Polar co-ordinates, higher plane curves, tangents, normals. Empirical equations, solid analytic geometry. 5 cred.; prereq., 11 and 12; 5 rec. hrs. per week.
24—Calculus I: Differential. Limit, derivative, simple application of derivative, maxima and minima, differentials, rates, radius of curvature, indeterminate forms, partial differentiation, the differential as an approximation, series, expansion of functions. 5 cred.; prereq., 13; 5 rec. hrs. per week.
25—Calculus II: Integral. Integration of standard elementary forms, rational fractions, by substitution, by parts; trigonometric integrals, definite integral, integration as a process of summation; geometric applications, liquid pressure, work, centroids, moments of inertia, double and triple integrals. 5 cred.; prereq., 24; 5 rec. hrs. per week.
32-33—Differential and Integral Calculus. Two-quarter course in calculus for students in the School of Mines and Metallurgy. 9 cred.; prereq., 13; 4 cred.; 4 rec. hrs. per week for 32; 5 cred.; 5 rec. hrs. per week for 33.
91*—Calculus (Arch., Prebus.). Short course, derivatives, maxima and minima, integration of simple forms, definite integrals, areas. 4 cred.; prereq., 13; 4 rec. hrs. per week.

* For permissible substitute, see page 54.

151—Differential Equations. Differential equations and their solutions. First order and first degree, first order and higher degree, singular solutions; total differential equations, linear differential equations, miscellaneous methods system of simultaneous equations, integration in series. 3 cred.; prereq., 25; 3 rec. hrs. per week.
152—Calculus III: Special Topics in Advanced Calculus. 3 cred.; prereq., 151; 3 rec. hrs. per week.
153—Calculus IV: Special Topics in Advanced Calculus. 3 cred.; prereq., 152; 3 rec. hrs. per week.
154—Vector Analysis. 3 cred.; prereq., 26; 3 rec. hrs. per week.
155—Vector Analysis and Dyadics with Applications. 3 cred.; prereq., 154; 3 rec. hrs. per week.
156—Elements of Tensor Analysis. 3 cred.; prereq., 154; 3 rec. hrs. per week.
164-165-166—Operational Methods and the Operational Calculus. 3 cred. per qtr.; prereq., 151 or by permission; 3 rec. hrs. per week.
167-168-169—Mathematics of Modern Engineering. 3 cred. per qtr.; prereq., 26; 3 rec. hrs. per week.
261-262-263—Functions of a Complex Variable. Elliptic functions and integrals with applications. 3 cred. per qtr.; prereq., 153.

For other courses see Combined Class Schedule Bulletin.

MECHANICS

26—Technical Mechanics: Statics. Concurrent force systems, parallel forces, couples, center of gravity, statics of rigid bodies, graphical methods, friction, work, theory of moment of inertia. 5 cred.; prereq., 25; 5 rec. hrs. per week.
84*—Technical Mechanics. (Chem., Chem.E., and Prebus.) Statics, resolution of forces, conditions of equilibrium, center of gravity, moment of inertia, stresses in framed structures and machines, kinematics, dynamics of a particle. Newton's laws of motion, work, energy, power, impulse, and momentum. 5 cred.; prereq., 25 or 91; 5 rec. hrs. per week.
92*—Mechanics of Architects. Statics, resolution of forces, conditions of equilibrium, center of gravity, moment of inertia of plane sections, stresses in framed structures. 4 cred.; prereq., 91; 4 rec. hrs. per week.
127—Technical Mechanics: Dynamics. Kinematics of the particle and rigid body, theorem of Coriolis, particle dynamics, dynamics of a rigid body in plane motion, the energy equation, impulse and momentum, applications to technical problems. 5 cred.; prereq., 26; 5 rec. hrs. per week.
161-162-163—Advanced Technical Mechanics. Moving axes, Eulerian angles, Lagrange's equations, generalized co-ordinates, dynamical problems soluble in terms of circular and elliptic functions, dynamical specifications of bodies, motion of a top, theory of vibrations, Hamilton's principle. Special problems. 3 cred. per qtr.; prereq., 127 or permission of instructor; 3 rec. hrs. per week.
297-298—Vibration Problems. 3 cred. per qtr.; prereq., 127; 3 rec. hrs. per week.

MATERIALS

85*—Strength of Materials. (Chem.E. and Prebus.) Mechanical and elastic properties of materials of construction, beams, shafts, columns, combined stresses, dynamic stresses. 3 cred.; prereq., 84; 3 rec. hrs. per week.
87—Materials Testing Laboratory. (Chem.E. and Prebus.) Investigation of the physical properties of various metals and engineering materials (steel, cast iron, wood, brick, etc.). Standard methods of testing. 1 cred.; prereq., 85 or reg. in 85; 2 lab. hrs. per week.
93*—Strength of Materials. (Arch.) Mechanical and elastic properties of materials of construction, design of riveted joints, beam theory, columns, arches. 4 cred.; prereq., 91 and 92; 4 rec. hrs. per week.
128—Strength of Materials. Mechanical and elastic properties of materials of construction; stresses and deformations in beams, shafts, and columns; stresses in statically indeterminate structures; combined stresses. 5 cred.; prereq., 26; 5 rec. hrs. per week.
141—Materials Testing Laboratory. Investigation of the physical properties of various metals and engineering materials (steel, cast iron, wood, cement, brick, etc.). Standard methods of testing. 2 cred.; prereq., 128 or reg. in 128; 1 lect. and 2 lab. hrs. per week.

* For permissible substitute, see page 54.

144—Materials Testing Laboratory. (Mines.) 2 cred.; prereq., 128; 4 lab. hrs. per week.
180—Advanced Strength of Materials. Stress analysis in statically indeterminate structures. Theory of superposition. Energy of strain. Elastic stability. 3 cred.; prereq., M.&M. 128; 3 lect. hrs. per week.
181-182-183—Applied Elasticity. Special problems in stress analysis. 3 cred. per qtr.; prereq., M.&M. 128; 3 lect. hrs. per week.
184-185-186—Advanced Testing Materials Laboratory. Special problems relating to the physical properties of engineering materials. 2 cred. per qtr.; prereq., 141; 6 lab. hrs. per week.
294-295-296—Mathematical Theory of Elasticity. 3 cred. per qtr.; prereq., 128, 153; 3 rec. hrs. per week.

HYDRAULICS

86*—Hydraulics with Laboratory. (Chem.E.) Hydrostatics, Bernoulli's theorem, flow through orifices, pipes, and over weirs, dynamic action of jets and streams, flow of gases through pipes. 3 cred.; prereq., 84; 2 rec. and 2 lab. hrs. per week.
129—Hydraulics. Laws of equilibrium of fluids, flow through orifices and over weirs, pressure and flow through tubes and pipes, flow in conduits and rivers, dynamic pressure of water, elementary principles of turbines and pumps. 4 cred.; prereq., 26; 4 rec. hrs. per week.
130—Open Channel Flow. Theory of uniform and varied flow in open channels, with practical applications to the design of hydraulic structures, computations of drawdown curves, backwater curves, hydraulic jump, measuring flumes, submerged weirs, etc. 3 cred.; prereq., 129 and 143; 3 rec. hrs. per week; ar.
132-133-134—Advanced Hydraulic Problems. Special problems in hydraulic design. 2 cred. per qtr.; prereq., 130 or reg. in 130; 6 lab. hrs. per week.
143—Hydraulics Laboratory. Experimental and demonstrational work. Pressure head, Peizometer tubes, gages, stability of flotation, Bernoulli's theorem. Venturi meter, flow through orifices, over weirs, and through pipes. Open channels, gaging, impact on vanes, pumps, and hydraulic machines. 1 cred.; prereq., 86 or 129 or reg. in 86 or 129; 2 lab. hrs. per week.
190—Mechanics of Similitude and Dimensional Analysis. Theory of the use of models in design; conditions for similarity in the case of hydraulic structures, elastic structures, aircraft, ships, waves, etc. 3 cred.; prereq., 127, 128, and 129 or permission of instructor; 3 rec. hrs. per week.
191—Hydraulic Motors and Pumps. Study of the hydraulic theory of the ram, impulse wheel, reaction turbine, and centrifugal pump. 3 cred.; prereq., 129; 3 rec. hrs. per week.
192—Natural and Artificial Waterways. Wave motion, tides, ship resistance, transportation of sediment. Control and regulation of rivers, design of ship canals, locks, dry docks, movable dams, harbors. 3 cred.; prereq., 130 or permission; 3 rec. hrs. per week.
193—Hydraulic Measurements. Detailed study of the current meter. Venturi meter, weir, orifice. Parshall flume, traveling screen, chemical method of gaging, etc. 3 cred.; prereq., 129; 3 rec. hrs. per week.
194-195-196—Advanced Hydraulics Laboratory. Special experimental studies concerning the characteristics of turbines, pumps, etc. Hydraulic models. 2 cred. per qtr.; prereq., 129 and 143; 6 lab. hrs. per week.
197-198-199—Mechanics of Soils. 2 cred. per qtr.; prereq., 129, 143; 2 rec. hrs. per week.
232-233-234—Advanced Fluid Mechanics. 3 cred. per qtr.; prereq., 190; 3 rec. hrs. per week.
281-282-283—Hydrodynamics. 3 cred. per qtr.; prereq., 129, 153; 3 rec. hrs. per week.
284-285-286—Advanced Hydrodynamics. 3 cred. per qtr.; prereq., 283; 3 rec. hrs. per week.

