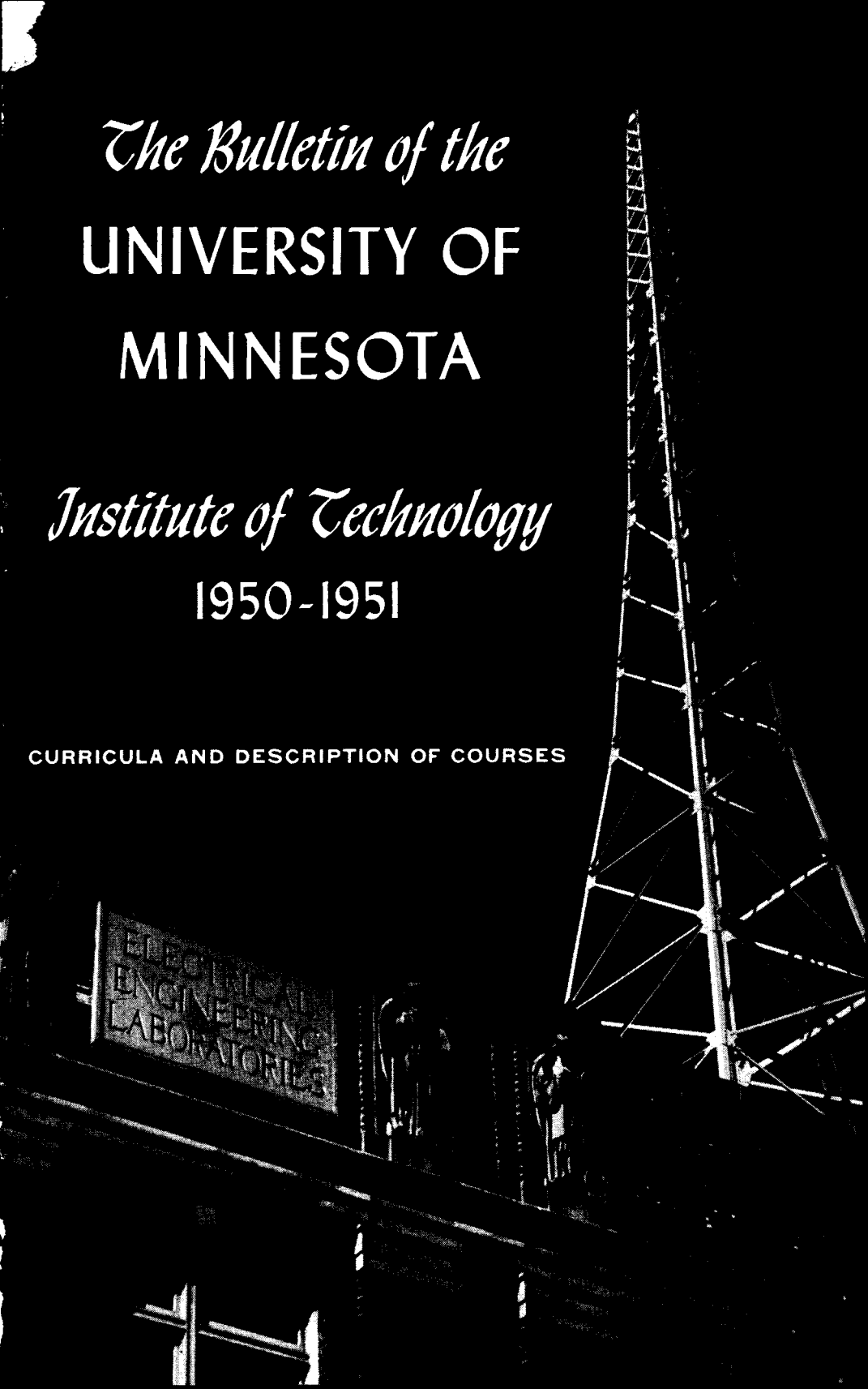
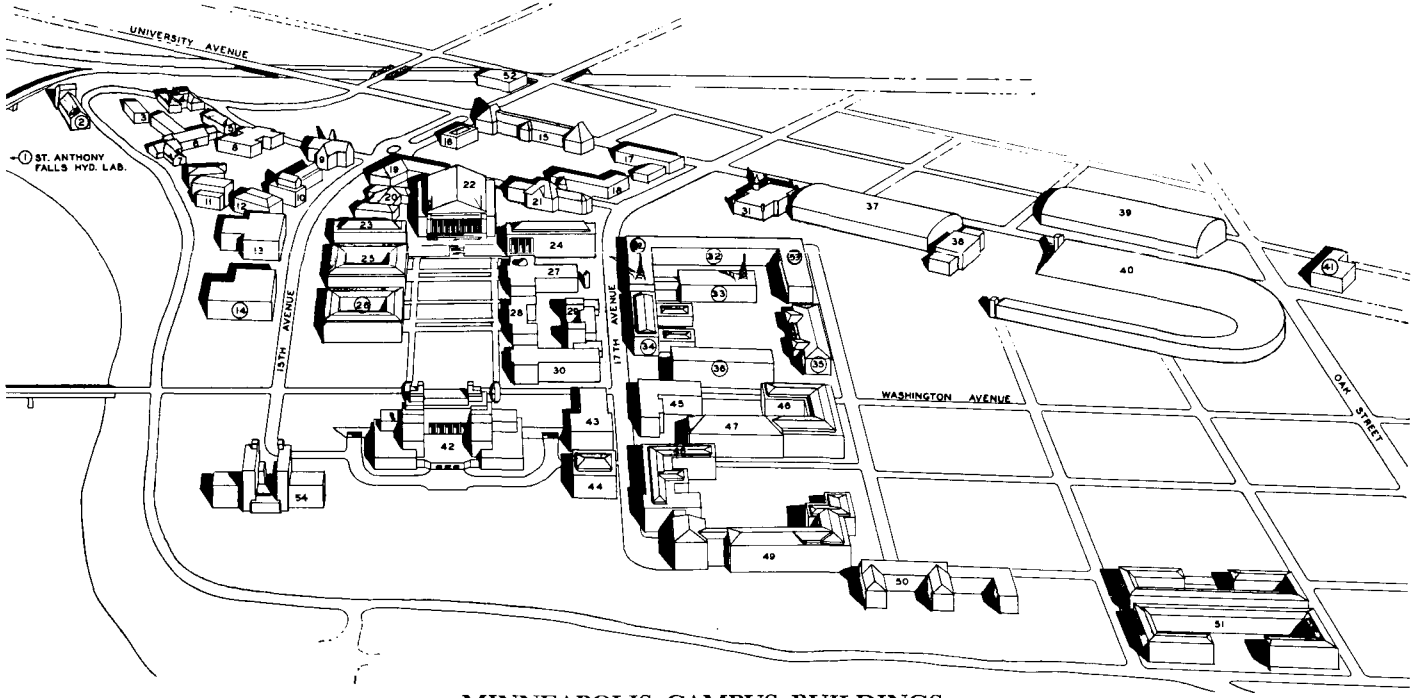
The Bulletin of the
UNIVERSITY OF MINNESOTA

Institute of Technology
1950-1951

CURRICULA AND DESCRIPTION OF COURSES





MINNEAPOLIS CAMPUS BUILDINGS

1. ST. ANTHONY FALLS HYDRAULIC LAB.
2. MINES EXPERIMENT STATION
3. University High School
4. Pattee Hall
5. Shevlin Hall
6. Norris Gymnasium
7. Women's Field House
8. Burton Hall
9. Eddy Hall
10. Scott Hall
11. Psychology and State Board of Health
12. Wulling Hall
13. Law
14. APPLEBY HALL
15. Folwell Hall
16. Jones Hall
17. Museum of Natural History
18. Continuation Study Center
19. Nicholson Hall
20. Wesbrook Hall
21. Pillsbury Hall
22. Northrop Auditorium
23. Johnston Hall
24. Administration
25. Library
26. CHEMISTRY
27. Physics
28. Vincent Hall
29. Murphy Hall
30. Ford Hall
31. Armory
32. MECHANICAL ENGR.
33. ELECTRICAL ENGR.
34. MAIN ENGR.
35. EXPERIMENTAL ENGR.
36. CHEMICAL ENGR.
37. Indoor Sports Arena
38. Cooke Hall
39. Williams Arena
40. Memorial Stadium
41. OAK STREET LAB.
42. Coffman Memorial Union
43. Zoology
44. Botany
45. Institute of Anatomy
46. Millard Hall
47. Medical Sciences
48. Students' Health Service
49. University Hospitals
50. Powell Hall
51. Pioneer Hall
52. Storehouse and Shops
53. AERONAUTICAL ENGR.
54. Comstock Hall

The Bulletin of the University of Minnesota
VOLUME LIII, NUMBER 29 JUNE 22, 1950

NSTITUTE OF TECHNOLOGY, 1950-1951

Curricula and Description of Courses

ENTERED AT THE POST OFFICE IN MINNEAPOLIS AS SEMI-MONTHLY SECOND-CLASS MATTER, MINNEAPOLIS, MINNESOTA. ACCEPTED FOR MAILING AT SPECIAL RATE OF POSTAGE PROVIDED FOR IN SECTION 1103, ACT OF OCTOBER 3, 1917, AUTHORIZED JULY 12, 1918

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Contents

General Information

ON THE INSTITUTE OF TECHNOLOGY

THE INSTITUTE OF TECHNOLOGY was established by action of the Board of Regents of the University of Minnesota in 1935. It embraces the College of Engineering, the School of Chemistry, the School of Mines and Metallurgy, and the School of Architecture. The offices of the Institute of Technology are located in the Main Engineering Building on the Minneapolis Campus.

The professional curricula in the Institute of Technology are developed in such a manner as to prepare the student to accept the challenge for professional leadership in our society and the responsibility of citizenship in our democracy. Each curriculum provides the student with basic training in the fundamentals of science and mathematics, a selection of courses within a single professional area, and an integrated program in the life sciences, social sciences, and the humanities. Emphasis is placed on developing the ability to apply fundamental principles to the problems to be met after graduation rather than giving detailed knowledge of industrial or professional practice which may be obtained by work experience.

College of Engineering

The College of Engineering had its origination in the College of Agriculture and Mechanics Arts which was authorized by a legislative act in 1868. In 1871, courses in civil and mechanical engineering were first offered. With the reorganization of the University in 1872 the College of Mechanics Arts was established. It successively became the College of Engineering, Metallurgy, and the Mechanics Arts in 1892, the College of Engineering and Mechanics Arts in 1897, the College of Engineering and Architecture in 1916, and College of Engineering in 1949. In 1887, a course in electrical engineering was first offered. Agricultural engineering started in 1925 and aeronautical engineering in 1928. Combined curricula in engineering and business administration were established in 1934. The five-year engineering curricula were started in 1946. In 1948 an engineering mathematics curriculum was established.

The departments of this college are located in Main Engineering, Electrical Engineering, Mechanical Engineering, Aeronautical Engineering, Oak Street Laboratories, and the Experimental Engineering buildings on the Minneapolis Campus and the Agricultural Engineering Building on the St. Paul Campus. The Hydraulic Laboratory is situated at the St. Anthony

Falls on the Mississippi River about a mile upstream from the Minneapolis Campus. The Rosemount Research Center is located about ten miles from the Minneapolis Campus at Rosemount, Minnesota. The Engineering Library and the college administration offices are located in the Main Engineering Building.

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; in 1919 its present name was adopted and its administration was correlated with that of the College of Engineering and Architecture under one dean. In 1935 it became one of the four units in the Institute of Technology.

The curricula in chemistry and chemical engineering were developed from the beginning of the school. The curriculum in physics was established in 1936.

The Department of Chemistry 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. The Department of Chemical Engineering occupies a new five-floor structure equipped with modern lecture rooms and extensive laboratory facilities.

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 1899. The school was affiliated with the College of Engineering under the name of the College of Engineering, Metallurgy, and the Mechanics 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. In 1935 it became one of the four units in the Institute of Technology.

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 mining districts of Minnesota are within a few hours of Minneapolis by rail or road. The heartiest cooperation 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.

School of Architecture

A course in architecture has been offered since the inception of the College of Agriculture and Mechanics Arts. A Department of Architecture was established in the College of Engineering and Mechanics Arts by the Board of Regents in 1913. The name was changed to the School of Architecture in 1925. It was affiliated with the College of Engineering and Architecture until 1949 at which time it became one of the four separate units in the Institute of Technology.

The school is located on the third and fourth floors of the Main Engineering Building and includes drawing and design rooms, classrooms, modeling and painting rooms, exhibition rooms, and a library.

Experimental Laboratories and Special Research Facilities

In addition to the regular departmental facilities, the Institute of Technology has a number of special facilities for research and technical investigations. The St. Anthony Falls Hydraulic Laboratory located on the Mississippi River, the Oak Street Laboratories, the Experimental Engineering Station, the Mines Experiment Station, and the Rosemount Research Center are equipped to carry out large-scale investigations in cooperation with industry, associations, technical societies, and the government. Opportunities for part-time employment and graduate fellowship are provided for many advanced students by these projects.

Curricula and Degrees

Five-year degrees are offered in each of the four schools and colleges of the Institute of Technology. In the College of Engineering there are curricula in aeronautical, agricultural, civil, electrical, industrial, and mechanical engineering, and engineering mathematics. The School of Chemistry offers curricula in chemistry, chemical engineering, and physics. The School of Mines and Metallurgy offers curricula in geological, metallurgical, mining, and petroleum engineering, and geophysics. The School of Architecture offers a five-year curriculum in architecture and a six-year curriculum in cooperation with the College of Science, Literature, and the Arts.

In cooperation with the School of Business Administration any one of

the above curricula may be combined with business administration leading to a degree in the Institute of Technology and a degree in the School of Business Administration. The Institute also offers the first two years of the four-year curriculum in engineering and business administration (industrial administration) given by the School of Business Administration.

Cooperative work-study programs are offered in mechanical and electrical engineering leading to the Bachelor's degree.

Two-year technical aid programs in drafting and industrial technician leading to certificates of technical aid are offered by the College of Engineering.

The Institute of Technology offers work in the Graduate School leading to the Master's and Doctor's degrees in the appropriate branch of architecture, chemistry, or engineering. Candidates register in the Graduate School.