MECHANICAL ENGINEERING

INDUSTRIAL LABORATORIES

1‡—Elementary Woodworking. (Ind.Ed.) Fundamental operations in bench practice layout and assembly of unit parts. Manipulation and care of hand tools. Elementary wood turning, demonstration and practice. Not an engineering elective. 2 cred.; no prereq.; 6 lab. hrs. per week.

* For permissible substitute, see page 54.
‡ A fee of $2 per quarter is charged for this course.

2‡—Machine Woodworking. (Ind.Ed.) Operation and setting up of woodworking machinery. Care and maintenance of cutting tools and power equipment. Advanced wood turning, demonstrations and practice. Not an engineering elective. 2 cred.; no prereq.; 6 lab. hrs. per week.

3‡—Wood Finishing and Furniture Construction (Ind.Ed., Arch., and others). Identification and use of woods and finishing materials, wood finishing methods, color blending of stains and fillers, use of undercoats, paints, lacquers, varnish, etc., and their application to wood surfaces. 2 cred.; no prereq.; 6 lab. hrs. per week.

4‡—General Woodwork. (Prebus.) Study of the principles involved in the construction of articles made of wood and wood products. Uses and compositions of paints, varnishes, stains, and wood preservatives. 2 cred.; no prereq.; 2 lect. and 3 lab. hrs. per week.

5‡—Pattern Practice. Study of the principles and uses of metal and wooden patterns, core boxes, and sweeps for the production of metal castings. Industrial practices and conventions. Inspection trips. 2 cred.; prereq., Chem. 5 or 15, and Dr. 2; 2 lect. and 3 lab. hrs. per week.

6‡—Advanced General Woodwork. Study of the factors in mass production of furniture, mill work, and interior finishings. Adaptation of plywoods and plastics. Use of machines in producing general wood products. 2 cred.; prereq., 3, 4, or 5; ar.

7‡—Nonmetal Manufacturing. Methods and processes of manufacturing goods from materials such as wood, glass, plastics, asbestos, bakelite, hard rubber, and other synthetic substances. 3 cred.; prereq., 3, 4, or 5.

8‡—Foundry Practice. (Ind.Ed.) Theory and practice in melting iron, brass, bronze, and aluminum. Practice in making cores and molds for ornamental and commercial castings. Not an engineering elective. 2 cred.; no prereq.; 6 lab. hrs. per week.

9‡—Foundry Practice. Theory and practice in melting, alloying, and casting ferrous and nonferrous metals. Theory of foundry control methods, risers, feeders, gates, and pattern design. Practice in making cores and molds in relation to part design. Problems and reports. 2 cred.; prereq., Chem. 4 or 14; 2 lect. and 3 lab. hrs. per week.

10‡—Advanced Foundry Practice. Foundry control methods. Laboratory practice in sand testing. Steel, malleable iron, and nonferrous castings. 2 cred.; prereq., 9; ar.

11‡—Metal Working. (Prebus.) Theory and practice in the working and joining of metals including soldering, brazing, and welding. 2 cred.; no prereq.; 2 lect. and 3 lab. hrs. per week.

12‡—General Metal Work. (Ind.Ed.) Working various metals. This course is designed to meet the needs of teachers of elementary forging and art metal courses. Projects designed for individual needs. Not an engineering elective. 2 cred.; no prereq.; 6 lab. hrs. per week.

13‡—Forging, Welding, and Heat Treating. Theory of production and working of metals; operation of furnaces; thermit, electric arc, oxyacetylene, and spot welding. 2 cred.; prereq., Chem. 5 or 15, and Dr. 2; 2 lect. and 3 lab. hrs. per week.

14‡—Advanced Welding. Engineering approach to the technique and application of electric arc, oxyacetylene, and resistance welding. Theory and practice. Problems. 2 cred.; prereq., 13; ar.

15—Survey of Manufacturing Processes. (Chem. and Chem.E.) Technique of machine shop, forge, and foundry practices. Lectures and demonstrations. 3 cred.; no prereq.; 3 lect. hrs. per week.

16‡—Machine Shop Practice (Mines, Met., Pet.E.). Fundamental operations on lathes, shaper, drill press, milling machine and grinder, bench work and job analysis. 2 cred.; prereq., 13; 2 lect. and 3 lab. hrs. per week.

17‡—Machine Shop Practice (E.E., Prebus.). Fundamental operations on lathes, shaper, drill press, milling machine and grinder, bench work and job analysis. 2 cred.; prereq., 13; 2 lect. and 3 lab. hrs. per week.

18‡—Machine Shop Practice (AeroE.). Fundamental operations on lathes, shaper, drill press, milling machine and grinder, bench work and job analysis. 2 cred.; prereq., 13; 2 lect. and 3 lab. hrs. per week.

19‡—Machine Shop Practice (Ind.Ed.). Fundamental operations on lathes, shaper, drill press, milling machine and grinder, bench work, and measurements. 2 cred.; no prereq.; 6 lab. hrs. per week.

71‡—Machine Shop Practice (M.E.). Care and operation of machine tools, measurements and writing operation sheets for quantity production of machined metal parts. 2 cred.; prereq., 13; 2 lect. and 3 lab. hrs. per week.

‡ A fee of $2 per quarter is charged for this course.

72‡—Machine Shop Practice (M.E.). Care and operation of turret lathes, milling machines, and grinders, machinability determinations operation sheets for production of complete units. 2 cred.; prereq., 71; 2 lect. and 3 lab. hrs. per week.

73‡—Advanced Machine Shop Practice. Setting up turret lathe, milling machines, and grinders for quantity production. 3 cred.; prereq., 16, 17, 18, or 72; 9 lab. hrs. per week.

80-81—Industrial Materials. Survey of materials used in industry. Characteristics, properties, methods of production, manufacturing, inspecting, testing, and application. 2 cred. per qtr.; prereq., Ch.E. 31 (open to soph.); 2 rec. hrs. per week.

110‡—Foundry Control Methods. X-ray analysis of castings. Laboratory practice in metals analysis, ferrous and nonferrous melting operations and control. Problems and reports. 3 cred.; prereq., 9, Chem. 16; ar.

111‡—Advanced Foundry Practice. Continuation of Course 110. 3 cred.; prereq., 110, Phys. 9, Chem. 16; ar.

112‡—Plastics Processing. Laboratory and lecture course dealing with the materials, equipment, and manufacturing of plastic products. Design and properties of plastic products. 3 cred.; prereq., Chem. 5 and Dr. 2.

MACHINE DESIGN

20—Elementary Machine Design. Technique and knowledge necessary to convey information from engineering department to shop. Design and shop standards; fits, limits, tolerances, heat treating, welding, material specifications, records, and changes. 2 cred.; prereq., Dr. 3; 6 lab. hrs. per week.

21—Kinematics. Instant centers, centroids, point paths, gear tooth profiles, cam construction, velocity diagrams. 2 cred.; prereq., 20; 6 lab. hrs. per week.

22—Mechanism. Motion studies. Displacements, velocities, and accelerations. Linkages, chains, flexible connectors, gearing gear trains, worm and wheel, screws, straight line motions, hoists, pulley blocks, ratchets, intermittent motions. Recitations and problems. 3 cred.; prereq., 21 and M.&M. 24; 2 rec. and 3 lab. hrs. per week.