A professional degree in engineering may be conferred upon a candidate who has obtained a Bachelor's or advanced degree from the Institute of Technology at least eight years prior to application. He must have practiced his profession for not less than eight years, and in at least four of these he shall have been in responsible charge of important work. The Engineer degree will be granted principally in recognition of the attainment of professional engineering competence and judgment by the candidate.

Application for the degree should be made to the dean of the Institute of Technology not later than October 1 preceding the June commencement at which it is to be awarded. Detailed statements of professional experience, evidence of professional work and/or activity in the planning and direction of engineering work will be required.

If accepted, the applicant will be requested to prepare and present a professional thesis which may not be a mere description of engineering work of usual character nor a digest of existing literature, but shall be based upon the candidate's direct contribution and relation to the work presented in the thesis. He will then be notified by a special Engineer Degree Committee as to the acceptability of his thesis and of the fulfillment of the technical requirements for the degree.

Cooperative Work-Study Plan

A cooperative five-year work-study plan of engineering education combining both theoretical and practical training into a single integrated program is offered in electrical and mechanical engineering. Alternate periods of university study and supervised work in industry will be pursued in the following manner: Starting in the third quarter of the second year, students selected for this program will be divided into two sections. While the first section is attending class for a quarter, the second will be at work on an industrial assignment in industry. The two sections alternate or exchange places with each other every quarter.

Two students will be selected for every industrial job which becomes available. It is expected that the magnitude and difficulty of the work per-

formed by each pair of students will be continually increased over the training period. At the end of each quarter of industrial training, the company will send a report on the student to the school. The student will also submit a written report on his work.

While at work the student is an employee of the company in every sense and is subject to the rules and regulations of the firm. The rate of pay for cooperative students will vary greatly and will be dependent upon such factors as ability, previous experience, personality, and economic conditions. In general, cooperative students will be paid on the same scale as regular employees who do the same type of work.

Mechanical and electrical engineering students should submit applications in the fall quarter of the sophomore year. Candidates will be selected on the basis of scholastic ability, personal qualifications, and fitness for work.

Admission

The student who intends to become a candidate for admission will find that the greater his attainment in high school and the wider his scope of intellectual development, the more he will be able to profit from study in the Institute of Technology. High school preparation should not be confined exclusively to technical subjects but be broad in nature. It is essential, however, that courses be taken in elementary algebra, plane geometry, either higher algebra or solid geometry—both if possible.

Students completing a year or more of work with at least a C average at another college or university of recognized standing may be admitted with advanced standing. Where possible this work should include mathematics, chemistry, English and drawing as outlined for the freshman year in the Institute of Technology.

Students who have completed less than a year of college work must satisfy the admissions requirements as specified for the high school graduate.

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 Dean of Admissions and Records, University of Minnesota.

Advanced Standing

Students who have pursued courses of study in other colleges or universities of recognized standing may receive advanced standing credits in accordance with the policies of this University and the Institute of Technology. (See Requirements for Graduation.)

No credit will be given in those courses in which a grade of D has been obtained.

Students entering the School of Chemistry as sophomores (48 to 101 required credits) may transfer not more than one half of the total number of elective credits required for graduation; students with 102 or more re-

quired credits will be permitted to transfer three quarters of the total number of elective credits required for graduation.

Registration

In order to register, all new students must present an admission certificate and an English classification card (freshmen only) or a record of advanced standing. Those entering the College of Engineering or the School of Architecture will begin their registration in the Main Engineering Building. Those entering the School of Chemistry will begin their registration in the Chemistry Building while those entering the School of Mines and Metallurgy will begin in Appleby Hall. Registration instructions furnished by the Office of Admissions and Records and published on bulletin boards in the buildings mentioned above should be followed.

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. 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.

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, or through practical experience.

The comprehensive examination will be of such thorough 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 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 comprehensive 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 and chemistry are offered by the General Extension Division of the University in evening classes and by correspondence study. Those who are unable to attend the regular university courses may

obtain valuable instruction in this manner. For information as to the credits which will be accepted toward a degree in the Institute of Technology, see page 93.

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.

Requirements for Graduation

The Bachelor's degree with departmental designation will be recommended for all students who satisfactorily complete all of the courses prescribed by their curricula, who earn sufficient credits to equal the number specified by their curricula, and who have an honor point average of 1.00 or better. In addition, a bachelor of science without designation will be awarded to those students who have an honor point average of 1.80 or better. This does not apply to architecture and the combined curricula of engineering and business administration.

In the event a program of graduate study leading to a graduate degree is to be pursued, students may petition the Students' Work Committee for the bachelor of science degree without designation during the third quarter of the fourth year of their curriculum. This will require an honor point average of 1.80 or better, completion of all of the required work including the social-humanities courses in the first four years of their curriculum, a total of 204 credits except chemical engineering which is 214, and departmental approval to pursue graduate study. This does not apply to the combined curricula of engineering with business administration, architecture, or the co-operative work-study curricula.

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. In any case such a student must spend two "quarters" of his senior year in residence.

Honor Point Average Requirements and Quality Credits

An honor point average of at least 1.00 is required for graduation in the Institute of Technology.

The honor point average is defined as the total number of earned honor points divided by the total number of credits earned and failed. Each credit with the grade of A carries three honor points; each credit with the grade of B, two honor points; each credit with the grade of C, one honor point. The grades of D and F carry no honor points.

Only credits and honor points earned at the University of Minnesota are used in calculating the honor point average.

Any student who has an accumulative honor point average of less than 1.00 will be placed on probation. Students on probation may be requested to cancel their registration if their work in succeeding quarters does not improve.

Only credits and honor points earned in the fall quarter, 1949 or later are used in calculating these honor point average requirements.

SPECIAL REQUIREMENTS OF THE SCHOOL OF CHEMISTRY

Students in the School of Chemistry must obtain a grade of C or better in all courses in analytic and inorganic chemistry, mathematics, and physics which are listed as required work in the first two years of their curricula. If grades of D or F are obtained, the courses must be repeated the next time they are offered.

An honor point average of at least 1.00 is required for *each* of the five years. This is a prerequisite to entrance into the required courses of the succeeding year.

As a special recognition of superior work, quality credits may be earned in the School of Chemistry on the basis of 1 credit for every 10 honor points in excess of a C average for work taken in this University. Quality credits may apply toward the credit requirement for graduation. Superior students who have accumulated sufficient quality credits may be able to register for graduate work in addition to undergraduate work their last quarter in school.

Inspection Trips

Inspection trips are required of seniors in aeronautical, agricultural, chemical, electrical, and mechanical engineering. These are usually taken during the spring vacation period. Midwestern industrial plants and other establishments of interest are visited. The expense of these trips which must be defrayed by the student usually varies from $50 to $75 except for mechanical engineering which costs $10.

Field trips in the School of Mines and Metallurgy are required at the end of the third and fourth years as indicated in the various curricula. Trips for about six weeks are taken to the iron ranges in northern Minnesota for the purpose of mine surveying and field work in geologic mapping. The approximate expense to the student is $75. Three-week trips starting in September are made to the western part of the country covering a study of mine plants and operations in leading mining or oil fields. The approximate expense to the student is $200. A geology trip embracing standard types of geological field work is made to the Black Hills region at a cost of about $150. The ferrous metallurgy trip includes inspection and reports from iron and steel plants, fabrication plants, and heat treating plants in the Middle West. The expense is approximately $100.

Fellowships and Assistantships

There are numerous fellowships and assistantships in the Institute of Technology open to graduates. Teaching assistantships with a stipend of $900 for one-half time are available in Chemical Engineering, Chemistry, Civil Engineering, Electrical Engineering, Mathematics and Mechanics, Mechanical Engineering, and Mines and Metallurgy. Research assistantships at $900 for one-half time are available in the Engineering Experiment Station. Various fellowships with stipends from $1,000 to $1,800 are open to graduate students in Chemical Engineering, Chemistry, Aeronautical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Physics.

Application for fellowships and assistantships should be made to the department concerned. Information as to procedures and forms to submit may be obtained from either the Graduate School or the department.

Scholarships and Awards

In the Institute of Technology many scholarships and prizes are awarded to the students. Some of the scholarships are:

James Cowin Scholarship. An annual scholarship of $1,500 open to graduate students of engineering with preference given to students specializing in Structural Engineering.

Consolidated Vultee Aircraft Corporation Scholarships. Two annual scholarships of $250 each to follow 32 weeks of in-service training with Consolidated Vultee Aircraft Corporation. Open to undergraduate students in Aeronautical Engineering.

Douglas Aircraft Scholarship. An annual scholarship of $500 open to senior students in Mechanical and Aeronautical Engineering.

David Grimes Memorial Scholarships. Five annual scholarships of $500 each by the Philco Corporation. Open to all students majoring in Electrical Engineering. No restrictions to undergraduates for this scholarship.

Milling Engineering Scholarships. A limited number of annual scholarships varying in amount from a minimum of tuition and fees to a maximum of $500 open to undergraduate students in the Institute of Technology who are pursuing or intend to pursue a career in Milling Engineering.

Northwestern Section—American Society of Civil Engineers Scholarship. An annual scholarship of $200 open to senior students in Civil Engineering who are members of the student section, ASCE.

Radio Corporation of America Scholarship. An annual scholarship of $600 open to all undergraduate students in the Institute of Technology.

National Association of Furniture Manufacturers Scholarships—Wood Utilization. One or more annual scholarships varying in amount from $250 to $750 open to undergraduate students in the Institute of Technology who are either specializing in or intending to specialize in Wood Utilization, Department of Mechanical Engineering.

Prizes are awarded by the Northern section of the American Society of Civil Engineers, the Minnesota Chapter of the American Society of Mechanical Engineers, Tau Beta Pi, Chi Epsilon, Eta Kappa Nu, Pi Tau Sigma, Phi Lambda Upsilon, Twin City Alumni Association of Alpha Chi Sigma, the Chemistry faculty, American Institute of Architects, Alpha Rho Chi, Scarab Fraternity, Alpha Alpha Gamma Sorority, the Gargoyle Club, Northern States Power Company, the George Melcher Prize by the Flour City Ornamental Co., the C. H. Johnston Prize, the Aeronautical Sciences Prize.

Placement Service

A placement service is maintained for the use of the graduating classes and the alumni. Without assuming the responsibility of finding employment for the graduate, every effort is made to assist graduates in securing the type of opening best suited for their aptitudes, training, and interests. Arrangements for printing of personnel sheets and interviews with prospective employers are made.

Reserve Officers Training Corps

A program of courses is available in Air Science and Tactics, Military Science and Tactics, and Naval Science leading to a commission in the Air Force Reserve, Army Officers Reserve Corps, or the Naval Reserve, respectively.

In the Institute of Technology it is possible to complete the requirements for a commission and also the Bachelor's degree in the normal time allotted for each engineering curriculum. This is accomplished by substituting ROTC credits for elective credits and for some of the requirements in the social-humanities area.

It is particularly desirable to enter the basic ROTC program in the fall quarter of the freshman year although it may be possible to enter at a later date. New students are urged to consider carefully the advantages of ROTC prior to entering the University so that it may be included in the fall quarter's program of courses.

Many of the courses in the military programs are particularly adapted for students in the Institute of Technology. All engineering students should investigate the Naval Reserve, Air Force Reserve, Antiaircraft Artillery, and the Transportation Corps. Civil engineering students should consider the Corps of Engineers, mechanical engineering students the Ordnance Department, electrical engineering and physics students the Signal Corps.

Detailed information concerning requirements, opportunities, and courses in these programs may be found in the *Bulletin of General Information*, the special *Bulletin of Army-Navy-Air ROTC*, on page 161 of this bulletin, and from the professors of air, military, and naval science in the Armory.

Student Loans

The Bureau of Student Loans and Scholarships in the Office of the Dean of Students has been established to aid students in need of financial assistance or help in planning a sound financial program. Application for financial aid should be made directly with this office in 211 Eddy Hall.

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 the Aeronautical Sciences. In addition there are the Architectural Society, the School of Mines and Metallurgy Society, and the University of Minnesota Flying Club.

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.

Institute of Technology

AT THE UNIVERSITY OF MINNESOTA

COLLEGE OF ENGINEERING

Aeronautical Engineering
Agricultural Engineering
Civil Engineering
Electrical Engineering
Engineering Mathematics
Industrial Engineering
Mechanical Engineering
Technical Aid

SCHOOL OF CHEMISTRY

Chemical Engineering
Chemistry
Physics

SCHOOL OF MINES AND METALLURGY

Geological Engineering
Geophysics
Metallurgical Engineering
Mining Engineering
Petroleum Engineering

SCHOOL OF ARCHITECTURE

Architecture

COMBINED CURRICULA

with the School of Business Administration

Curricula for the Freshman Year

FIRST YEAR FOR FRESHMEN ENTERING THE INSTITUTE OF TECHNOLOGY

Chemistry, Chemical Engineering, and Physics majors see the next page. Geophysics majors see page 60. Industrial Administration majors see page 51. Prearchitecture majors see page 26.

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	Written and Spoken Communication	3	3	.....	.....
Draw. 1	Engineering Drawing	3	.....	.....	8
G.E. 21	Orientation	1	.....	1	.....

Second Quarter

M.&M. 12	Trigonometry	5	5	.....	.....
Inorg.Chem. 5	General Inorganic Chemistry	4	1	3	3
Engl. 5	Written and Spoken Communication	3	3	.....	.....
Draw. 2	Engineering Drawing	3	.....	.....	8

Third Quarter

M.&M. 13	Analytic Geometry	5	5	.....	.....
Inorg.Chem. 11†	Semimicro Qualitative Analysis	4	.....	3	4
Engl. 6	Written and Spoken Communication	3	3	.....	.....
Draw. 3§	Descriptive Geometry	3	.....	.....	8
P.H. 3¶	Personal Health	2	.....	2	.....

SPECIAL REGULATIONS

Removal of deficiencies.—Applicants may be admitted with deficiencies in either higher algebra or solid geometry but not both. These deficiencies together with Preparatory English must be removed the *first quarter* in residence or the student will not be able to continue in the Institute of Technology.

Chemistry.—Students entering the School of Chemistry without high school chemistry will take Inorganic Chemistry 6-7, 12 instead of Inorganic Chemistry 9-10, 12. All others entering without high school chemistry will take Inorganic Chemistry 1-2, 11.

† Freshmen in Milling specialization of Mechanical Engineering required to take Agricultural Biochemistry 1 instead of Inorganic Chemistry 11.