23—Dynamics of Machine Design. Static and inertia forces; governors, static, dynamic, and reciprocating balance; crank effect diagrams. 3 cred.; prereq., M.&M. 127; 2 lect. and 3 lab. hrs. per week.

24—Elements of Machine Design. Design of beams, shafting, columns, screw fastenings, springs, friction clutches, and brakes. Endurance limits; Mohr's diagrams. Stresses due to suddenly applied loads. Riveted and welded joints. Working stresses. 3 cred.; prereq., M.&M. 128; 2 rec. and 3 lab. hrs. per week.

26—Mechanism and Kinematics. (E.E., Aero.E., and Ag.E.) Kinematics of machines. Levers, linkwork, flexible connections, gearing, screws, cams, epicyclic trains. Graphical studies of velocities. Motion; intermittent, parallel, quick return, and escapements. 3 cred.; prereq., M.&M. 24; 3 rec. hrs. per week.

27—Machine Design. (Aero.E. and Ag.E.) Fundamental principles of design of machine elements; lubrication, theory and application; friction drives, shafts, screws, gears, belt connectors, springs, flywheels, machine frames, shrink fits. 3 cred.; prereq., M.&M. 128; 2 lect. and 3 lab. hrs. per week.

120—Advanced Engineering Design Drafting. Design analysis, layout and detail drafting of a complete machine, punch press, engine, pump, or automatic machine or special machinery by group. 2 cred.; prereq., 24; 6 lab. hrs. per week.

121—Machine Design. Advanced machine elements. Spur, bevel, and worm gears; flywheels and pulleys; rotating discs; belt and rope transmission; force and shrink fits; critical speeds; lubrication, theory and practice, cylinders, flat plates. 2 cred.; prereq., 24; 1 rec. and 3 lab. hrs. per week.

122-123—Mechanical Engineering Design. Machine elements as applied to complete machines. Mathematical theory of lubrication; vibration analysis; stress analysis by photoelastic methods. Gyroscopes. Study of materials for special purposes, high temperatures, etc. 2 cred. per qtr.; prereq., 121; 1 rec. and 3 lab. hrs. per week.

125—Machine Design Laboratory. Experimental studies of critical speeds, vibration, balancing, and noise in high speed machinery; complex stresses in machine parts; the use of vibrograph, oscillograph, stoboscope, photoelastic polariscope, and noise meter. 2 cred.; prereq., 23; 1 lect. and 3 lab. hrs. per week.

127—Lubrication. Hydrodynamic theory of lubrication and applications to the design and construction of thrust and journal bearings. Pressure distribution, end leakage, film thickness, temperatures, and heat losses. 3 cred.; prereq., 121; 3 lect. or rec. hrs. per week.

‡ A fee of $2 per quarter is charged for this course.

128—Photoelastic Stress Analysis. Fundamentals of stress analysis; optics of the polariscope; studies in tension, bending, and shear; combined stresses; concentrated stresses; auxiliary equipment; Mohr's diagrams; complex stress analysis. 3 cred.; prereq., M.&M. 128; 2 lect. and 3 lab. hrs. per week.

129—Vibration Engineering. Fundamental analysis; factors influencing vibration, critical speeds, rotating, reciprocating, torsional vibration; balancing; instruments for measuring and recording vibration. 3 cred.; prereq., M.&M. 127; 3 lect. or rec. hrs. per week.

221-222-223—Advanced Mechanical Engineering Design. Application of analysis by advanced strength of materials, dynamics, and mathematics to special problems in design. 3 cred. per qtr.; prereq., 121; 3 lect. hrs. per week.

228—Photoelasticity. Review of fundamentals of stress analysis; optics of the polariscope; applications of photoelasticity in tension, bending, shear, and combined stresses. Use of photoelastic polariscope and solution of problems. 3 cred.; prereq., M.&M. 128; 2 lect. and 3 lab. hrs. per week.

HEAT POWER

32—Elementary Mechanical Laboratory. (Aero.E.) Calibration of pressure gages, anemometers, indicator springs. Use of steam calorimeters, planimeters, indicators. Calculations from indicator cards. Tests of mechanical appliances, lubricating oils. 2 cred.; prereq., reg. in 131; 4 lab. hrs. per week.

33—Elementary Mechanical Laboratory. Calibration of pressure gages. Use of planimeters, indicators, gas calorimeter. Calculations from indicator cards. Test of steam engine and boiler-feed pump. Proximate analysis of fuels. 2 cred.; prereq., 131 or reg. in 131; 1 lect. and 3 lab. hrs. per week.

34—Mechanical Laboratory. Tests of lubricating oils, greases, and other petroleum products. Study and tests of temperature-measuring instruments and gas analyzers. Test of a turbine-generator. 2 cred.; prereq., 33; 1 lect. and 3 lab. hrs. per week.

35—Elementary Steam and Power Laboratory. Test of insulation materials, boiler waters, calorific value of fuels. Calibration of steam flow meter and boiler control devices. Use of steam calorimeters and power plant maintenance equipment. Test of a steam generator. Inspection trip. 2 cred.; prereq., 34 and 141 or reg. in 141; 1 lect. and 3 lab. hrs. per week.

38—Heat Engines. (Chem.E.) Study of steam properties, steam calorimetry, elementary thermodynamics, fuels, and combustion. Construction, selection, and operation of steam power plant equipment. 3 cred.; prereq., Phys. 7; 3 rec. hrs. per week.

39—Heat Engine Laboratory. (Chem.E.) Calibration and use of instruments; tests of engines, boilers, compressors, and power plant auxiliaries. 1 cred.; prereq., 38 or reg. in 38; 3 lab. hrs. per week.

40-41—Heat Engines. (E.E.) Properties of steam; principles of operation of steam machinery; fuels, combustion, and smoke prevention; construction, operation, and testing of engines, turbines, boilers, condensers, pumps, and power plant equipment. Selection of equipment for different types of plants. 3 cred. per qtr.; prereq., Phys. 7; 2 rec. and 3 lab. hrs. per week.

42—Heat Engines. (C.E.) Elementary thermodynamics. Steam generation. Fuels and combustion. Construction and operation of boilers and accessories. Engine-room instruments. Types, details, of steam engines, steam turbines, gas engines, air compressors, and auxiliary equipment. 4 cred.; prereq., Phys. 7; 4 rec. hrs. per week.

131-132—Thermodynamics. Critical study of the properties of gases and vapors and the fundamental laws for conversion of heat energy into mechanical energy in steam engines, gas engines, air compressors, refrigeration machines, steam turbines, etc. 3 cred. per qtr.; prereq., M.&M. 25 and Phys. 8; 3 lect. and 2 lab. hrs. per week for 131; 3 rec. hrs. per week for 132.

138—General Laboratory. (a) Calibration of pressure gages. Steam calorimetry. Steam indicator practice, card calculation. Test of oils, engines, turbines, air compressors, and pumps. (b) The use of weirs, differential gages, etc., in the tests of centrifugal pumps, hydraulic turbines, etc. 2 cred.; prereq., Min.E. 122; 4 lab. hrs. per week.

141-142—Heat-Power Engineering. Study of fuels and combustion, stokers, furnaces, boilers, superheaters, economizers, feed water treatment, etc. Theory, practice, and economics relating to heat engines and steam generating equipment, including the auxiliary units; air, water, and steam heat exchangers and purifiers. 3 cred. per qtr.; prereq., 132; 3 rec. hrs. per week.

144—Steam Turbines. Theory and practice applied to various types. Thermodynamics and mechanical analysis of problems involved in the design of nozzles, blades, rotors, etc. Condition of operation; systems of transmission; lubrication; economy; field service. Laboratory investigation. 3 cred.; prereq., 132; 3 rec. hrs. per week.

145—Applied Thermodynamics. Laws of heat transmission, as applied to steam, air, and gas power units and auxiliary equipment including cooling towers, accumulators, stills, evaporators, intercoolers, preheaters, etc., flow of fluids through pipes, tube banks, nozzles, slots, labyrinths, etc. 3 cred.; prereq., 35, 132; 3 rec. hrs. per week.

146—Fuels and Combustion. Fuels: classification and analyses. Hand and stoker treatment; regulation. Pulverized and liquid fuels. Types of burners, controls. Combustion; generation of heat; furnace gases; stratification; flame way; smoke prevention. Furnaces. Lectures and recitations. 3 cred.; prereq., 142; 3 rec. hrs. per week.

147—Design of Steam Machinery. Piping systems, furnace and gas passage dimensions, stokers, oil, gas, and pulverized fuel burners, superheaters, feed water heaters, and pumps, air preheaters, automatic controls, chimneys, etc. 2 cred.; prereq., 142 or reg. in 142; 6 lab. hrs. per week.

148—Design of Power Plant Units. Treatment of condensers, air pumps, cooling towers, stage evaporators, reheaters, etc. 2 cred.; prereq., 147; 6 lab. hrs. per week.

149—Advanced Steam Laboratory. Tests of steam turbines, uniflow and compound steam engines, condensers, evaporators, and vacuum pumps. Tests of compound steam pump. Air compressor, boiler, superheater, and power plant. Studies of fluid flow meters and air-conditioning apparatus. 2 cred.; prereq., 132 and 35, 142 or reg. in 142; 4 lab. hrs. per week.

185—Industrial Instrumentation and Automatic Control. General characteristics of measuring, indicating, integrating, and recording devices. Types of control. Transmission of instrument impulse powering. Lags and transients in systems; optimum conditions in automatic control. Applications as to power plants and process industries. 3 cred.; sr. M.E. and Chem.E.; 2 lect., 3 hrs. lab.; ar.

241—Advanced Thermodynamics. Reversible changes of state and efflux of wet and superheated vapors. Flow of compressible fluids in mains, moving channels, into receivers, and communicating vessels. Gas mixtures, critical points, liquefaction. Power plant cycles: regenerative, reheating, and bleeding. 3 cred.; prereq., 145; grad. only.

242-243—Power Plant Design. Problems, designs, and estimates for power plants and central stations. Selection of motive powers, relative advantages of steam, producers, and gas plants. Choice of engines and boilers; pumps, piping, and accessories. 2 cred. per qtr.; prereq., 148; grad. only.

244—Power Plant Management. Operation and maintenance of boilers, engines, steam turbines, and accessory apparatus. Smoke prevention, lubricants and lubrication. Power plant finance. Daily logs and power costs. Study of recent power researches. 3 cred.; prereq., 141; grad. only.

INTERNAL COMBUSTION ENGINES

50—Auto and Airplane Engines. Principles and types. Electrical systems. Lubrication and cooling. Carburetors. Accessories. 3 cred.; soph.; 3 rec. hrs. per week.

55—Internal Combustion Engines. (E.E.) Brief course in theory and laboratory, including gas cycles, combustion, fuels and lubrication; construction and performance of gasoline, Diesel, and compression-ignition engines. 3 cred.; prereq., 41; 2 rec. and 3 lab. hrs. per week.

150—Internal Combustion Engines. Thermodynamics and combustion processes of real gas and vapors in Otto, Diesel, and compression-ignition engines; volatile fuels, mixtures of real gases and vapors; cylinder pressures, flame temperatures, combustion phenomena; heat losses, real cycle efficiencies. 3 cred.; prereq., 131; 3 rec. hrs. per week.

151—Advanced Internal Combustion Engines. Special reference to automobile, truck, and airplane engines. Theoretical consideration of fuels, combustion, detonation, lubrication, supercharging, carburetion and fuel injection. Recent developments in automotive and airplane engines. 3 cred.; prereq., 150; 3 rec. hrs. per week.

152—Diesel Engines. Advanced course in the theory, design, operation, and economics of the Diesel engine with emphasis on high speed combustion and injection systems. 3 cred.; prereq., 55 or 150; 3 rec. hrs. per week.

153—Engine Service Management. Instruments and methods used in servicing or reconditioning automobile and airplane engines. Causes of mechanical failure and wear. Permissible tolerance in worn parts. Lubrication and ignition service. 3 cred.; prereq., 150; 3 rec. hrs. per week.

154—Design of Airplane Engines. Study of the designs of radial and in-line aircraft engines. Drawing room problems, including graphical and analytical calculations of stresses in moving parts. Combined polar diagrams of bearing loads, etc. 2 cred.; prereq., 27, 150; 6 lab. hrs. per week.

155—High Speed Engine Testing. Advanced laboratory procedure and instrumentation. Effects of fuel mixture, distribution, etc., upon general engine performance. 2 cred.; prereq., 158 or 159 and minimum honor point average of 1.5; 6 lab. hrs. per week.

156-157—Design of Internal Combustion Engines. Detailed study of design of automotive and stationary engines. Problems, including calculation of cylinders, bearing loads, stresses in moving parts, and valve mechanisms. 2 cred.; prereq., 121, 150 for 156, 154 or 156 for 157; 6 lab. hrs. per week.

158—Aero Engine Testing. Use of modern instruments for testing gasoline, Diesel, and aircraft engines. Use of dynamometers and torque stands in determining engine performance. 2 cred.; prereq., 150 or reg. in 150; 6 lab. hrs. per week.

159—Internal Combustion Engine Laboratory. Tests of gasoline, semi-Diesel, and Diesel engines. Power plant units, automotive engines, aircraft engines. 2 cred.; prereq., 150 or reg. in 150; 4 lab. hrs. per week.

250—Dynamics of High Speed Engines. Advanced study of inertia forces; balancing high speed multi-cylinder engines; engine torque analysis; torsional vibration, etc. Conferences, assigned readings, and problems. 3 cred.; grad. only; prereq., 121, 150.

251-252-253—Automotive Vehicles. Study of transmission systems, running gears, chassis, bodies, riding qualities of vehicles, and current developments; lecture and problems. Cred. ar.; grad. only.

254—Automobile Fleet Maintenance. Study of available types of motor coaches and trucks, their design features from a maintenance viewpoint, a survey of service depot requirements with a study of fleet service methods and maintenance practice. 3 cred.; grad. only; prereq., 150.

255-256-257—Engine Testing and Research. Problems involving volumetric efficiency, manifolding, friction losses, oil deterioration, cylinder corrosion, and other engine performance factors of current interest. 2 cred. per qtr.; grad. only.

258—Motor Truck and Bus Transportation. Problems involving motor truck transportation, capacity of trucks, trailers, drawbar pull. Efficiencies. Effect of road surface. Freight handling. Analysis of costs of truck operation and maintenance. Relative costs of transportation. 3 cred.; grad. only; prereq., 153.

HEATING, VENTILATION, AND REFRIGERATION

160—Heating and Ventilation. Principles of heating, ventilation, and air conditioning. Warm air, steam, hot water, vapor, vacuum, and fan systems of heating; pipe systems; heat regulation. Ventilation and air conditioning, central station heating. 3 cred.; prereq., 131, M.&M. 127, 129; 1 lect. and 2 rec. hrs. per week.

161-162—Heating, Ventilation, and Air Conditioning Design. Calculation of heating and cooling loads; selection and arrangement of equipment; design of complete heating, ventilation, and air conditioning systems for various types of buildings. 2 cred. per qtr.; prereq., 160; 6 lab. hrs. per week.

165—Advanced Heating, Ventilation, and Air Conditioning. Requirements for comfort, health, and industrial processes. Thermodynamics of air vapor mixtures. Heating, cooling, humidification, dehumidification. Atmospheric impurities, sources, classifications, methods of elimination. Air supply and distribution. Methods of control and application. 3 cred.; prereq., 160; 3 rec. hrs. per week.

167—Advanced Heating, Ventilation, and Air Conditioning. Special problems including air conditioning, heat transfer, heating and cooling loads, solar radiation, etc. Equipment and test methods. 3 cred.; prereq., 160; 3 rec. hrs. per week.

169—Heating and Ventilation Laboratory. Tests of heating, ventilation, and air conditioning equipment. The determination of air qualities as required for comfort and for specific industries. Tests and studies of complete installation. 2 cred.; prereq., 35, 160 or reg. in 160; 4 lab. hrs. per week.

180—Refrigeration. Refrigeration cycles. Thermodynamics of refrigeration, refrigerants, load calculations, compression, steam jet, and absorption refrigeration, refrigeration equipment. 3 cred.; prereq., 132; 3 rec. hrs. per week.

181—Advanced Refrigeration. Fluid flow and heat transmission applied to refrigeration. Condensers and evaporators, refrigeration piping, refrigeration controls, low temperature refrigeration, refrigeration applications. 3 cred.; prereq., 166; 3 rec. hrs. per week.