§ Not required of students in four-year curriculum in Engineering and Business Administration (Industrial Administration).

¶ Not required of students taking NROTC or ROTC or students in the College of Engineering.

English.—Students assigned to Preparatory English by their English assignment card must complete this course their first quarter in school. No credit is given for this course. Registration for this course is in the General Extension Division in Nicholson Hall. A fee of $11.25 is charged for it.

Mathematics and Mechanics.—Students entering without higher algebra will take M.&M. 9, Higher Algebra, their first quarter in school. No credit is given for this course.

Solid Geometry.—Students entering without solid geometry must register for Drawing 10, Solid Geometry, during their first quarter in school. No credit is given for this course.

FOR ALL FRESHMEN ENTERING THE SCHOOL OF CHEMISTRY

(Chemistry, Chemical Engineering, and Physics)

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	Written and Spoken Communication	3	3	.....	.....
Draw. 7	Engineering Drawing	3	.....	.....	8
G.E. 21	Orientation	1	.....	1	.....

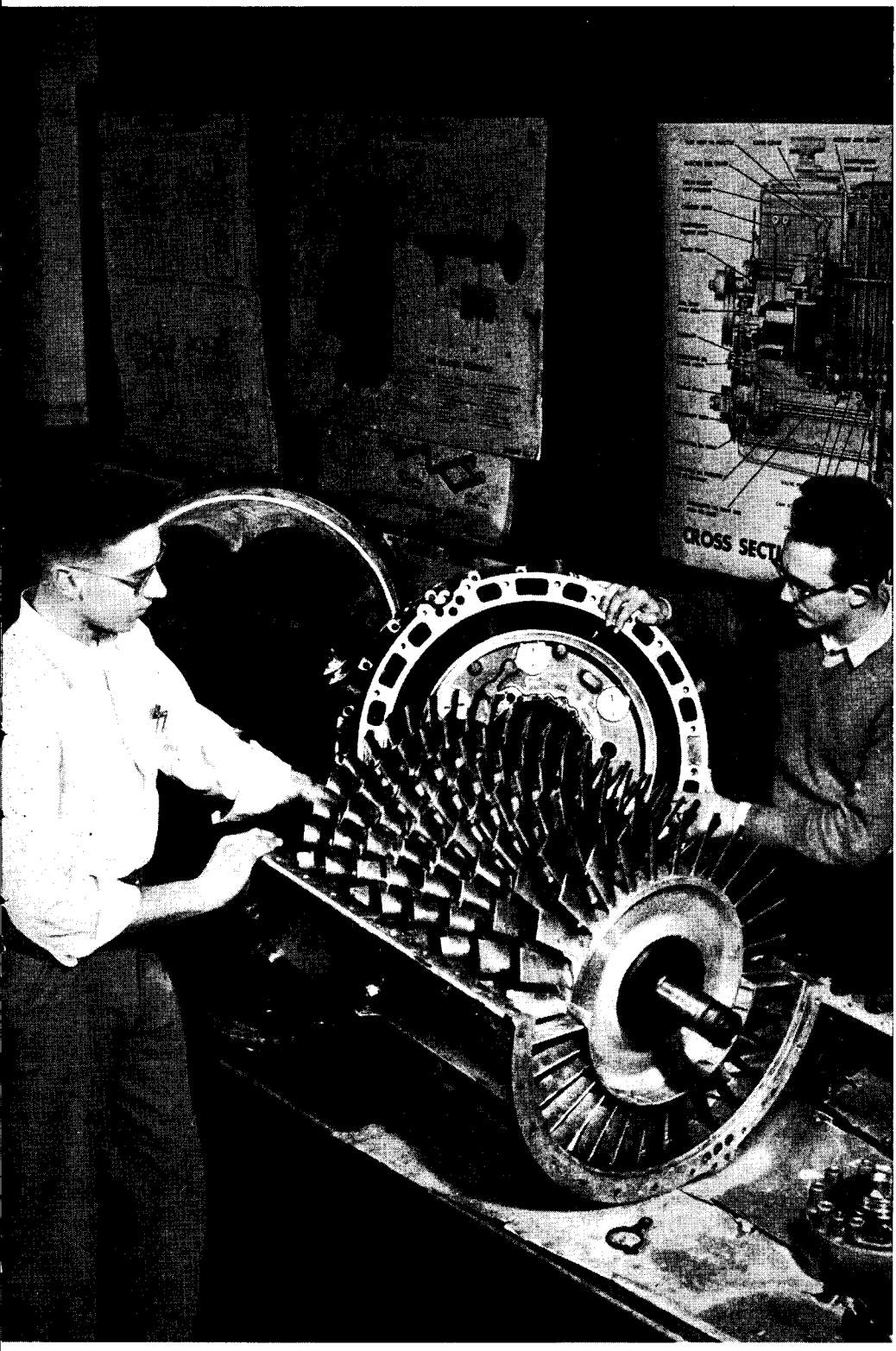
Second Quarter

M.&M. 12	Trigonometry	5	5	.....	.....
Inorg.Chem. 10	General Inorganic Chemistry	5	1	3	5
Engl. 5	Written and Spoken Communication	3	3	.....	.....
Draw. 8	Engineering Drawing	3	.....	.....	8

Third Quarter

M.&M. 13	Analytic Geometry	5	5	.....	.....
Inorg.Chem. 12	Semimicro Qualitative Analysis	5	1	2	6
Engl. 6	Written and Spoken Communication	3	3	.....	.....
P.H. 3¶	Personal Health	2	.....	2	.....

¶ Not required of students taking NROTC or ROTC or students in the College of Engineering.


CROSS SECTI

Aeronautical Engineering

A five-year curriculum is offered which leads to the degree of bachelor of aeronautical engineering, B.Aero.E.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of at least 253 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, development, and use of equipment requires a thorough knowledge of the most recent developments in the aeronautical sciences, including high altitude and supersonic flight problems. 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.

Because of the extensive developmental work being done, new opportunities in the field of aeronautical engineering are continually being created.

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, 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, the U.S. Air Force's Air Corps, the National Guard, the Naval Reserve, or private organizations.

Students with an honor point ratio of 1.50 or better may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3 or 11-12-13 or 21-22-23, English 85-86 and electives.

For freshman year, see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
Draw. 28	Drafting	2	.....	.....	6
M.E. 18	Materials and Processing	3	.....	2	6
Nat.Sci. 7*	General Biology	3	.....	2	4

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
Aero.E. 1	Aerodynamics	3	.....	3	.....
Nat.Sci. 8*	General Biology	3	.....	2	4
	Elective				

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
Nat.Sci. 9*	General Biology	4	.....	2	4
	Elective				

THIRD YEAR

First Quarter

M.&M. 86	Fluid Mechanics	3	3	.....	.....
Aero.E. 142	Aircraft Installation I	2	.....	1	3
M.E. 26	Mechanism and Kinematics	3	3	.....	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....
	Elective				

Second Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Aero.E. 158	Physics of the Atmosphere	2	1	2	.....
Phys. 73	Intermediate Thermodynamics	3	3	.....	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....
	Elective				

Third Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
Aero.E. 140	Aeronautical Laboratory	4	.....	3	3
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....
	Elective				

FOURTH YEAR

First Quarter

M.&M. 167	Selected Topics in Mathematics for Senior Aeronautical Engineers	3	3	.....	.....
Aero.E. 83	Stresses in Simple Structures	4	.....	3	2
Aero.E. 100	Aerodynamics	3	.....	3	.....
E.E. 46	Electrical Engineering Survey and Aeronautical Radio	3	2	.....	2
Hum. 1*	Humanities of the Modern World I	5	.....	5	.....

* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

Aero.E. 101	Aerodynamics	3	.....	3	.....
Aero.E. 115	Airplane Stresses	3	.....	2	2
E.E. 47	Electrical Engineering Survey and Aeronautical Radio	3	2	.....	2
M.E. 150A	Internal Combustion Engines	4	4	.....	.....
Hum. 2*	Humanities in the Modern World II	5	.....	5	.....

Third Quarter

Aero.E. 102	Aerodynamics	3	.....	3	.....
Aero.E. 110	Vibration and Flutter	3	.....	3	.....
Aero.E. 141	Aerodynamics Laboratory	2	.....	.....	6
M.E. 151A	Advanced Internal Combustion Engines	2	2	.....	.....
M.E. 154A	Design of Airplane Engines	2	.....	.....	6
Hum. 3*	Humanities in the Modern World III	5	.....	5	.....

FIFTH YEAR

First Quarter

Aero.E. 120	Airplane Design	2	.....	2	.....
Aero.E. 130	Aerodynamic Design	2	.....	.....	6
Aero.E. 143	Aircraft Installation II	3	.....	1	6
Engl. 85	Advanced Technical Communication	3	3	.....	.....
M.E. 158	Aero Engine Testing	2	.....	.....	6
	Electives				

Second Quarter

Aero.E. 106	Advanced Aerodynamics	3	.....	3	.....
Aero.E. 121	Airplane Design	2	.....	2	.....
Aero.E. 131	Airplane Design Laboratory	2	.....	.....	6
Aero.E. 190	Seminar	1	1	.....	.....
Engl. 86	Advanced Technical Communication	3	3	.....	.....
G.E. 103	Professional Problems	1	.....	1	.....
	Elective				

Third Quarter

Aero.E. 122	Airplane Design	2	.....	2	.....
Aero.E. 132	Airplane Design Laboratory	2	.....	.....	6
Aero.E. 135	Airplane Static Test	2	.....	1	3
Aero.E. 155	Aeronautical Calculations	2	.....	2	.....
Aero.E. 159	Inspection Trip (Spring Vacation)	1	.....	.....	.....
Aero.E. 191	Seminar	1	1	.....	.....
M.E. 157	Gas Turbine and Jet Propulsion Power Plants	3	.....	3	.....
	Elective				

* See page 92 for alternate sequences which may be substituted as a unit.

Agricultural Engineering

A five-year curriculum, in cooperation with the College of Agriculture, Forestry, Home Economics, and Veterinary Medicine, is offered which leads to the degree of bachelor of agricultural engineering, B.Ag.E.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of at least 253 credits for graduation.

Agricultural engineering activities are usually grouped under the heads of Farm Power and Machinery, Farm Structures, Rural Electrification, and Soil and Water Conservation. The curriculum allows the student, by proper choice of electives, to concentrate in one of these four fields or to get a more general training by taking work in all four.

The work in farm power and machinery includes management of power and machinery to produce good results under specified farm conditions, design and construction of machinery to meet field requirements, and the application of gasoline, diesel, and steam power to meet agricultural requirements.

The work in agricultural physics and rural electrification includes electric circuits, electrical machinery, lighting, and applications of electricity to agricultural needs.

The work in farm structures includes the study of building materials; the design, construction, and location of houses, animal shelters, crop storage, and service buildings for the farmstead; and insulation and ventilation of farm buildings.

The work in soil and water conservation includes the development of unused but potentially productive land by drainage or irrigation; the improvement and conservation of land already under cultivation by means of drainage, soil erosion control, water conservation, and supplemental irrigation; and the design, construction, and operation of the works needed to accomplish these benefits.

The field of agricultural engineering offers a variety of opportunities among which the following are prominent: as executives, development and design engineers, publicity and sales managers, and technical field experts for manufacturers of farm machinery, equipment, and building materials; as managers of large farms requiring extensive machinery and equipment; as advisers and technicians with power companies or with government agencies in the development of rural electric service; as engineering specialists with agencies of the federal, state, and local governments, with educational institutions, and with consulting engineers, contractors and development companies requiring experts in the fields of land drainage, erosion control, irrigation, water utilization, farm power and machinery, application of electricity to agriculture, and farm structures.

Students with an honor point ratio of 1.50 or better may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 21-22-23, English 85-86 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
Draw. 21	Drafting	2	.....	.....	6
or M.E. 20	Elementary Machine Design	2	.....	.....	6
Nat.Sci. 7	General Biology	3	.....	2	4
or Bot. 1	General Botany	3	.....	2	4
	Agricultural Sequence (See page 23.)	3 or 4	3 or 4		

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
Nat.Sci. 8	General Biology	3	.....	2	4
or Bot. 2	General Botany	3	.....	2	4
Soils 4	Soils	3	.....	3	.....
M.E. 8	Machine Shop Practice	2	.....	2	3

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
Nat.Sci. 9	General Biology	4	.....	2	4
or Bot. 3	General Botany	4	.....	2	4
Ag.E. 21†	Elements of Surveying	5	.....	1	12

THIRD YEAR

First Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Testing Laboratory	1	.....	.....	2
M.E. 131	Thermodynamics	3	3	.....	.....
Ag.E. 43	Mechanical Laboratory	3	.....	1	5
M.E. 26§	Kinematics and Mechanism	3	.....	3	.....
	Agricultural Sequence (See page 23.)	3 or 4	3 or 4		

Second Quarter

M.&M. 129	Fluid Mechanics	4	3	1	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
Econ. 8	General Economics	3	3	.....	.....
Ag.E. 51	Soil and Water Conservation	3	.....	3	.....
Ag.E. 18	Agricultural Automotives	3	.....	2	3
	Agricultural Sequence	3 or 4	3 or 4		

Third Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.E. 24	Elements of Machine Design	3	2	.....	3
Econ. 9	General Economics	3	3	.....	.....
	Electives (See page 24.)	6 or 7			

† Students taking Biology must postpone Ag.E. 21 to third quarter of third year.

§ Students planning to take advanced work in farm power and machinery are advised to substitute M.E. 21 and M.E. 22 for M.E. 26.