189—Refrigeration Laboratory. Tests of reciprocating, rotary, absorption, and steam jet refrigeration equipment. Study of refrigeration controls, dry and flooded evaporators, operating characteristics of condensing units. 2 cred.; prereq., 166 or reg. in 166; hrs. ar.

197—Mechanical Equipment of Buildings. Investigation of heating, ventilating, refrigerating, power, elevator, fire protection, and special equipment for large buildings. Disposal of wastes, light distribution, communication, and plumbing. Lectures, inspection trips, reports with equipment layouts. 3 cred.; prereq., 160, Phys. 9.

265—Advanced Heating, Ventilation, and Air Conditioning. Taken in connection with research work in the laboratory. Cred. ar.; grad. only; prereq. 160.

INDUSTRIAL ENGINEERING

70—Mechanical Technology. Study of mechanical processes involved in various manufacturing industries and in the development and utilization of power. Lectures by various specialists. 1 cred.; open only to soph., jr., and sr.; 2 lect. hrs. per week.

74—Industrial Engineering Problems. Calculation of problems faced by industrial engineers. Estimating, purchasing, selection of materials, labor and overhead costs, inventory and storage costs; economic justification of machines, small tools, and changes in methods, etc. 3 cred.; prereq., 171, 172, 174.

77—Manufacturing Costs. Determination of factory costs as applied to quantity production. Cost background essential to the industrial engineer. Collection, analysis, distribution of the cost of labor, materials, and overhead, together with the study factors which control costs. 3 cred.; prereq., 171.

83—Quality Control. Statistical approach to inspection of parts in a manufacturing plant. Statistical techniques involved, determination of sample quantity for large and small lots, parts inspection, process inspection, economic advantages of statistical approach. 3 cred.; prereq., 72 and reg. in 171.

170—Tool Design. The design of jigs, fixtures, die casting dies, moulds for plastic products and dies for sheet metal products to guarantee low cost production. 3 cred.; prereq., 72 and 171; 1 lect. and 6 lab. hrs. per week.

171—Production Control. Detailed study of principles used to facilitate factory production. The theoretical considerations involved in getting materials and machines co-ordinated to produce products at minimum costs. 3 cred.; prereq., 72; 3 rec. hrs. per week.

172—Industrial Plants. Geographical location, design, and layout of industrial plants. Includes discussions on lighting, heating, ventilation, sanitation, distribution of power, material handling equipment. Laboratory work includes problems taken directly from local plants. 3 cred.; prereq., 171, 174; 2 lect. and 3 lab. hrs. per week.

173—Industrial Organization. Problems involved in organizing and controlling factory organizations. 3 cred.; prereq., 172; 3 rec. hrs. per week.

174—Motion and Time Study Laboratory. Training in motion and time study as a tool in industrial management. Wage systems, rate setting. Particular emphasis on cost reduction due to better methods. Laboratory problems taken directly from local industries. 2 cred.; prereq., 72, 171, or B.A. 89, or reg. in 171; 1 lect. and 3 lab. hrs. per week.

175—Materials Handling. Detailed study of equipment necessary for economical transportation and storage of materials and parts during the process of manufacturing; economic considerations involved in the selection of proper type of material handling equipment. 2 cred.; prereq., 162 or reg. in 172; 1 lect. and 2 lab. hrs. per week.

179—Industrial Relations. Human problems in an industrial organization and relationship to industrial engineering. Functions of a personnel department, foreman training, job analysis, shop rules and grievance, arousing interest in work service departments, safety engineering. 3 cred.; prereq., 171.

277-278-279—Industrial Engineering Problems. Special investigations of practical problems and suggested methods of procedure. Lectures, assigned reading, shop visits, and reports. 3 cred. per qtr.; grad. only; prereq., 173, 174.

GENERAL

186—Railway Technology. Systematic course of visits to the various railroad shops in the vicinity to study locomotive details and classifications. Locomotive practice. 2 cred.; prereq., 141 and M.&M. 127, 128, 129.

188—Hydraulic Machinery. Theory of operation, design, construction, and regulation of water turbines. Turbine testing; characteristics, selection of type. Cost of turbines and water power. 3 cred.; sr.; prereq., M.&M. 129.

190-191-192—Seminar. Reading of assigned articles in current technical press. Classroom presentation of principal features of assigned articles. 1 cred. per qtr.; sr.; 1 rec. hr. per week.

193—Engineering Economics. Cost factor in engineering problems as affected by plant location, kinds of products, size of industry, transportation, marketing, class of labor, etc. Allocation of costs, sunk costs, excess production costs, break even costs, ultimate economy, estimating, specifications, and contracts. 3 cred.; prereq., jr. or sr. in engineering; 3 rec. hrs. per week.

194—Advanced Engineering Problems. Opportunity will be offered for carrying on special investigations in the various fields of mechanical engineering. 2 to 4 cred.; reg. by permission of the division chief in charge of work. Open only to sr. M.E. with 1.5 honor point average.

195—Inspection Trip. During the spring vacation of the senior year an inspection trip is made to various industrial plants to study mechanical equipment, manufacturing methods and processes. Req. of sr. mech. engr. 1 cred. Discontinued for the duration.

290-291-292—Mechanical Engineering Research. Investigations in connection with lubrication, fuels, furnaces, boilers, steam engines, turbines, gas engines, heating and ventilation, industrial and other engineering problems. Cred. as ar. per qtr.; grad. only. Reg. by permission of the division chief in charge of work.

293—Graduate Seminar. Colloquium for graduate students and staff. Reports and discussion by members on research or specific problems to be assigned. Recommended for graduate students and junior staff members. No cred.

METALLURGY

1—Assaying. Lectures on the fire assaying of ores and metallurgical products. Theory of sampling, balance manipulation, furnaces, slag calculations, oxidation, reduction, special methods, etc. 2 cred.; prereq., Chem. 5 or equiv.; 3 lect. hrs. per week.

2—Assaying Laboratory. Application of the principles of fire assaying. Practical determination of gold, silver, and lead in ores and metallurgical products. Metallurgists 3 cred.; prereq., reg. in Met. 1; 8 lab. hrs. per week.

3—Assaying Laboratory. Application of the principles of fire assaying. Practical determination of gold, silver, and lead in ores and metallurgical products. 1 cred.; miners, geologists, and petroleum engineers; prereq., reg. in Met. 1; 4 lab. hrs. per week.

11—Metallurgy of Pig Iron. Raw materials, construction, and basic principles of the blast furnace process. Chemistry of the process. Fluxes and slags. Principles for controlling operation and products. 3 cred.; prereq., Chem. 5 or equiv.; 1 rec. and 3 lect. hrs. per week.

12—Metallurgy of Steel. Steel producing processes and various types of steel. Modern furnace construction. Chemistry of refining processes. The application of protective coatings to steel products. 3 cred.; prereq., 11; 1 rec. and 3 lect. hrs. per week.

14—Metallurgy of Copper, Lead, and Zinc. Short course for mechanical, electrical, or chemical engineers. Methods of extraction, recovery, smelting, and refining. 3 cred.; prereq., Inorg. Chem. 8 or equiv.; 3 lect. hrs. per week.

106—Nonferrous Metallurgy. Pyrometallurgy and hydrometallurgy of the recovery and refining of lead, zinc, copper, nickel, aluminum, tin, manganese, and mercury. Brief consideration is given to the metallurgy of magnesium, arsenic, bismuth, cadmium, and cobalt. 2 cred.; prereq., General Inorg. Chem.; 3 lect. hrs. per week.

107—Nonferrous Metallurgy. Continuation of Course 106. 2 cred.; prereq., 106.

108—Nonferrous Metallurgy. Pyrometallurgy and hydrometallurgy of the recovery and refining of gold, silver, platinum, and the rare metals. 2 cred.; prereq., 107.

110—Ore Dressing. Study of jaw and gyratory crushers, ball mills, rod mills, tube mills, volumetric sizing, gravimetric sizing. Concentration by tables, jigs, bowl classifiers, log washers, and miscellaneous devices used in ore dressing. 2 cred.; prereq., Geol. 24; 3 lect. hrs. per week.

111—Ore Dressing Laboratory. Practical examination of ores and use of ore dressing machinery as outlined in Course 110. 1 cred.; prereq., with 110; 4 lab. hrs. per week.

112—Ore Dressing. Flotation principles. Special attention to chemical and physical action of the different reagents used, such as frothing, collecting, depressing, activating, conditioning, etc. Study of liberation and particle size, grinding circuits and flotation machinery. 2 cred.; prereq., 110; 3 lect. hrs. per week.

113—Ore Dressing Laboratory. Practical examination of ores by flotation. Course involves the grinding, use of proper reagents, and examination of products. 1 cred.; prereq., reg. in 112; 4 lab. hrs. per week.

114—Ore Dressing. Advanced course designed primarily for Group A metallurgists. Continuation of Course 112 giving more detailed study of ore dressing problems. 2 cred.; prereq., 113; 3 lect. hrs. per week.

115—Ore Dressing Laboratory. Special problems in ore dressing involving the use of the microscope. Study of polished sections to determine the minerals present, grain size, and association of minerals. 1 cred.; prereq., 114, Geol. 165; 4 lab. hrs. per week.

116—Ore Dressing Laboratory. Course designed for students of mining and geology. It incorporates a part of Course 111 and Course 113. 1 cred.; prereq., 112; 4 lab. hrs. per week.

121—Ore Testing (Iron Ores). Methods of beneficiation, principles, methods and machines, concentration, formulae, metallurgical and economic considerations. 2 cred.; prereq., 110; 1 lect. and 3 lab. hrs. per week.

122—Ore Testing. Determination of methods for metallurgical and economic extraction of nonferrous metals from ores. Lecture and laboratory. 4 cred.; prereq., 121; 2 lect. and 8 lab. hrs. per week.

123—Ore Testing. Continuation of Course 122. Consideration of factors affecting extraction. Study of distribution of values in mill and metallurgical products. 4 cred.; prereq., 122; 2 lect. and 8 lab. hrs. per week.

124—Special Problems in Ore Testing. Detailed study of ore testing, problems. Causes of nonextraction. Methods of correction. Relation of values. Cred. and hrs. ar.; prereq., 112.

125—Special Problems in Ore Testing. Continuation of Course 124. Cred. and hrs. ar.; prereq., 124.

126—Special Problems in Metallurgy for Miners. Study of metallurgical problems in relation to mine development. Conferences, together with laboratory work. 3 cred.; prereq., 121; 2 rec. and 4 lab. hrs. per week.

130-131-132—Special Problems in Metallurgy. Seminar work on metallurgical problems. Cred. and hrs. ar.; prereq., sr. Met.E. or grad.

133—Electrometallurgy. Application of electricity to thermometallurgy. Design and operation of electric furnaces and their use in smelting of metals and in the production of ferro alloys. 3 cred.; prereq., 12; 3 lect. and 3 lab. hrs. per week.

134—Advanced General Metallurgy. Refractories, fuels, and principles of combustion. Thermochemistry of important reactions in process metallurgy. 4 cred.; prereq., 12; 3 lect. and 4 lab. hrs. per week.

135—Advanced Metallurgy of Iron and Steel. Detailed study of the blast furnace process. Economics of raw materials, their size, preparation, and physical properties. Control of slag-metal reactions. Trend in furnace design and practice. 4 cred.; prereq., 134; 3 lect. and 4 lab. hrs. per week.

136—Advanced Metallurgy of Iron and Steel. Detailed study of steel processes and current problems in controlling quality of product. Physical chemistry of steel making and its application to production problems. 4 cred.; prereq., 135; 3 lect. and 4 lab. hrs. per week.

137-138—Metallurgical Problems (Nonferrous). Conferences, lectures, and laboratory on selected problems. 4 cred. per qtr.; prereq., 108; 1 lect. and 8 lab. hrs. per week.

139—Field Work in Metallurgy. Study of metallurgical operations at mills, smelters, and refineries. Detail reports are required covering plants visited. 6 cred.; 3 weeks beginning about September 1.

140—Advanced Ore Testing (Iron Ores). Continuation of Course 121. Metallurgical calculations and report writing. 2 cred.; prereq., permission of instructor.

141-142-143—Special Problems. Special problems in the production of iron and steel. Conferences, laboratory work. 3 cred. per qtr.; prereq., sr. Met.E. or grad.; 9 lab. hrs. per week.

175—Field Trip. Study of metallurgical operations in important iron and steel centers. 6 cred.; prereq., jr. year; three weeks beginning about September 1.

204-205-206—Special Problems in Advanced Metallurgy. Intended primarily for research work for graduate students. Cred. and hrs. ar.

METALLOGRAPHY

150—Metallography for Electrical Engineers. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, microscopic and photomicrographic technique; study of typical alloys with special reference to electrical resist-

ance, conductivity, magnets, etc. Laboratory work and demonstrations. 3 cred.; jr., sr. E.E.; 2 lect. and 3 lab. hrs. per week.

152—Metallography for Aeronautical Engineers. Principles; metallography of iron and steel with special reference to alloy steels, and light alloys used in airplane construction. Laboratory work and demonstrations. 3 cred.; prereq., sr. Aero.E.; 2 lect. and 2 lab. hrs. per week.

153-154-155—Metallography. (Long course for metallurgical engineers.) Theory of metallic alloys. Metallographic technique. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallography. Laboratory work. 4 cred. per qtr.; prereq., Met.E. 12 or equiv.; 3 lect. and 4 lab. hrs. per week.

156—Metallography for Mechanical, Mining, and Petroleum Engineers. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, microscopic and photomicrographic technique; metallography and heat treatment of iron and steel. 3 cred.; prereq., jr., sr. M.E., Min.E., or Pet.E.; 2 lect. and 3 lab. hrs. per week.

157—Advanced Metallography for Mechanical, Mining, and Petroleum Engineers. Metallography of alloy steels, tool steels, high speed tool steels, and important nonferrous alloys; metallography applied to engineering practice and specifications. Outside reading and special reports. Laboratory work. 3 cred.; prereq., 152, 156, or 160; 2 lect. and 3 lab. hrs. per week.

160—Metallography. (Chem.) Principles of metallography, including constitution, diagrams, preparation and standardization of thermocouples, preparation and thermal analysis of alloys, their microscopic examination and photomicrographs; typical alloy systems such as iron carbon (steel, cast iron), and some nonferrous alloys. Lab. work; 3 cred.; prereq., Anal. Chem. 1, 2; 2 lect. and 3 lab. hrs. per week.

161—Advanced Metallography. (Chem.) Metallography and heat treatment of iron and steel, including alloy steels, commercial uses of various steels, and engineering specifications. 3 or 4 cred. depending on lab.; prereq., 152, 156, or 160; 3 lect. and 3 lab. hrs. per week.

162—Advanced Metallography. (Chem.) Metallography of the nonferrous metals with a study of the constitution diagrams, properties, and uses of important commercial alloys. 2 or 3 cred. depending on lab.; prereq., 152, 156, or 160; 2 lect. and 3 lab. hrs. per week.

163—Advanced Metallography. Seminar work on recent advances in metallography. Lectures and recitations, with outside reading and special reports. May be accompanied by laboratory work. 3 cred.; prereq., 6 cred. in metallography; 3 lect. hrs. per week.

164—Advanced Metallography. Advanced consideration of the structures, properties, and uses of metals and alloys. May be accompanied by laboratory work. 3 cred.; prereq., 6 cred. in metallography; 3 lect. hrs. per week.

165—Advanced Metallography. Technical metallography as applied to the automotive industry. Lectures and special reports. May be accompanied by laboratory work. 3 cred.; prereq., 6 cred. in metallography; 3 lect. hrs. per week.

166-167-168—Laboratory. Laboratory work on special problems in ferrous, nonferrous, and X-ray metallography. 3 cred. per qtr.; prereq., 155; 1 lect. and 4 lab. hrs. per week for 166 and 168; 9 lab. hrs. per week for 167.

170-171-172—Special Problems in Metallography. Seminar work in metallographic problems. Cred. and hrs. ar.; prereq., sr. Met.E. or grad.

201-202-203—Advanced Metallography for Graduate Students. Intended primarily for research work.

210-211-212—Thesis Courses for Graduate Students. Intended primarily for research work. Cred. and hrs. ar.

MILITARY SCIENCE AND TACTICS

All physically fit male students in the Institute of Technology who are citizens of the United States may take instruction in military science for three hours per week as prescribed for the Basic Course, Senior Division, Reserve Officers' Training Corps. This course as offered for the duration of the war covers general military subjects which are a valuable background for service in any branch of the Army. At present only the Basic Course is offered, as no commissions will be granted from ROTC units for the duration of the war.