FOURTH YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Hum. 21*	American Life I	3	.....	3	.....
E.E. 36	Electrical Engineering Survey	3	.....	2	2
Ag.E. 53	Farm Structures	3	1	1	3
or Ag.E. 52	Elements of Farm Machinery	3	1	1	3
C.E. 37	Elementary Structural Engineering	3	.....	1	3
	Electives (See page 24.)	5 or 6			

Second Quarter

Hum. 22*	American Life II	3	.....	3	.....
E.E. 37	Electrical Engineering Survey	3	.....	2	2
Ag.Econ. 102	Farm Management: Organization	3	3	.....	.....
Ag.E. 61	Irrigation	3	.....	3	.....
Econ. 161	Labor Problems and Trade Unionism	3	.....	3	.....
	Electives	2 or 3			

Third Quarter

Hum. 23*	American Life III	3	.....	3	.....
E.E. 38	Electrical Engineering Survey	3	.....	2	2
Ag.E. 172	Applied Electricity	3	.....	2	4
Econ. 164	Labor Legislation and Social Insurance	3	.....	3	.....
	Electives	5 or 6			

FIFTH YEAR

First Quarter

Engl. 85	Advanced Technical Communications	3	3	.....	.....
Ag.E. 52	Elements of Farm Machinery	3	1	1	3
or Ag.E. 53	Farm Structures	3	1	1	3
Ag.E. 63	Farm Structures Laboratory	3	.....	.....	6
Geol. 5	Engineering Geology	3	.....	3	.....
	Electives (See page 24.)	5 or 6			

Second Quarter

Engl. 86	Advanced Technical Communications	3	3	.....	.....
Ag.E. 36	Rural Sanitation and Water Supply	3	.....	3	.....
Rhet. 22	Public Speaking (or other elective to complete social-humanistic requirement)	3	3	.....	.....
	Electives	6 or 7			

Third Quarter

G.E. 101	Contracts and Specifications	3	.....	3	.....
G.E. 103	Professional Problems	1	.....	1	.....
Ag.E. 150	Inspection Trip	1	.....	.....	.....
	Electives	3 to 11			

Agricultural Sequences

Each student is required to take the courses shown in one of the following sequences (a minimum of 9 credits) and one course in another sequence. The total number of credits will be at least 12.

RECOMMENDED COURSES		CREDITS	QUARTER AND YEAR	
Agronomy Sequence:				
Agron. 1	General Farm Crops	3	f,s	2
Agron 23	Forage Crops	4	f	3
Agron. 21	Grain Crops	4	w	3

* See page 92 for alternate sequences which may be substituted as a unit.

RECOMMENDED COURSES		CREDITS	QUARTER	YEAR
Animal Husbandry Sequence:				
A.H. 1	Livestock Production	4	f,s	2
A.H. 56	Livestock Feeding	3	f	3
A.H. 57	Livestock Feeding	3	w	3
Dairy Sequence:				
D.H. 1	Elements of Dairying	3	f,s	2
D.H. 101	Milk Production	5	f	3
D.H. 103	Dairy Stock Feeding	3	w	3
or				
D.H. 1	Elements of Dairying	3	f,s	2
D.H. 3	Testing Dairy Products	2	f	3
D.H. 110	Dairy Products	3	w	3
D.H. 114	Milk By-products	3	w	4
Soils Sequence:				
Soils 4	Soils	3	w	2
Soils 108	Physical Properties of Soils	3	w	3
Soils 5	Soil Management	3	s	3
Weed Control Sequence:				
Agron. 1	General Farm Crops	3	f,s	2
Pl.Path. 3	Weeds	3	s	3
Agron. 135	Weed Control	3	f	4

Electives

A minimum of 9 credits must be selected from the following list of courses offered as electives.

AG.E.	TITLE	CREDITS	QUARTER
73	Steam Boilers and Heat Engines	3	w
105	Drainage Irrigation and Soil Erosion Control Design	4	s
106	Agricultural Hydrology	3	w
125	Topics in Agricultural Physics	3	s
126	Management of Agricultural Machinery	3	w
167	Advanced Farm Structures	3	w
171	Design of Agricultural Machinery	3	f
101,102,103	Advanced Problems in Soil Moisture Regulation	2-6	f,w,s
111,112,113	Farm Building Problems	2-6	f,w,s
121-122-123	Farm Power and Machinery Problems	2-6	f,w,s
131-132-133	Rural Electrification Problems	2-6	f,w,s

Additional electives appropriate to the student's interest and as prerequisites for advanced courses should in general be selected from the above list, from the list of courses suggested for agricultural sequences, or from the following list of recommended electives in other departments. Other courses may be taken as electives with the approval of the adviser.

Farm Power and Machinery—Ch.E. 31; C.E. 146, 190, 191; Draw. 22, 37, 38; M.&M. 80, 167; M.E. 11, 12, 14, 21, 22, 23, 121, 132, 150, 151, 152, 154, 160, 180; Met. 156; Pl.Path. 1; Soils 103, 108.

Agricultural Physics and Rural Electrification—Ag.Ec. 144; Ch.E. 31; C.E. 146; Draw. 22, 37, 38; M.&M. 80, 154, 167; M.E. 11, 23, 24, 132, 160, 180; Phys. 146.

Farm Structures—Ch.E. 31; C.E. 130, 131, 132, 141, 146, 147, 190; Draw. 22, 37, 38; M.&M. 80, 154, 167; M.E. 11, 121, 132, 160, 180; Met. 156.

Soil and Water Conservation—Agron. 1, 21, 23, 133; C.E. 146, 147, 159, 160, 183, 190, 191; Geol. 6; Hort. 1, 6; M.&M. 80; Soils 5, 103, 108, 109, 110, 111.

Architecture

The School of Architecture offers work leading to the degrees of bachelor of architecture, bachelor of arts with a major in architecture, and a combined curriculum leading to both degrees.

PROFESSIONAL CURRICULUM

The professional curriculum leads to the degree of bachelor of architecture (B.Arch.), in the Institute of Technology. This curriculum is intended for students who expect to enter the practice of architecture. It is assumed that the students taking it have an interest in and a natural aptitude for the process design of buildings. Five years of study, including one year of prearchitecture and four years in the School of Architecture, are required for this degree.

GENERAL CURRICULUM

In addition to the regular professional curriculum, the School of Architecture offers a general course in the College of Science, Literature, and the Arts, leading to the degree of bachelor of arts (B.A.) with a major in architecture. The general curriculum is intended for students who wish to combine some study of architecture with their general education. It provides an advantageous approach to the complete professional curriculum in architecture, or to further training at other schools in the special fields of city planning, landscape architecture, or decorative, industrial, and interior design.

COMBINED CURRICULUM

The combined curriculum leads to the degrees of bachelor of arts and bachelor of architecture. It combines the general and professional courses in architecture and is known as the six-year curriculum in arts and architecture. It includes four years of registration in the College of Science, Literature, and the Arts and two years in the School of Architecture of the Institute of Technology.

Admissions Procedure

To become a candidate for the B.Arch. degree and to enroll in the architectural courses scheduled for the second or subsequent years, the student must have substantially completed a year of college work as described on page 27, and must have secured the approval of the School of Architecture. Application must be made on forms furnished by the School of Architecture or the Office of Admissions and Records, and submitted not later than July 15 preceding the beginning of the academic year for which admission is sought. Approval will be based on a consideration of (1) the student's scholastic standing in previous high school and college work; (2) his maturity and experience; (3) his professional aptitude and objective; and (4) the work space and instructional facilities available in the School of Architecture.

Students desiring admission to the general curriculum leading to the B.A. degree or to the combined curriculum must also make application in the manner described above, after they have completed the junior college requirements of the College of Science, Literature, and the Arts.

Outline for Professional Curriculum

The professional curriculum prescribes courses in three general divisions. The first is theory, presenting the technical, analytical and historical knowledge on which architecture is based. The second is drawing and the allied means of visual communication. The third and principal division is continued practice in all phases of architectural design including analysis of function, structure, and esthetics.

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 professional student elects the five-year curriculum or the broader six-year combined curriculum will depend on the time and means at his disposal. He will find it highly desirable to take as much general work as possible. College work taken at institutions other than the University of Minnesota can be readily adjusted to the professional curriculum. In any such work, college algebra, trigonometry, and analytic geometry should 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 normally takes four years to complete the required technical work regardless of how much college work they may have to their credit, and should calculate their time accordingly.

The five-year curriculum provides, in addition to basic professional training, opportunity for a certain amount of specialization in general design, city planning, interior design, or building construction and equipment. This specialization is accomplished by (1) a choice of electives and (2) a choice of problems in architectural design and in the selection of a thesis.

In addition to the prescribed courses, sufficient approved electives must be taken to make a minimum total of 225 credits. The first year consists of prearchitectural college work, which may be taken at the Universty of Minnesota or elsewhere, and whose satisfactory completion is a prerequisite for the student's admission to the second year's work as a candidate for the B.Arch. degree.

The specific requirements are listed in the following program. This program is typical for students who have completed high school with acceptable credits in higher algebra, solid geometry, and preparatory English, and who maintain a normal rate of progress.

FIRST YEAR

(Prearchitectural)

The first year may be taken at—

1. Any accredited institution other than the University of Minnesota.
2. At the University of Minnesota in the College of Science, Literature, and the Arts.
3. At the University of Minnesota in the modified first year course offered for prearchitects by the Institute of Technology.

Prospective students without previous college training should consult advisers in the School of Architecture as to which of the plans listed above is best suited to their needs.

The following courses offered by the University of Minnesota, or their equivalents if taken elsewhere, are required for the bachelor of architecture degree, and should be included in the first year of prearchitectural work:

College Algebra, Trigonometry, and Analytic Geometry (Math. 6, 7, and 30 or M.&M. 11, 12, and 13) ..... 15 credits
English Composition (Engl. 4, 5, and 6) ..... 9 credits
Additional courses, totaling approximately ..... 21 credits
These courses may include, as approved electives, selections from foreign language, history, economics, political science, sociology, free-hand drawing, descriptive geometry, chemistry, geology, geography, etc. Inorganic chemistry must be included if not taken in high school.
Normal total for first year ..... 45 credits

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Arch. 40	Graphic Representation	6	.....	3	15
Art 20	Drawing and Painting, I	2	.....	.....	4
M.&M. 91	Calculus for Architects	4	4	.....	.....
Phys. 1	Introduction to Physical Science	3	.....	3	.....

Second Quarter

Arch. AD-I	Architectural Design, Grade I	6	.....	.....	18
Art 21	Drawing and Painting, I	2	.....	.....	4
M.&M. 92	Mechanics for Architects	4	4	.....	.....
Phys. 2	Introduction to Physical Science	3	.....	3	.....

Third Quarter

Arch. AD-I	Architectural Design, Grade I	6	.....	.....	18
M.&M. 93	Strength of Materials for Architects	4	4	.....	.....
Phys. 3	Introduction to Physical Science	3	.....	3	.....
	Approved Elective				

THIRD YEAR

First Quarter

Arch. 57	Building Materials and Methods, Part I	4	.....	4	.....
Arch. AD-II	Architectural Design, Grade II	6	.....	.....	18
Art 60A	Drawing and Painting, II	2	.....	.....	6
C.E. 38	Elementary Structural Design (Steel)	3	.....	3	.....

Second Quarter

Arch. 58	Building Materials and Methods, Part II	4	.....	4	.....
Arch. AD-II	Architectural Design, Grade II	6	.....	.....	18
Art 61A	Drawing and Painting, II	2	.....	.....	6
C.E. 39	Elementary Structural Design (Steel and Timber)	3	.....	3	.....

Third Quarter

Arch. 59	Building Materials and Methods, Continuation of Part II	4	.....	4	.....
Arch. AD-II	Architectural Design, Grade II	6	.....	.....	18
Art 62A	Drawing and Painting, II	2	.....	.....	6
C.E. 41	Elementary Structural Design (Concrete)	3	.....	3	.....

FOURTH YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Arch. 51	History of Architecture	4	.....	4	.....
Arch. 71	Building Equipment	2	.....	3	.....
Arch. AD-III	Architectural Design, Grade III	9	.....	.....	27

Second Quarter

Arch. 52	History of Architecture	4	.....	4	.....
Arch. 72	Building Equipment	2	.....	3	.....
Arch. AD-III	Architectural Design, Grade III	9	.....	.....	27

Third Quarter

Arch. 53	History of Architecture	4	.....	4	.....
Arch. 73	Building Equipment	2	.....	3	.....
Arch. AD-III	Architectural Design, Grade III	9	.....	.....	27

FIFTH YEAR

First Quarter

Arch. 104	City Planning	3	.....	3	.....
Arch. AD-IIIA	Architectural Design, Grade III	9	.....	.....	27
	Approved Elective				

Second Quarter

Arch. 105	Professional Relations	3	4	.....	.....
Arch. AD-IIIA	Architectural Design, Grade III	9	.....	.....	27
	Approved Elective				

Third Quarter

Arch. AD-IV	Thesis	12	.....	.....	36
	Approved Elective				

Outline of Six-Year Curriculum in Arts and Architecture

In this curriculum the student normally is registered for the first four years in the College of Science, Literature, and the Arts and for the last two years in the School of Architecture of the Institute of Technology.

While registered in the College of Science, Literature, and the Arts he follows the plan of study prescribed for a bachelor of arts degree with a major in architecture. See Junior and Senior College requirements as given in the *Bulletin of the College of Science, Literature, and the Arts*; and Architecture, in the *Class Schedule*.

The following courses should be taken during this period:

COURSE NO.	TITLE	CREDITS
Arch. 40	Graphic Representation	6
Arch. 51-52-53	History of Architecture	12
Arch. 57	Building Materials and Methods, Part I	4
Art 20,21,60A, 61A,62A	Drawing and Painting, I and II	10
Arch. AD-I,II	Architectural Design, Grades I and II	30
Additional Special 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
	Junior and Senior College courses to make a total for the bachelor of arts degree of 189 credits.	

NOTE: Of the courses listed above, Civil Engineering 38-39, 41 (9 credits) is not accepted for credit toward the bachelor of arts degree. It is an extra requirement which should be taken as a prerequisite for the work of the last two years of the six-year course in arts and architecture.

Upon completion of the requirements for the bachelor of arts degree and subject to approval by the School of Architecture, the student is registered in the Institute of Technology to complete the requirements for a bachelor of architecture degree. These requirements include the following additional courses:

Arch. 58-59	Building Materials and Methods, Part II	8
Arch. 71-72-73	Building Equipment	6
Arch. 104	City Planning	3
Arch. 105	Professional Relations	3
Arch. AD-III	Architectural Design, Grade III	45
Arch. AD-IV	Thesis	12
	Approved electives to make a minimum total of 270 credits for the two degrees.	