The program is designed to supplement the student's college work with enough background to enable him to be of greater value to his country when and if called to

service in some branch of the Army and at the same time should be of material advantage to the individual in his Army career.

The University allows six credits for the two years' Basic Course. These credits may be applied as elective credits in qualifying for a degree.

Some of the subjects covered are: Military History and Policy of the United States, Military Courtesy, Military Law, Organization of the Army, Map and Aerial Photograph Reading, Rifle Marksmanship, Infantry Drill, Sanitation and First Aid, Leadership.

Two hours a week are devoted to lecture work and one hour to drill and leadership training.

Since a good physical condition is essential for service in any branch of the present-day Army, each student registered in ROTC is required to take one credit of physical education per quarter unless it is actually impossible to fit it into his program.

1-2-3—First Year Basic Course. 1 cred. per qtr.; no prereq.; 3 hrs. per week.

4-5-6—Second Year Basic Course. 1 cred. per qtr.; prereq., 1-2-3, or permission of department; 3 hrs. per week.

MINING AND PETROLEUM ENGINEERING

MINING

11-12-13—Mine Surveying. Land subdivision and description, stadia, triangulation, railroad curves, cross sections, earthwork, areas, differential and trigonometric leveling, plane-table, topographic map reading, solar and stellar observations, mining claims, bore holes, shaft plumbing, underground traversing and leveling. 3 cred. per qtr. for 11 and 12; 2 cred. for 13; prereq., Dr. 3, M.&M. 12; 3 lect. and 1 quiz per week for 11 and 12; 2 lect. and 1 quiz per week for 13.

14—Field Work. General work in plane surveying and adjustment of instruments. 5 cred.; prereq., 11, 12; 20 hrs. per week.

15—Field Trip. Field work on the iron ranges of Minnesota. Surveying of an underground mine, including shaft plumbing. Survey of open-pit mine including an estimate of the surface stripping. Solar and stellar observations. 8 cred.; prereq., 13, 14; 4 weeks beginning about June 15.

106—Mine Mapping. Mine mapping in accordance with prevalent practice in various mining districts including a map of the mine surveyed during the sophomore field trip. Ore estimating, based on current practice. 2 cred.; prereq., 15; 8 lab. hrs. per week.

107—Mine Mapping. Mapping mine surveyed during the field trip. 1 cred.; prereq., 15; 3 lab. hrs. per week.

111—Exploration. Prospecting, boring drill steel, drill bits. 3 cred.; prereq., reg. in Geol. 105; 4 lect. hrs. per week.

112—Exploration and Development. Explosives, blasting; timbering, timber treating; tunneling, drifting. 3 cred.; prereq., 111; 4 lect. hrs. per week.

113—Development and Exploitation. Shaft sinking, raising, stoping, mining methods; support of excavations. 3 cred.; prereq., 112; 4 lect. hrs. per week.

120—First Aid. This course is given by members of the United States Bureau of Mines staff and all students must have completed the course and received the U.S.B.M. certificate before graduation. One week, 3 hrs. per day.

121-122-123—Mine Plant. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, rock drills, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. 3 cred. per qtr.; prereq., M.&M. 33, Phys. 8; 5 lect. hrs. per week.

124—Mining Hydraulics. Application of hydraulic principles to mining and metallurgical problems. Flow measurements and stream gaging. Diversion dams, flumes, and laws of flow. Transporting power of water. Handling of slimes, sands, etc. 4 cred.; prereq., M.&M. 127; 5 lect. hrs. per week.

125—Metallurgical Hydraulics. Application of hydraulic principles to metallurgical problems. Flow measurements. Diversion dams, flumes, and laws of flow. Transporting power of water. Handling of slimes, sands, etc. 3 cred.; 3 lect. hrs. per week.

126—Engineering Construction. Theory of structure, loading, analytic and graphic resolution of stresses in frame structures, stresses in ore bins, head frames, etc. 3 cred.; prereq., M.&M. 127; 8 lab. hrs. per week.

127—Engineering Construction. Design of structures for mining and petroleum plant. 3 cred.; prereq., 126; 8 lab. hrs. per week.

130—Mine Rescue. One week's intensive course in the use of oxygen breathing apparatus. Course is given by members of the staff of the United States Bureau of Mines and is required of all mining and petroleum engineering students. One week, 3 hrs. per day.

138—The Stone Industries. Monumental and building stones, crushed stone, sand and gravel plants and operations. 2 cred.; prereq., 112.

139—Practical Mining (Field Trip). Study of mining operations, mine plant, and mining in one or more mining camps. 6 cred.; prereq., jr. year. Three weeks beginning about September 1.

141—Report and Administration. Examinations and reports; valuation and amortization; depletion and depreciation; taxation; corporations; capitalization; stocks and bonds; contracts and specifications. 3 cred.; prereq., 112; 4 lect. hrs. per week.

142—Coal Mining. Coal mining methods; mechanization; tipple arrangements and coal preparation; mine gases; safety lamps and tests; safety work and organization; labor organizations and agreements. 3 cred.; prereq., 141; 4 lect. hrs. per week.

143—Mining Law, Quarries, and Placers. Mineral laws, court interpretations; mining laws of foreign countries; state mining codes and accident prevention. Placer mining, panning, rockers, sluicing, hydraulicking, dredging, underground methods. Quarries: requirements, methods of working, machines used, field for product. 3 cred.; prereq., 142; 4 lect. hrs. per week.

144-145—Advanced Mining. Preparation of a report on a mining property or some phase of the mineral industry. 3 cred. per qtr.; prereq., 113; 8 lab. hrs. per week.

146—Nonmetallic Minerals. Mining and preparation of cement, lime, gypsum, refractories, ceramic materials, fillers, pigments. 2 cred.; prereq., 112.

147—Earth Handling and Excavation. Excavation by shovels, draglines, dredges; handling materials by railroad, trucks, conveyors, and sluices. 2 cred.; prereq., 112.

151-152-153—Special Problems in Mining. Seminar work on mining problems. Cred. and hrs. ar.; prereq., reg. in 141-142-143.

PETROLEUM ENGINEERING

111—Oil Field Development. Drilling and completion of oil wells, methods and equipment involved. Problems and protection of completed well; directional drilling, well surveying; electrical and mechanical logging and other methods of securing underground information; well records. 3 cred.; prereq., reg. in Geol. 105; 4 lect. hrs. per week.

112—Oil Field Production. Principles and methods of producing oil. Characteristics of oil reservoirs; of oil and gas, phase relations under reservoir conditions, condensate fields; sand drainage; oil reservoir performance; lifting oil; secondary methods of recovery; gas wells. 3 cred.; prereq., 111; 4 lect. hrs. per week.

131—Petroleum Refining. Distillation and fractionation processes used in making commercial products from crude petroleum. General physical and chemical properties of petroleum; oil refinery methods, principles of cracking; polymerization; alkylation. 2 cred.; prereq., Inorg. Chem. 16, Phys. 7; 2 lect. hrs. per week.

134—Petroleum Plant. Mechanical features of drilling equipment, gas lift, pumping, natural gasoline extraction. Special devices for abnormal condition. Oil emulsions. Mechanical features of transmission lines for oil and gas. Flow formulas, soil corrosion and prevention. 2 cred.; prereq., Min.E. 122; 3 lect. hrs. per week.

135—Field Work. Study of equipment and operations in one or more oil fields. 6 cred.; prereq., jr. year. Three weeks beginning about September 1.

138—Oil Field Mapping. A study of the methods and practices of graphically displaying, studying, and interpreting oil field data. Oil and gas well logs; property, contour, cross-section and correlation maps; methods of displaying data and records, etc. 2 cred.; prereq., Min.E. 107; 6 lab. hrs. per week.

144-145—Advanced Petroleum Engineering. Lectures on explosives, rock drilling and blasting, oil well shooting. Shaft sinking, timbering, timber treating, marine foundations, and caissons. Coal mining methods, oil shale and oil sand mining. Proration, utilization, and legal problems of the industry. Valuation, amortization, and depletion. Preparation of a report on the exploration and development of an oil property or some phase of the industry. 5 cred. per qtr.; prereq., 141; 4 lect. and 6 lab. hrs. per week.