Chemical Engineering

A five-year curriculum is offered which leads 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 272 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 thorough understanding of the fundamental physicochemical, 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 thoroughly 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 semiworks 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 process, 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, textiles, fibers, rubber, soap, lacquers, solvents, plastics, 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, starch, and refrigeration, dehydration, and canning. There are many others such as leather, paper, 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 with an honor point average of 1.50 may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3, English 85-86.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
Anal.Chem. 2	Quantitative Analysis	5	1	1	10
Nat.Sci. 7*	General Biology	3	.....	2	4

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
Anal.Chem. 1	Quantitative Analysis	5	1	1	10
Nat.Sci. 8*	General Biology	3	.....	2	4

Third Quarter

M.&M. 84	Technical Mechanics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
Chem.E. 100	Chemical Engineering Stoichiometry	3	.....	3	.....
Chem.E. 105	Fuels and Combustion	2	.....	2	4
Nat.Sci. 9*	General Biology	4	.....	2	4

THIRD YEAR

First Quarter

Chem.E. 80	Chemical Engineering Materials	1	.....	2	.....
Chem.E. 101	Unit Operations	3	2	2	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Org.Chem. 61	Elementary Organic Chemistry	4	2	3	4
Phys.Chem. 101	Physical Chemistry	3	1	3	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

Chem.E. 102	Unit Operations	5	3	3	.....
Org.Chem. 62	Elementary Organic Chemistry	4	2	3	4
Met. 160	Metallography	3	.....	2	3
Phys.Chem. 102	Physical Chemistry	3	1	3	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....

Third Quarter

Chem.E. 103	Unit Operations	5	2	3	.....
Org.Chem. 63	Elementary Organic Chemistry	3	1	3	.....
Org.Chem. 64	Elementary Organic Chemistry Laboratory	3	.....	1	6
Phys.Chem. 103	Physical Chemistry	3	1	3	.....
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

* See page 92 for alternate sequences which may be substituted as a unit.

FOURTH YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Chem.E. 111	Unit Operations Laboratory	1	.....	.....	4
Chem.E. 119	Chemical Engineering Thermodynamics	3	3	.....	.....
Chem.E. 131	Inorganic Technology	4	1	4	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
Phys.Chem. 104	Physical Chemistry Laboratory	2	1	.....	5
Hum. 1*	Humanities in the Modern World	5	.....	5	.....
	Elective	3 or 5			

Second Quarter

Chem.E. 112	Unit Operations Laboratory	1	.....	.....	4
Chem.E. 120	Chemical Engineering Thermodynamics	3	3	.....	.....
Chem.E. 132	Organic Technology	3	1	4	.....
Phys.Chem. 105	Physical Chemistry Laboratory	2	1	.....	5
Hum. 2*	Humanities in the Modern World	5	.....	5	.....
Chem.E. 187	Chemical Engineering Trip (spring vacation)	2	.....	.....	.....
	Elective	3 or 5			

Third Quarter

Chem.E. 113	Unit Operations Laboratory	1	.....	.....	4
M.E. 38	Heat Engines	3	3	.....	.....
M.&M. 85	Strength of Materials	3	3	.....	.....
M.&M. 87	Materials Testing Laboratory	1	.....	.....	2
Phys.Chem. 106	Physical Chemistry Laboratory	2	1	.....	5
Hum. 3*	Humanities in the Modern World	5	.....	5	.....
	Elective	3 or 5			

Summer Session

Chem.E. 151,152	Chemical Manufacture	6	.....	.....	.....

NOTE. At the end of the fourth year, students with an honor point average considerably greater than 1.00 should consult their adviser regarding the possibility of arranging a special course of study to follow in the fifth year.

Students who are planning to take graduate work are urged to take French or other approved foreign languages as one of the electives in the fifth year.

FIFTH YEAR

First Quarter

Chem.E. 117	Chemical Engineering Equipment Design	3	3	.....	4
Chem.E. 191	Seminar	1	1	.....	.....
E.E. 43	Electrical Engineering Survey	3	.....	2	2
Engl. 85	Advanced Technical Communication	3	3	.....	.....
German 24	Chemical German	3	3	.....	.....
	Elective	4			

Second Quarter

Chem.E. 118	Chemical Engineering Equipment Design	3	3	.....	4
Chem.E. 192	Seminar	1	1	.....	.....
E.E. 44	Electrical Engineering Survey	3	.....	2	2
Engl. 86	Advanced Technical Communication	3	3	.....	.....
German 25	Chemical German	3	3	.....	.....
	Elective	4			

* See page 92 for alternate sequences which may be substituted as a unit.

Third Quarter

Chem.E. 121	Chemical Engineering Economics	3	.....	3	.....
Chem.E. 193	Seminar	1	1	.....	.....
E.E. 45	Electrical Engineering Survey	3	.....	2	2
M.E. 39	Heat Engine Laboratory	1	.....	.....	3
German 26	Chemical German	3	3	.....	.....
G.E. 103	Professional Problems	1	.....	1	.....
	Elective	4			

Specialization in Bacteriology, Biochemistry, and Geology

On page 37 a selected group of electives is listed for chemical engineers interested in specializing in bacteriology, biochemistry, or geology. The *Bulletin of Agriculture, Forestry, Home Economics, and Veterinary Medicine* also lists courses in food technology which are of value to those interested in this field.

Chemistry

A five-year curriculum is offered which leads 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 255 credits.

This professional course in chemistry is designed to provide thorough 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, teaching, in chemical industries, the government service, in colleges and laboratories, etc.

Students with an honor point ratio of 1.50 may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3, English 85-86, and Electrical Engineering 38 or 45.

For freshman year, see page 15.

SECOND 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: Mechanics and Heat	5	1	4	2
Nat.Sci. 7*	General Biology	3	.....	2	4

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Anal.Chem. 1	Quantitative Analysis	5	1	1	10
Phys. 8	General Physics: Electricity	5	1	4	2
Nat.Sci. 8*	General Biology	3	.....	2	4

Third Quarter

M.&M. 84	Technical Mechanics	5	5	.....	.....
Anal.Chem. 2	Quantitative Analysis	5	1	1	10
Phys. 9	General Physics: Sound and Light	5	1	4	2
Nat.Sci. 9*	General Biology	4	.....	2	4

* See page 92 for alternate sequences which may be substituted as a unit.

THIRD YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Org.Chem. 61	Elementary Organic Chemistry	4	2	3	4
Phys.Chem. 101	Physical Chemistry	3	1	3	.....
Phys.Chem. 104	Physical Chemistry Laboratory	2	1	.....	5
German 24 or 27†	Chemical German (or Chemical Prose)	3	3	.....	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

Org.Chem. 62	Elementary Organic Chemistry	4	2	3	4
Phys.Chem. 102	Physical Chemistry	3	1	3	.....
Phys.Chem. 105	Physical Chemistry Laboratory	2	1	.....	5
German 25 or 28†	Chemical German (or Chemical Prose)	3	3	.....	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....

Third Quarter

Org.Chem. 63	Elementary Organic Chemistry	3	1	3	.....
Org.Chem. 64	Elementary Organic Chemistry Lab.	3	.....	1	6
Phys.Chem. 103	Physical Chemistry	3	1	3	.....
Phys.Chem. 106	Physical Chemistry Laboratory	2	1	.....	5
German 26 or 29†	Chemical German (or Chemical Prose)	3	3	.....	.....
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

FOURTH YEAR

First Quarter

Anal.Chem. 131	Applications of Indicators	3	.....	2	5
Org.Chem. 102	Characterization of Organic Compounds	3	.....	1	6
Hum. 1*	Humanities in the Modern World I	5	.....	5	.....
	Electives	6 or 8			

Second Quarter

Anal.Chem. 132**	Electrometric Measurements and Titration	3	.....	2	5
Chem.E. 89	Chemical Engineering Survey	5	2	3	.....
Inorg.Chem. 104	Advanced Inorganic Chemistry	3	.....	3	.....
Hum.2*	Humanities in the Modern World II	5	.....	5	.....
	Electives	1 or 3			

Third Quarter

Chem.E. 90	Chemical Engineering Survey	5	2	3	.....
Inorg.Chem. 105	Advanced Inorganic Chemistry	3	.....	3	.....
Hum. 3*	Humanities in the Modern World III	5	.....	5	.....
	Electives	4 or 6			

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* See page 92 for alternate sequences which may be substituted as a unit.

† German 27-28-29 is for those who have had two years of German in high school or one year in college. Others should take German 24-25-26.

** Anal.Chem. 105 may be substituted for Anal.Chem. 132.

FIFTH YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Anal.Chem. 104†	Qualitative Inorganic Microanalysis	3	.....	1	6
Engl. 85	Advanced Technical Communication	3	3	.....	.....
German 41§	Readings from German Chemical Periodicals	2	2	.....	.....
Phys.Chem. 116¶¶	Advanced Physical Chemistry	3	.....	3	.....
	Seminar††	1	1	.....	.....
	Electives	5 or 7			

Second Quarter

Anal.Chem. 107†	General Technical Analysis	2	.....	1	1
Anal.Chem. 140†	Water Analysis	2	.....	1	1
Engl. 86	Advanced Technical Communication	3	3	.....	.....
German 42§	Readings from German Chemical Periodicals	2	2	.....	.....
Org.Chem. 101	Intermediate Organic Chemistry	3	.....	3	.....
Phys.Chem. 117¶¶	Advanced Physical Chemistry	3	.....	3	.....
	Seminar††	1	1	.....	.....
	Electives	1 or 3			

Third Quarter

Anal.Chem. 127†	Optical Methods in Analytical Chemistry	2	.....	2	.....
E.E. 38 or 45¶	Electrical Engineering Survey	3	.....	2	2
German 43§	Readings from German Chemical Periodicals	2	2	.....	.....
G.E. 103	Professional Problems	1	.....	1	.....
	Seminar††	1	1	.....	.....
	Electives	8 or 10			

NOTE. Near the close of the fourth 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.

Students who are planning to take graduate work are urged to take French or other approved foreign languages as one of the electives in the senior year.

List of Advisers for Seniors

Inorganic Chemistry: Professors Heisig, Pervier, Maynard.
Analytical Chemistry: Professors Kolthoff, Sandell, Meehan.
Organic Chemistry: Professors Smith, Lauer, Koelsch, Arnold, Parham, Dodson.
Physical Chemistry: Professors Livingston, Crawford, Lipscomb.
Chemical Engineering: Professors Amundson, Ceaglske, Stoppel, Piret.

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† Senior Thesis, 10 credits, is required of all students whose honor point average is greater than 1.50 and is open only to those meeting this requirement. Anal.Chem. 104, 107, 127, and 140 (9 credits) is required of all whose honor point average is less than 1.50. These courses are not required of those whose honor point average exceeds 1.50.

§ German 41-42-43 is not required of those who have had German 27-28-29.

¶ Recommended course; may be replaced by electives, with the approval of adviser.

†† Students in the five-year curriculum are required to attend a divisional seminar during each quarter of the fifth year (not necessarily the same divisional seminar for all three quarters). These seminars are Inorg.Chem. 52-53-54, Anal.Chem. 135-136-137, Org.Chem. 151-152-153, Phys.Chem. 150-151-152, and Chem.E. 191-192-193.

¶¶ Other courses (6 cred.) in advanced Physical Chemistry may be substituted with the approval of the Division of Physical Chemistry or the major adviser.

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 last two years in addition to the required courses of the regular chemistry curriculum. The completion of one of these groups will qualify the chemistry graduate to enter graduate work toward the Ph.D. degree in that department, thus providing an exceptionally strong foundation in chemistry for specialization in the chosen field.

MINOR IN BACTERIOLOGY

FOURTH YEAR

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Zool. 14†	General Zoology	3	.....	2	4
Zool. 15†	General Zoology	3	.....	2	4
Bact. 53	General Bacteriology	5	.....	3	6

FIFTH YEAR

Bact. 121	Physiology of Bacteria	3	.....	3	.....
Bact. 122	Physiology of Bacteria	3	.....	3	.....
Bact. 123	Applied Bacteriology	3	.....	3	.....

MINOR IN BIOCHEMISTRY

FOURTH YEAR

Zool. 14†	General Zoology	3	.....	2	4
Zool. 15†	General Zoology	3	.....	2	4
Bact. 53	General Bacteriology	5	.....	3	6

FIFTH YEAR

Ag.Biochem. 119	Colloids	3	.....	3	.....
Ag.Biochem. 129	Colloids Laboratory	2	.....	.....	6

Three credits in Agricultural Biochemistry 120 or 121 should be taken in the winter quarter. Five or six credits in Agricultural Biochemistry 122, 123, 132, or 133 should be taken in the spring quarter.

NOTE. Humanities 21, 22, and 23 should be taken in the fourth year. Inorganic Chemistry 104 should be taken in the winter of the fifth year and Organic Chemistry 101 in the winter of the fourth year.

MINOR IN GEOLOGY

FOURTH YEAR

Geol. 1	General Geology	3	.....	3	.....
Geol. 23	Mineralogy	5	1	3	4
Geol. 24	Mineralogy	5	1	3	4
Geol. 2	General Geology	3	.....	3	.....

FIFTH YEAR

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

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

Civil Engineering

Two five-year curricula are offered: Civil Engineering and Sanitary Engineering Option.

In addition to the prescribed courses and exclusive of summer camp, sufficient approved electives must be taken to total at least 253 credits for graduation.

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 sanitary engineering occupy the greater part of the last three years. In the fifth year, there is a course of lectures and conferences on the relations of engineering projects to business and to public affairs. Elective courses are available in each of the two 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.

Students with an honor point ratio of 1.50 or better may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3, English 85-86 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
C.E. 11	Surveying	3	1	.....	7
Draw. 21	Drafting	2	.....	.....	6
Nat.Sci. 7*	General Biology	3	.....	2	4

Second Quarter

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

* See page 92 for alternate sequences which may be substituted as a unit.

Third Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
C.E. 13	Surveying	3	1	.....	7
Draw. 23	Structural Detailing	2	.....	.....	6
Nat.Sci. 9*	General Biology	4	.....	2	4

THIRD YEAR

First Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	1	.....	.....	2
C.E. 14	Surveying	3	.....	1	7
C.E. 31	Stresses in Structures	3	.....	3	3
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

M.&M. 129	Fluid Mechanics	4	4	.....	.....
M.&M. 143	Hydraulic Laboratory	1	.....	.....	2
C.E. 15	Surveying	2	.....	1	3
C.E. 21	Route Surveying	2	.....	1	4
C.E. 32	Design in Steel	3	.....	3	3
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....

Third Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
C.E. 16	Surveying	2	.....	1	4
C.E. 22	Railway Engineering	2	.....	1	3
C.E. 33	Design in Timber	3	.....	3	3
C.E. 160	Applied Hydraulics	3	.....	2	4
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

Summer Camp

C.E. 23	Summer Camp	9			

FOURTH YEAR

First Quarter

C.E. 51	Highways and Pavements	3	.....	2	3
C.E. 130	Statically Indeterminate Structures	3	.....	2	2
C.E. 161	Hydrology	3	.....	2	4
Geol. 5	Engineering Geology	3	.....	3	.....
Hum. 1*	Humanities in the Modern World I	5	.....	5	.....

Second Quarter

C.E. 52	Highways and Pavements	3	.....	2	4
C.E. 131	Structural Analysis	2	.....	1	3
C.E. 162	Water Supply	3	.....	2	4
Geol. 6	Engineering Geology	3	.....	3	.....
Hum. 2*	Humanities in the Modern World II	5	.....	5	.....

Third Quarter

C.E. 53	Elements of Soil Mechanics	3	.....	2	3
C.E. 132	Structural Design	2	.....	1	3
C.E. 163	Sewerage and Sewage Treatment	3	.....	2	4
M.E. 42	Power	4	2	2	.....
Hum. 3*	Humanities in the Modern World III	5	.....	5	.....

* See page 92 for alternate sequences which may be substituted as a unit.

FIFTH YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
C.E. 121	Railway Engineering	3	.....	1	6
C.E. 141	Reinforced Concrete	3	.....	2	3
C.E. 146	Concrete and Concrete Materials	3	.....	2	4
Engl. 85	Advanced Technical Communication	3	3	.....	.....

Second Quarter

C.E. 142	Reinforced Concrete Design	3	.....	2	2
C.E. 147	Foundations	3	.....	3	.....
Engl. 86	Advanced Technical Communication	3	3	.....	.....

Third Quarter

E.E. 42	Electrical Engineering Survey	3	3	.....	.....
G.E. 101	Contracts and Specifications	3	.....	3	.....
G.E. 103	Professional Problems	1	.....	1	.....

Sanitary Engineering Option

The option in sanitary engineering should be selected by the beginning of the fifth year in the civil engineering curriculum. If the selection of this option is made before or during the fourth year, the courses identified with a dagger in the list of recommended electives for sanitary engineering may be substituted, upon approval, for any of the following: C.E. 15, 16, 21, 22, 52, 121, 130, 131, 132.

FIFTH YEAR

First Quarter

COURSE NO.	TITLE	CREDITS
P.H. 100	Elements of Preventive Medicine and Public Health	5
C.E. 141	Reinforced Concrete	3
C.E. 173	Sanitary Engineering Problems (Water)	3
C.E. 179	Sanitary Laboratory	3
Engl. 85	Advanced Technical Communication	3
C.E. 180	Sanitary Engineering Seminar	1
	Electives (from list of recommended electives)	

Second Quarter

P.H. 102	Environmental Sanitation	3
G.E. 101	Contracts and Specifications	3
C.E. 174	Sanitary Engineering Problems (Sewage and Industrial Wastes)	3
Engl. 86	Advanced Technical Communication	3
C.E. 181	Sanitary Engineering Seminar	1
	Electives (from list of recommended electives)	

Third Quarter

C.E. 165	Public Health Engineering	3
C.E. 146	Concrete and Concrete Materials	3
E.E. 42	Electrical Engineering Survey	3
G.E. 103	Professional Problems	1
C.E. 182	Sanitary Engineering Seminar	1
	Electives (from list of recommended electives)	

List of Recommended Electives for Sanitary Engineering

COURSE NO.	TITLE	CREDITS
Inorg.Chem. 11	Semimicro Qualitative Analysis	4
Ag.Bi. 1	Introduction to Organic Chemistry	5
Anal.Chem. 2†	Quantitative Analysis	3
Bact. 53†	General Bacteriology	5
C.E. 142	Reinforced Concrete	3
C.E. 147†	Foundations	3
C.E. 164	Water Conservation	3
C.E. 166†	Water Power	3
C.E. 168	Irrigation and Drainage	3
C.E. 172	City Planning	3
C.E. 175	Industrial Waste Disposal	3
C.E. 176	Public Works Engineering	3
C.E. 183†	Open Channel Flow	3
C.E. 190†	Mechanics of Similitude and Dimensional Analysis	3
C.E. 191†	Hydraulic Motors and Pumps	3
C.E. 192†	Natural and Artificial Waterways	3
C.E. 193†	Hydraulic Measurements	3
P.H. 104	Epidemiology	3
P.H. 106	Public Health Administration	3
P.H. 117	Sanitary Biology	3
Pol.Sci. 120	Municipal Functions	3
Pol.Sci. 121	Municipal Administration	3
Pol.Sci. 122	Municipal Problems	3

† See statement under Sanitary Engineering Option.

Electrical Engineering

A five-year curriculum is offered which leads to the degree of bachelor of electrical engineering, B.E.E.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of at least 253 credits for graduation.

This course is designed to fit the student for a position of responsibility in the electrical field by providing studies of two kinds: (1) fundamental technical studies in mathematics, physics, and engineering, and (2) broad, liberalizing studies to provide a background for an understanding of the world in which we live and its social relationships.

There are several optional courses offered in the fifth year in the specialized fields of communications, electronics, power, and physics and mathematics. An honor point average of 1.80 and the written approval of the Electrical Engineering Department is required for entrance into the physics and mathematics option.

Students with an honor point ratio of 1.50 or better may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3, English 85-86 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
E.E. 11	Elements of Electrical Engineering	3	.....	3	.....
E.E. 12	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Nat.Sci. 7*	General Biology	3	.....	2	4

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
E.E. 13	Elements of Electrical Engineering	3	.....	3	.....
E.E. 14	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Nat.Sci. 8*	General Biology	3	.....	2	4

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
E.E. 15	Elements of Electrical Engineering	3	.....	3	.....
E.E. 16	Elements of Electrical Engineering Laboratory	2	.....	.....	4
Nat.Sci. 9*	General Biology	4	.....	2	4

* See page 92 for alternate sequences which may be substituted as a unit.

THIRD YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 86	Hydraulics	3	3	.....	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
E.E. 109	Electric and Magnetic Fields	3	3	.....	.....
E.E. 111	Electrical Engineering	3	3	.....	.....
E.E. 112	Electrical Engineering Laboratory	1	.....	.....	2
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

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	3	.....	.....
E.E. 118	Engineering Electronics Laboratory	1	.....	.....	2
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....

Third Quarter

M.&M. 85	Strength of Materials	3	3	.....	.....
M.&M. 87	Materials Laboratory	1	.....	.....	2
E.E. 115	Electrical Engineering	3	3	.....	.....
E.E. 116	Electrical Engineering Laboratory	1	.....	.....	2
E.E. 119	Engineering Electronics	3	3	.....	.....
E.E. 120	Engineering Electronics Laboratory	1	.....	.....	2
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

FOURTH YEAR

First Quarter

E.E. 121	Electrical Engineering	3	3	.....	.....
E.E. 122	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 161	Electric Communication	4	3	.....	2
M.E. 26	Mechanism and Kinematics	3	3	.....	.....
Hum. 1*	Humanities in the Modern World I	5	.....	5	.....
	Electives				

Second Quarter

E.E. 123	Electrical Engineering	3	3	.....	.....
E.E. 124	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 162	Electric Communication	4	3	.....	2
M.E. 8	Machine Shop Practice	2	.....	2	3
Hum. 2*	Humanities in the Modern World II	5	.....	5	.....
	Electives				

Third Quarter

E.E. 125	Electrical Engineering	3	3	.....	.....
E.E. 126	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 163	Electric Communication	4	3	.....	2
Hum. 3*	Humanities in the Modern World III	5	.....	5	.....
	Electives				

FIFTH YEAR

First Quarter

	E.E. Option	6			
E.E. 127	Transient Analysis	3	2	.....	2
Engl. 85	Advanced Technical Communication	3	3	.....	.....
M.E. 40	Heat Engines	3	2	.....	3
	Electives				

* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
	E.E. Option	6			
E.E. 128	Transient Analysis	3	2	.....	2
Engl. 86	Advanced Technical Communication	3	3	.....	.....
M.E. 41	Heat Engines	3	2	.....	3
	Electives				

Third Quarter

	E.E. Option	6			
E.E. 129	Transient Analysis	3	2	.....	2
G.E. 103	Professional Problems	1	.....	1	.....
M.E. 55	Internal Combustion Engines	3	2	.....	3
E.E. 100	Inspection Trip (between winter and spring quarters)	2	.....	.....	.....
	Electives				

Electrical Engineering Options

One option unit must be completed. Courses may not be split between options.

			CREDITS F	W	S	REC.	LAB.
Communication Option	E.E. 164-165-166	Communication Circuits	3	3	3	2	2
	E.E. 167-168-169	Radio Communication	3	3	3	2	2
Electronics Option	E.E. 131-133-135	Electronic Circuit Design	3	3	3	2	2
	E.E. 157-158-159	Industrial Electronics	3	3	3	2	2
Power Option	E.E. 132-134-136	Electric Design	3	3	3	3	.....
	E.E. 138-139-140	Power Systems	3	3	3	3	.....

Physics and Mathematics Option (H.P.A. of 1.80 and written approval of the Electrical Engineering Department required for this option)

	Phys. 101-103-105	Theoretical Physics	5	5	5	5	.....
	M.&M. 150-152-153	Advanced Calculus	3	3	3	3	.....

Cooperative Work-Study Curriculum in Electrical Engineering

A cooperative work-study curriculum is offered in cooperation with industry leading to the degree of bachelor of electrical engineering. The awarding of the degree will require the satisfactory completion of all of the university work as outlined below plus 18 months of supervised industrial experience.

This curriculum is designed to provide both theoretical and practical training in engineering work over a period of five years and is equivalent to the regular electrical engineering curriculum.

Applications will be accepted from sophomore electrical engineering students in the first quarter of the second year. Candidates will be selected on the basis of scholastic ability, personal qualifications and fitness for work.

For freshman year see page 15.

SECOND YEAR

SECTION I

Fall Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
E.E. 11	Elements of Electrical Engineering	3	.....	3	.....
E.E. 12	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Psy. 1*	General Psychology	3	.....	3	.....

Winter Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
E.E. 13	Elements of Electrical Engineering	3	.....	3	.....
E.E. 14	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Psy. 2*	General Psychology	3	.....	3	.....

Spring Quarter

Industrial Assignment I

Summer Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
E.E. 15	Elements of Electrical Engineering	3	.....	3	.....
E.E. 16	Elements of Electrical Engineering Laboratory	2	.....	.....	4

THIRD YEAR

Fall Quarter

Industrial Assignment II

Winter Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
E.E. 109	Electric and Magnetic Fields	3	3	.....	.....
E.E. 111	Electrical Engineering	3	3	.....	.....
E.E. 112	Electrical Engineering Laboratory	1	.....	.....	2
M.E. 40	Heat Engines	3	2	.....	3
Econ. 8*	General Economics	3	3	.....	.....

Spring Quarter

Industrial Assignment III

Summer Quarter

M.&M. 85	Strength of Materials	3	3	.....	.....
M.&M. 87	Materials Testing Laboratory	1	.....	.....	2
E.E. 113	Electrical Engineering	3	3	.....	.....
E.E. 114	Electrical Engineering Laboratory	1	.....	.....	2
E.E. 117	Engineering Electronics	3	3	.....	.....
E.E. 118	Engineering Electronics Laboratory	1	.....	.....	2
M.E. 41	Heat Engines	3	2	.....	3
Econ. 9*	General Economics	3	3	.....	.....

* See page 92 for alternate sequences which may be substituted as a unit.

FOURTH YEAR

Fall Quarter

Industrial Assignment IV

Winter Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 86	Hydraulics	3	3	.....	.....
E.E. 115	Electrical Engineering	3	3	.....	.....
E.E. 116	Electrical Engineering Laboratory	1	.....	.....	2
E.E. 119	Engineering Electronics	3	3	.....	.....
E.E. 120	Engineering Electronics Laboratory	1	.....	.....	2
M.E. 55	Internal Combustion Engines	3	2	.....	3
Pol.Sci. 1*	American Government and Politics	3	.....	3	.....

Spring Quarter

Industrial Assignment V

Summer Quarter

E.E. 121	Electrical Engineering	3	3	.....	.....
E.E. 122	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 161	Electric Communication	4	3	.....	2
E.E. 127	Transient Analysis	3	2	.....	2
Pol.Sci. 2*	American Government and Politics	3	.....	3	.....
Hum. 21*	American Life I	3	.....	3	.....

FIFTH YEAR

Fall Quarter

Industrial Assignment VI

Winter Quarter

E.E. 123	Electrical Engineering	3	3	.....	.....
E.E. 124	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 162	Electric Communication	4	3	.....	2
E.E. 128	Transient Analysis	3	2	.....	2
Hum. 22*	American Life II	3	.....	3	.....
Engl. 85	Advanced Technical Communication	3	3	.....	.....

Spring Quarter

E.E. 125	Electrical Engineering	3	3	.....	.....
E.E. 126	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 163	Electric Communication	4	3	.....	2
E.E. 129	Transient Analysis	3	2	.....	2
Hum. 23*	American Life III	3	.....	3	.....
Engl. 86	Advanced Technical Communication	3	3	.....	.....

Six credits of electives must also be included with the above.

SECTION II

For freshman year, see page 15.

SECOND YEAR

Fall Quarter

M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
E.E. 11	Elements of Electrical Engineering	3	2	1	.....
E.E. 12	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Psy. 1*	General Psychology	3	.....	3	.....

* See page 92 for alternate sequences which may be substituted as a unit.

Winter Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
E.E. 13	Elements of Electrical Engineering	3	2	1	.....
E.E. 14	Elements of Electrical Engineering Laboratory	1	.....	.....	2
Psy. 2*	General Psychology	3	.....	3	.....

Spring Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
E.E. 15	Elements of Electrical Engineering	3	2	1	.....
E.E. 16	Elements of Electrical Engineering Laboratory	2	.....	.....	4

Summer Quarter

Industrial Assignment I

THIRD YEAR

Fall Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
E.E. 109	Electric and Magnetic Fields	3	3	.....	.....
E.E. 111	Electrical Engineering	3	3	.....	.....
E.E. 112	Electrical Engineering Laboratory	1	.....	.....	2
M.E. 40	Heat Engines	3	2	.....	3
Econ. 8*	General Economics	3	3	.....	.....