152-153-154—Petroleum Production Technology. Problems in oil and gas production. Mud fluids, core analysis, including permeability and porosity, electrical and mechanical coring, oil well cements, oil flow and drainage through porous formations, water analysis, oil shales, problems. 3 cred. per qtr.; prereq., 112; 1 lect. and 6 lab. hrs. per week.

155-156-157—Special Problems in Petroleum Engineering. Seminar in petroleum problems. Cred. and hrs. ar.; prereq., reg. in 144-145.

NAVAL SCIENCE AND TACTICS

Courses in Naval Science and Tactics are open to V-12 students only.

PHYSICAL EDUCATION FOR MEN

The courses in sports education are offered by the Department of Physical Education to men students of the University for the purpose of providing instruction and practice in sports of a recreational nature in which men may participate as a means of obtaining recreation, regular exercise, and social intercourse.

A towel and locker fee of $1.25 per quarter is charged all students taking exercise courses.

The University furnishes uniforms to students for class work or recreational play for $1 per quarter.

The facilities of the Department of Physical Education including the golf course, tennis courts, gymnasium, swimming pools, handball and squash courts, golf gymnasium, table tennis room, and playing fields, are available for use by the general student body. All men are invited to participate in some form of physical activity. For information regarding the intramural and intercollegiate athletic programs see the physical education handbook published by the Department of Physical Education for Men or inquire at the offices in Cooke Hall.

Elective with credit.

SPORTS EDUCATION

Supervisor of Physical Education: Mr. Piper.

1-2-3—Sports Education. 1 cred. per qtr.

Substitution of athletic team practice may be allowed by the department.

PHYSICAL EDUCATION FOR WOMEN

Consult Combined Class Schedule for hours and statement of fees.

PHYSICS

1-2-3—Introduction to Physical Science. Lectures and experimental demonstrations of the principles underlying physical phenomena. Open to students in architecture. 3 cred. per qtr.; all; prereq., M.&M. 9 or equiv.; 3 lect. hrs. per week. Mr. Rassweiler.

7‡-8‡-9‡—General Physics. Mechanics, heat, electricity, sound, and light. Laboratory work an integral part of course. 5 cred. per qtr.; all; prereq., reg. in M.&M. 24; 4 lect., 1 quiz, and 2 lab. hrs. per week. Mr. Wall.

100-102-104—Intermediate Physics. 3 cred. per qtr.; all; prereq., calculus and 15 cred. in phys.; 3 rec. hrs. per week.

101-103-105—Theoretical Physics. An analytical survey of fundamental principles of mechanics, sound, heat, light, electricity, and magnetism, designed to supplement the general course and to prepare students for more specialized graduate courses. 5 cred. per qtr.; jr., sr., grad.; prereq., 15 cred. in phys. and Differential Equations or reg. in Differential Equations; 5 rec. and lect. hrs. per week.

107-109-111—Modern Physics. 3 cred. per qtr.; prereq., 15 cred. in phys; 3 lect. hrs. per week.

110‡-112‡§—Modern Experimental Physics. 3 or 4 cred. per qtr.; prereq., 144; 3 lab. hrs. per week.

114-116-118—Elementary Physical Investigation. 3 cred. per qtr.; prereq., 15 cred. in phys. Staff.

131—Geometrical and Physical Optics. 3 cred.; prereq., 15 cred. in phys.; ar.

134‡—Experimental Optics. 3 or 4 cred.; prereq., 15 cred. in phys.; 6 lect. and lab. hrs. per week.

136‡—Spectrum Analysis. 3 or 4 cred.; prereq., 15 cred. in phys.; 6 lect. and lab. hrs. per week.

‡ A fee of $2 per quarter is charged for this course.

§ Students may enter any quarter.

144‡—Electricity measurements. Devoted mainly to the study of potentiometer methods, capacitance, inductance, magnetic flux. 3 cred.; prereq., 15 cred. in phys., M.&M. 25; 1 lect., 1 quiz, and 4 lab. hrs. per week.

146‡—Physics of Vacuum Tubes. Thermionics, vacuum tube circuits. 3 cred.; prereq., 144 and permission of instructor; ar.

152—X Rays. Study of the nature and production of X rays. 3 cred.; prereq., 15 cred. in phys.; 3 lect. hrs. per week.

154‡—X-Ray Spectroscopy. 3 cred.; prereq., 15 cred. in Phys. 152, M.&M. 25 and permission of instructor; ar.

181-183-185—Atomistic and Elementary Quantum Mechanics. Atomic structure, X ray, spectrum analysis, and an introduction to wave mechanics. 3 cred. per qtr.; sr., grad.; prereq., 101-103-105, or reg. in 101-103-105.

PHYSIOLOGICAL CHEMISTRY

100-101—Physiological Chemistry. Components of the animal body; foods, digestion and excreta, and metabolism. Prereq., physics, organic chemistry. 222 hours; 13 cred.; 4 lect., 1 quiz, and 6 lab. hrs. per week.

153—Problems in Physiological Chemistry. Special work arranged with qualified students. May be taken one or more quarters. Prereq., 100, 101; cred. ar.; ar. Mr. Burr, Dr. Armstrong, Messrs. Barnes, Samuels, and Barnum.

154—Review of Current Literature in Physiological Chemistry. 1 cred. Mr. Burr, Dr. Armstrong, Messrs. Barnes, Samuels, and Barnum.

155—Seminar in Dental and Oral Biochemistry. 1 cred. Dr. Armstrong.

180—General Survey of Colloid Chemistry. 3 cred.; prereq., Physiol. Chem. 103.

182—Colloids and Biology and Medicine. 3 cred.; prereq., Physiol. Chem. 180.

200—Seminar in Physiological Chemistry. 11 hrs.; 1 cred. Mr. Burr, Dr. Armstrong, Messrs. Barnes, Samuels, and Barnum.

205—Research in Physiological Chemistry. Cred. ar. Mr. Burr, Dr. Armstrong, Messrs. Samuels and Barnum.

POLITICAL SCIENCE

1-2†-3—American Government and Politics. An explanation and analysis of the principles, organization, procedures, and functions of American Government—national, state, and local. Attention will be given throughout to the impact of the war and the postwar world upon American government and politics. 3 cred. per qtr.; no prereq.; 3 lect. hrs. per week. Mr. Kirkpatrick.

5—American Government and Politics. This course covers essentially the same materials as Political Science 1-2. 5 cred.; no prereq.; 5 lect. hrs. per week. Mr. Hawkins.

RHETORIC

(College of Agriculture, Forestry, and Home Economics)

22‡‡—Public Speaking. Practical course in fundamentals of speech making. 3 cred.; prereq., Engl. 6; 3 lect. and rec. hrs. per week. Mr. Nichols.

SOILS

4—Soils. Origin, formation, and classification of soils. The soil profile and its development; physical and chemical properties of soils; organic matter and biological relationships; forms and movement of soil water; erosion control. 3 cred.; soph., jr., sr.; prereq., Gen. Chem.; 3 lect. hrs. per week. Mr. Caldwell.

53—Soil Management. Nutrient requirements of crops; fertilizers and fertilizer materials; fertilizer practices; use of lime; farm manures, their composition, value, and use; green manuring; soil management and fertility maintenance. 3 cred.; soph., jr., sr.; prereq., Soils 4; 3 lect. hrs. per week. Mr. Rost.

† To receive credit for any part of this course a student must complete the parts preceding the dagger.

‡ A fee of $2 per quarter is charged for this course.

‡‡ A fee of $1 per quarter is charged for this course.

108—Physical Properties of Soils. Determination of physical constants of soils, including mechanical composition. 3 cred.; jr., sr.; prereq., 9; 1 lect. and 6 lab. hrs. per week. Mr. McMiller.

ZOOLOGY

1‡-2‡-3†‡§—General Zoology. 10 cred.; no prereq.; 2 lect. and 4 lab. hrs. per week. Messrs. Minnich, Wodsedalek, and Dawson.

14‡-15‡—General Zoology. Structure, physiology, embryology, classification, and evolution of animals. Textbook, lectures, laboratory, and quizzes. 3 cred. per qtr.; no prereq.; 2 lect. and 4 lab. hrs. per week. Mr. Dawson.

† The entire course must be completed before credit is received for any quarter.

‡ A fee of $1 per quarter is charged for this course.

§ Students should elect lecture sections in which they can continue throughout the three quarters. Changes from one lecture or laboratory to another may be made only with the consent of the department office.

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