Winter Quarter

Industrial Assignment II

Spring Quarter

M.&M. 85	Strength of Materials	3	3	.....	.....
M.&M. 87	Materials Testing Laboratory	1	.....	.....	2
E.E. 113	Electrical Engineering	3	3	.....	.....
E.E. 114	Electrical Engineering Laboratory	1	.....	.....	2
E.E. 117	Engineering Electronics	3	3	.....	.....
E.E. 118	Engineering Electronics Laboratory	1	.....	.....	2
M.E. 41	Heat Engines	3	2	.....	3
Econ. 9*	General Economics	3	3	.....	.....

Summer Quarter

Industrial Assignment III

FOURTH YEAR

Fall Quarter

M.&M. 86	Hydraulics	3	3	.....	.....
E.E. 115	Electrical Engineering	3	3	.....	.....
E.E. 116	Electrical Engineering Laboratory	1	.....	.....	2
E.E. 119	Engineering Electronics	3	3	.....	.....
E.E. 120	Engineering Electronics Laboratory	1	.....	.....	2
M.E. 55	Internal Combustion Engines	3	2	.....	3
Pol.Sci. 1*	American Government and Politics	3	.....	3	.....

* See page 92 for alternate sequences which may be substituted as a unit.

Winter Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
	Industrial Assignment IV				

Spring Quarter

E.E. 121	Electrical Engineering	3	3	.....	.....
E.E. 122	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 161	Electric Communication	4	3	.....	2
E.E. 127	Transient Analysis	3	2	.....	2
Pol.Sci. 2*	American Government and Politics	3	.....	3	.....
Hum. 21*	American Life I	3	.....	3	.....

Summer Quarter

Industrial Assignment V

FIFTH YEAR

Fall Quarter

E.E. 123	Electrical Engineering	3	3	.....	.....
E.E. 124	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 162	Electric Communication	4	3	.....	2
E.E. 128	Transient Analysis	3	2	.....	2
Hum. 22*	American Life II	3	.....	3	.....
Engl. 85	Advanced Technical Communication	3	3	.....	.....

Winter Quarter

Industrial Assignment VI

Spring Quarter

E.E. 125	Electrical Engineering	3	3	.....	.....
E.E. 126	Electrical Engineering Laboratory	2	.....	.....	4
E.E. 163	Electric Communication	4	3	.....	2
E.E. 129	Transient Analysis	3	2	.....	2
Hum. 23*	American Life III	3	.....	3	.....
Engl. 86	Advanced Technical Communication	3	3	.....	.....

Six credits of electives must also be included with the above.

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* See page 92 for alternate sequences which may be substituted as a unit.

Engineering and Business Administration

As a result of the vast industrial expansion which has taken place in the United States, a need has arisen for engineers with more training in economics and business administration than is normally possible in the regular engineering curricula. To meet this need two special curricula have been developed, the combined curricula in engineering and business administration, and the four-year program in engineering and business administration (industrial administration).

Combined Curricula in Engineering and Business Administration

The combined curricula in engineering or chemistry and business administration enables the student to complete the requirements for two degrees, one in the Institute of Technology and one in the School of Business Administration in a period of approximately five years. The Institute of Technology will allow business courses to be substituted for the requirements in natural science, social science, and the humanities to satisfy the requirements for the Bachelor's degree as indicated in each curriculm. The School of Business Administration accepts 74 credits of business subjects listed on the following page as satisfying the requirements for the degree of business administration. Required courses have been waived in both colleges with the understanding that the courses in the two colleges will be carried simultaneously and supplement each other. The work is to be completed as a unit and both degrees obtained at the same commencement period.

Application for admission to this program may be made by filing a petition with the Students' Work Committee for the combined engineering and business curricula, located in 133 Main Engineering Building. An honor point average of 1.50 in each field, i.e., engineering and business, based on at least two quarters of work in the Institute of Technology, is required for entrance into and for continuation in this program. Freshmen should submit applications at the beginning of their third quarter in school while advanced standing students should apply after completing two quarters in the Institute of Technology. It is not desirable to delay in submitting an application because the total enrolment in this program is restricted to 160 students.

After being officially admitted, the student will be registered in both the Institute of Technology and the School of Business Administration for the entire program. Registration each quarter is subject to the approval of the advisers in both the School of Business Administration and the Institute of Technology. The business courses are intended to be spread over the last four years as indicated below. Not more than 28 credits of business subjects should be left to the fifth year.

The following order and distribution of business courses by years are suggested. When necessary, approval to vary this schedule should be obtained from the adviser in the School of Business Administration.

See page 15 for freshman year.

SECOND YEAR

COURSE NO.	TITLE	CREDITS F	W	S
Econ. 8-9	General Economics	3	3	
Econ. 28	Business Law			3

THIRD YEAR

Econ. 54-55	Elementary Accounting, Combined Course	4	4	
B.A. 77¶	Survey in Marketing			3

FOURTH YEAR

B.A. 58§	Elements of Public Finance		3	
B.A. 70	Statistics Survey	3		
B.A. 71	Transportation: Services and Charges I			3
B.A. 89 or B.A. 187†	Production Management			3
B.A. 74 or B.A. 112	Business Statistics		3	
B.A. 66 or B.A. 152	Cost Accounting Survey			3
Econ. 142	Monetary and Banking Policy	3		
B.A. 167	Introduction to Industrial Relations		3	
Econ. 161	General Manpower Economics	3		

FIFTH YEAR

Econ. 155	The Modern Corporation	3		
Econ. 80-81††	Intermediate Economic Analysis	3	3	
B.A. 180-181-182G	Senior Topics: Production Management	3	3	3
Econ. 149	Business Cycles		3	
Econ. 85	Government Regulations of Business			3
One of the following:				
B.A. 133	Standard Costs			3
B.A. 170	Methods Analysis and Work Measurement		3	
B.A. 171	Motion Study Applications			3
B.A. 173	Market Analysis		3	
Psy. 130	Vocational and Occupational Psychology		3	
	Total credits		74	

Any engineering graduate who has taken the courses in Group A below as an undergraduate, or who will satisfy the requirements in these undergraduate courses after graduation, may be accepted as a candidate for the degree of master of business administration upon the completion of 45 credits in the courses included under Group B, or with approved substitutions.

The requirements of the Graduate School must be met in the Group B courses. He must maintain a B average in these courses and must take an oral examination in the Core Group and in his field of specialization.

GROUP A

Econ. 8-9	General Economics for Engineers
Econ. 28	Business Law for Engineers
Econ. 54-55	Elementary Accounting, Combined Course
B.A. 58 or Econ. 189§	Elements of Public Finance

† Mechanical engineering students substitute M.E. 171 for B.A. 89 and replace the latter with an approved business course, preferably B.A. 173. Credit will not be given for both M.E. 171 and B.A. 89.

§ Econ. 189 may be substituted for B.A. 58.

¶ Econ. 185 may be substituted for B.A. 77.

†† Econ. 103-104 may be substituted for Econ. 80-81.

B.A. 70	Statistics Survey
B.A. 71	Transportation: Services and Charges I
B.A. 77¶¶	Survey in Marketing
B.A. 89 or B.A. 187	Production Management
Econ. 85	Government Regulation of Business

GROUP B

B.A. 152	Cost Accounting Survey
Econ. 155	The Modern Corporation
Econ. 161	General Manpower Economics
Econ. 103-104	Advanced Economic Theory
B.A. 112	Time Series Analysis and Quality Control
B.A. 133	Standard Costs
Econ. 142	Monetary and Banking Policy
B.A. 167	Introduction to Industrial Relations
B.A. 180-181-182G	Senior Topics: Production Management
B.A. 184	Scientific Management in Industry
Psy. 130	Vocational and Occupational Psychology
I.A. 174	Methods Analysis and Work Measurement
B.A. 149	Business Cycles

Four-Year Curriculum in Engineering and Business Administration (Industrial Administration)

This curriculum has been arranged for students who wish to prepare for positions in industry which require some basic technical training plus 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.

The work in the first two years of this curriculum is taken while registered in the Institute of Technology. The work in the last two years is taken while registered in the School of Business Administration.

Transfer is made to the School of Business Administration at the beginning of the junior year. A minimum of 97 credits including an honor point ratio of 1.00 is required for admission.

Elective credit earned in the Institute of Technology or any other accredited school during the first two years may be applied toward the elective requirement in the junior and senior years of this curriculum.

Completion of all the required work and a total of 187 credits leads to the degree of bachelor of business administration which is given by the School of Business Administration.

FRESHMAN YEAR

(In the Institute of Technology)

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.E. 1	Metal Working	2	.....	2	3

Second Quarter

M.E. 12	Materials and Processing II	2	.....	2	3

¶¶ Econ. 185 may be substituted for B.A. 77.

Third Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.E. 4	Machine Woodwork	2	.....	2	3

See page 15 for the balance of the requirements for the freshman year. Drawing 3, Descriptive Geometry is not required.

SOPHOMORE YEAR

(In the Institute of Technology)

First Quarter

M.&M. 91†	Calculus	4	4	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
Econ. 8	General Economics	3	.....	3	.....
M.E. 8	Machine Shop Practice	2	.....	2	3
M.E. 70	Mechanical Technology	1	.....	2	.....
	Electives				

Second Quarter

Econ. 3 or B.A. 57	Elements of Money and Banking	5/3	3	2/0	.....
Econ. 9	General Economics	3	3	.....	.....
Econ. 54	Elementary Accounting	4	4	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
	Electives				

Third Quarter

M.&M. 84†	Technical Mechanics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
B.A. 70§	Elements of Statistics	3	.....	.....	.....
Econ. 55	Elementary Accounting	4	4	.....	.....

JUNIOR YEAR¶

(In the School of Business Administration)

	CREDITS
Strength of Materials (M.&M. 85)†	3
Materials Testing Laboratory (M.&M. 87)†	1
Business Law (Bus.Adm. 51-52-53)	9
Business Statistics (Bus.Adm. 74)	3
Corporation Finance (Econ. 74)	3
Monetary and Banking Policy (Econ. 142)	3
Transportation: Services and Charges I (Bus.Adm. 71)	3
Survey in Marketing (Bus.Adm. 77)††	3
Production Management (Bus.Adm. 89)	3
Cost Accounting Survey (Bus.Adm. 66)	3
Tabulating Equipment Laboratory (Bus.Adm. 91)	1
Motion Economy (Bus.Adm. 170)	3
Electives (see page 53)	7

† For permissible substitute, see page 93.

§ Econ. 5 may be substituted for B.A. 70.

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

†† Econ. 185 may be substituted for B.A. 77.

SENIOR YEAR¶

(In the School of Business Administration)

	CREDITS
Transportation: Services and Charges II (Bus.Adm. 174)	3
Intermediate Economic Analysis (Econ. 80-81)	6
Business Cycles (Econ. 149)	3
Manpower Economics and Problems (Econ. 73)	3
Introduction to Industrial Relations (Bus.Adm. 167)	3
Elements of Public Finance (Bus.Adm. 58)	3
Government Regulation of Business (Econ. 85)	3
Senior Topics: Production Management (Bus.Adm. 180-181-182G)	9
Standard Costs (Bus.Adm. 133)	3
Market Analysis and Research (Econ. 173)	3
Electives (see below)	6

Recommended Electives

	HOURS
Economic History of Europe (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
Insurance Principles (Econ. 50)	3
Contracts and Specifications (G.E. 101)	3
General Psychology (Psy. 1-2)	6
Vocational Psychology (Psy. 130)	3

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

Engineering Mathematics

A five-year curriculum is offered which leads to the degree of bachelor of engineering mathematics, B.E.Math.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of 253 credits for graduation.

This course of study is designed to prepare the student for those positions in industry which require the use of more mathematics than is offered in the usual engineering curricula. It provides a fundamental study in physics and in some engineering field selected by the student, and a more advanced study of the courses in mathematics and mechanics.

Students who maintain an honor point average of 1.80 or better throughout the first four years of the course may elect, upon petitioning therefor, to receive a bachelor of science degree (without departmental designation) at the end of the fourth year. This will permit honor students who so desire to register in the Graduate School in the fifth year and pursue work toward a Master's degree with a major in mathematics and mechanics. Alternatively they may pursue the regular work of the engineering mathematics curriculum leading to the degree of bachelor of engineering mathematics at the end of the fifth year.

Students with an honor point ratio of 1.50 or better may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3, English 85-86 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
Nat.Sci. 7*	General Biology	3	.....	2	4
	Option†	4 or 5			

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
Nat.Sci. 8*	General Biology	3	.....	2	4
	Option†	3 or 4			

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
Nat.Sci. 9*	General Biology	4	.....	2	4
	Option†	4 or 5			

* See page 92 for alternate sequences which may be substituted as a unit.

† Option to be selected from one of the Engineering Departments in the Institute of Technology or by petition.

THIRD YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.&M. 150	Calculus III: Intermediate Calculus	3	3	.....	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....
	Elective	3			

Second Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 152	Calculus IV: Special Topics in Advanced Calculus	3	3	.....	.....
Math. 62	Introduction to the Theory of Equations	3	3	.....	.....
M.&M. 141	Materials Testing Laboratory	1	.....	.....	2
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....
	Electives	3			

Third Quarter

M.&M. 130	Fluid Mechanics	5	5	.....	.....
M.&M. 153	Calculus V: Special Topics in Advanced Calculus	3	3	.....	.....
M.&M. 151	Ordinary Differential Equations	3	3	.....	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....
	Electives	3			

FOURTH YEAR

First Quarter

M.&M. 132	Industrial Statistics	3	3	.....	.....
M.&M. 154	Vector Analysis	3	3	.....	.....
M.E. 131	Thermodynamics	3	3	.....	.....
Hum. 1*	Humanities in the Modern World I	5	.....	5	.....
	Electives	3 or 5			

Second Quarter

M.&M. 133	Industrial Statistics	3	3	.....	.....
M.&M. 155	Vector Analysis and Dyadics with Applications	3	3	.....	.....
M.&M. 168	Elementary Theory of Complex Variables	3	3	.....	.....
Hum. 2*	Humanities in the Modern World II	5	.....	5	.....
	Electives	3 or 5			

Third Quarter

M.&M. 134	Industrial Statistics	3	3	.....	.....
M.&M. 156	Elements of Tensor Analysis	3	3	.....	.....
M.&M. 169	Mathematical Theory of Flow	3	3	.....	.....
Hum. 3*	Humanities in the Modern World III	5	.....	5	.....
	Electives	3 or 5			

FIFTH YEAR

First Quarter

M.&M. 161	Advanced Technical Mechanics	3	3	.....	.....
M.&M. 181	Applied Elasticity	3	3	.....	.....
Phys. 101	Theoretical Physics	5	5	.....	.....
Engl. 85	Advanced Technical Communication	3	3	.....	.....
	Electives	3			

* See page 92 for alternate sequences which may be substituted as a unit.

Geological Engineering

A five-year curriculum is offered which leads to the degree of bachelor of geological engineering, B.Geol.E.

In addition to the prescribed courses and exclusive of summer field trips, a total of 255 credits is required for graduation.

The curriculum 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.

Many ore deposits are of no particular value economically at the present time, either because the cost of mining is excessive or because there is no known method of separating the minerals in the ore at a profit. In addition to thorough 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 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. Large, well-lighted, and fully equipped laboratories are available 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.

Geophysics courses are recommended to supplement this curriculum. Geophysics aids in geological interpretations, provides knowledge of the earth's crust, and is used in the discovery of mineral deposits and petroleum. Geophysics courses may be substituted for electives to be chosen from courses offered by the College of Science, Literature, and the Arts or, with approval, for prescribed credits.

Students taking the combined curriculum with business administration may substitute business courses for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3 or 11-12-13 or 21-22-23 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 23	Mineralogy	5	1	3	4
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Nat.Sci. 7*	General Biology	3	.....	2	4
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2

* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 24	Mineralogy	5	1	3	4
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Nat.Sci. 8*	General Biology	3	.....	2	4
Phys. 8	General Physics: Electricity	5	1	4	2

Third Quarter

Geol. 11	General Geology (Physical and Historical)	5	.....	5	.....
Geol. 25	Rock Study	2	1	1	2
Met. 1	Assaying	3	.....	3	4
Nat.Sci. 9*	General Biology	4	.....	2	4
Phys. 9	General Physics: Sound and Light	5	1	4	2

THIRD YEAR

First Quarter

Geol. 106	Petrography	3	1	1	4
Geol. 125	Structural Geology	3	.....	3	.....
Met. 110	Mineral Dressing	3	.....	2	3
Min. 11	Surveying	3	1	3	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

Anal.Chem. 9	Quantitative Analysis	3	1	1	6
Geol. 144	Geologic Maps	3	.....	.....	6
Met. 111	Mineral Dressing	3	.....	2	3
Min. 12	Surveying	3	1	3	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....
	Electives in S.L.&A.	3			

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Min. 13	Surveying	2	1	2	.....
Min. 14	Surveying Field Work	5	.....	.....	20
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

Summer Field Trips

Min. 15	Field work in surveying on the iron ranges of Minnesota	6
Geol. 100	Field work in geology on the iron ranges of Minnesota	3
or Geol. 115	Field work in southeastern Minnesota	3

FOURTH YEAR

First Quarter

Geol. 107	Invertebrate Paleontology	3	.....	1	4
M.E. 131	Thermodynamics	3	.....	3	.....
Geophys. 108	Introduction to General Geophysics	3	.....	3	.....
or Met. 106	Nonferrous Metallurgy	3	.....	3	.....
Min. 111	Elements of Mining	3	.....	4	.....
Hum. 21*	American Life I	3	.....	3	.....

Second Quarter

Geol. 131	Petrology	4	1	2	4
Geol. 151	Stratigraphy	3	.....	3	.....
Met. 107	Nonferrous Metallurgy	3	.....	3	.....
or Geophys. 109	Introduction to General Geophysics	3	.....	3	.....
Min. 106	Mine Mapping	2	.....	.....	8
Min. 112	Elements of Mining	3	.....	4	.....
Hum. 22*	American Life II	3	.....	3	.....

* See page 92 for alternate sequences which may be substituted as a unit.

Third Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 132	Petrology	4	1	2	4
Geol. 152	Stratigraphy	3	.....	3	.....
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Min. 113	Elements of Mining	3	.....	4	.....
Hum. 23*	American Life III	3	.....	3	.....

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			

FIFTH YEAR

First Quarter

Engl. 85	Advanced Technical Communication	3	3	.....	.....
Geol. 101	Sedimentation	3	.....	3	.....
Geol. 110	Economic Geology	3	.....	3	.....
Geol. 118	Principles of Geomorphology	3	.....	3	.....
Min. 141	Examination and Valuation	3	.....	4	.....
Geol. 153†	Subsurface Stratigraphy	3	.....	1	4

Second Quarter

Engl. 86	Advanced Technical Communication	3	3	.....	.....
Geol. 61	Blowpipe Analysis	3	.....	.....	6
Geol. 111	Economic Geology	3	.....	3	.....
Geol. 140	Applied Petrography	3	.....	1	4
Geol. 166	Mineralography	3	.....	.....	6
	Electives in S.L.&A.	3			

Third Quarter

Geol. 112	Petroleum Geology	3	.....	3	.....
Geol. 145	Aerial Photographs	3	.....	.....	6
M.&M. 129	Fluid Mechanics	4	3	1	.....
Geophys. 110	Introduction to Exploration Geophysics	3	.....	3	.....
G.E. 103	Professional Problems	1	.....	1	.....

* See page 92 for alternate sequences which may be substituted as a unit.

† Geol. 137, Principles of Chemical Geology, may be substituted for this course. It is given in the spring quarter.

Geophysics

A five-year curriculum is offered which leads to the degree of bachelor of geophysics.

A total of 258 credits is required for graduation exclusive of the summer field trip.

Geophysics means physics of the earth, and is concerned with the application of the laws and techniques of physics to earth problems. In practice, a division is made between problems dealing with the entire earth or large portions of it and local problems which arise in exploration for minerals or petroleum. In the former category are topics such as the age, shape, and internal construction of the earth, gravitational and magnetic fields, isostasy, tides, and poles; particular emphasis is placed on earthquake study because of the valuable data supplied by it to the fields of physics and geology. Exploration geophysics makes use of differences in physical properties of rocks to provide information on materials buried hundreds or thousands of feet beneath the surface.

Both the geophysics curriculum and individual geophysics courses place primary emphasis on basic principles and fundamental techniques, in order to prepare students either for graduate work in geophysics and related fields or for responsible positions in geophysical companies or research institutions. The curriculum includes a thorough background in geology, physics, and mathematics; field work in geology is also required in order to help the geophysics student understand the nature of geologic problems. Courses in geophysics attempt to provide not only geophysical data but also the evidence on which such data are based.

FIRST YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 11	College Algebra	5	5	.....	.....
In.Chem. 4	General Inorganic Chemistry	4	1	3	3
Engl. 4	Written and Spoken Communication	3	3	.....	.....
Draw. 1	Engineering Drawing	3	.....	.....	8
G.E. 21	Orientation	1	.....	1	.....
Geol. 1	General Geology: Physical	3	.....	3	.....

Second Quarter

M.&M. 12	Trigonometry	5	5	.....	.....
In.Chem. 5	General Inorganic Chemistry	4	1	3	3
Engl. 5	Written and Spoken Communication	3	3	.....	.....
Draw. 2	Engineering Drawing	3	.....	.....	8
Geol. 2	General Geology: Historical	3	.....	3	.....

Third Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 13	Analytic Geometry	5	5	.....	.....
In.Chem. 11	Semimicro Qualitative Analysis	4	.....	3	4
Engl. 6	Written and Spoken Communication	3	3	.....	.....
Draw. 3	Descriptive Geometry	3	.....	.....	8
P.H. 3	Personal Health	2	.....	2	.....

SECOND YEAR

First Quarter

Geol. 23	Mineralogy	5	1	3	4
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Nat.Sci. 7*	General Biology	3	.....	2	4
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2

Second Quarter

Geol. 24	Mineralogy	5	1	3	4
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Nat.Sci. 8*	General Biology	3	.....	2	4
Phys. 8	General Physics: Electricity	5	1	4	2

Third Quarter

Geol. 25	Rock Study	2	1	1	2
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
Nat. Sci. 9*	General Biology	4	.....	2	4

THIRD YEAR

First Quarter

M.&M. 150	Intermediate Calculus	3	3	.....	.....
Geol. 125	Structural Geology	3	.....	3	.....
Phys. 101	Theoretical Physics	5	.....	5	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....
E.E. 46	Electrical Engineering Survey	3	2	.....	2

Second Quarter

M.&M. 151	Ordinary Differential Equations	3	3	.....	.....
Geol. 144	Geologic Maps	3	.....	.....	6
Phys. 103	Theoretical Physics	5	.....	5	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....
E.E. 47	Electrical Engineering Survey	3	2	.....	2

Third Quarter

M.&M. 90	Elementary Engineering Statistics	3	3	.....	.....
Phys. 105	Theoretical Physics	5	.....	5	.....
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....
	Electives in S.L.&A.	3			

FOURTH YEAR

First Quarter

Phys. 131	Geometrical Optics	3	.....	3	.....
Geophys. 108	Introduction to General Geophysics	3	.....	3	.....
Geol. 107	Invertebrate Paleontology	3	.....	1	4
Hum. 21*	American Life I	3	.....	3	.....
Phys. 191	Mathematical Physics	3	.....	3	.....
Phys. 144	Electricity Measurements	3	.....	3	4

* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Phys. 133	Physical Optics	3	.....	3	.....
Geophys. 109	Introduction to General Geophysics	3	.....	3	.....
Geol. 151	Stratigraphy	3	.....	3	.....
Hum. 22*	American Life II	3	.....	3	.....
Phys. 192	Mathematical Physics	3	.....	3	.....

Third Quarter

Geophys. 120	Theoretical Seismology	2	.....	2	.....
Geol. 152	Stratigraphy	3	.....	3	.....
Hum. 23*	American Life III	3	.....	3	.....
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Phys. 193	Mathematical Physics	3	.....	3	.....

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			

FIFTH YEAR

First Quarter

Pet. 111	Oil Field Development	3	.....	4	.....
Geophys. 125	Principles of Seismic Exploration	2	.....	2	2
Geol. 110	Economic Geology	3	.....	3	.....
Geol. 153	Subsurface Stratigraphy	3	.....	1	4
Geol. 70	Geologic Field Methods	2	Arrange		
Phys.Chem. 101	Physical Chemistry	3	1	3	.....
	Electives in S.L.&A.	3			

Second Quarter

Pet. 112	Oil Field Production	3	.....	4	.....
Geophys. 126	Principles of Gravity and Magnetic Exploration	2	.....	2	2
Geol. 111	Economic Geology	3	.....	3	.....
Astr. 51	General Astronomy	3	.....	3	.....
Phys.Chem. 102	Physical Chemistry	3	1	3	.....
	Electives in S.L.&A.	3			

Third Quarter

Pet. 138	Oil Field Mapping	2	.....	.....	6
Geophys. 127	Principles of Electrical Exploration	2	.....	2	2
Geol. 112	Petroleum Geology	3	.....	3	.....
Phys.Chem. 103	Physical Chemistry	3	1	3	.....
	Electives in S.L.&A.	3			

* See page 92 for alternate sequences which may be substituted as a unit.

Industrial Engineering

A five-year curriculum is offered which leads to the degree of bachelor of industrial engineering, B.I.E.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of at least 253 credits for graduation.

Industrial engineers perform an essential service for manufacturing and other industries in planning and establishing the manufacture of new products, controlling and reducing the cost of existing operations, making special surveys and economic studies for management, and supervising and managing manufacturing plants and departments.

In setting up for the manufacture of new products and reducing the cost of existing operations, the industrial engineer studies product designs to adapt them for economical production, determines the necessary operations on the product, develops effective methods for the various operations, selects production equipment, designs special tools and jigs, and assists in training the operators in correct work procedures. He is also concerned with the development and design of special production equipment, the overall planning and coordination of manufacturing processes, and the layout and planning of industrial plants.

In connection with the day-to-day operation of manufacturing plants, industrial engineers are engaged in planning and scheduling the flow of work through the plant, following up the progress of the work, establishing quality standards, and controlling the quality of the product as it goes through the various operations. Other important activities include work measurement, the establishment of production standards, estimating the costs of new operations, and the administration of wage incentive, cost control, and waste reduction programs. Industrial engineers are also engaged in plant and equipment maintenance, safety engineering, technical sales, purchasing, and other activities which require engineering background and a knowledge of manufacturing.

Top-management decisions on the adoption of new products, major equipment installations, plant locations, and plant expansion and construction programs are based on industrial engineering studies to determine the required capital expenditures and the probable annual returns on the expenditures. Industrial engineering surveys are also the basis for determining the needs for production equipment and plants to meet anticipated sales volumes, developing orderly expansion programs, and determining probable capital requirements of the business. Industrial engineers also make periodic surveys of existing plants to determine possible improvements and to develop cost-reduction programs.

Industrial engineering principles and the analytical approach to production and management problems are applied not only in manufacturing, but also in mining, construction, agriculture, and in such diverse businesses as retail stores, mail-order houses, banks, insurance companies, laundries, and hotels.

The objectives of the industrial engineering curriculum are twofold: (1) to give the student sufficient basic knowledge and practical background in production engineering and the control of manufacturing operations to qualify him upon graduation for subordinate positions in these fields with a minimum of in-plant training; (2) to afford sufficiently broad training in the management aspects of production to equip the graduate for future responsibilities in production management, higher administrative and staff positions, and management consulting work. In view of this latter objective, emphasis is placed on the broader policy considerations and on the analytical approach to production and management problems rather than on specific manufacturing techniques.

The functions of the industrial engineer involve working with people extensively, and his success depends in a large measure on his ability to work effectively with others in an organization. It is therefore important that he have a broad understanding of human relations and a native aptitude for this type of activity.

In addition to the specific courses in industrial engineering, the curriculum includes an extensive background in mechanical engineering, the first three years being substantially the same for the two programs. Also included are related courses in economics, cost accounting, statistics, and industrial relations.

Students with an honor point ratio of 1.50 or better may petition for admission to the combined course with business administration. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3, English 85-86 and electives. Because of the close relationship between industrial engineering and general management functions, this combination is especially appropriate for students in industrial engineering.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5		
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
M.E. 11	Materials and Processing I	2		2	
M.E. 20*	Elementary Machine Design	2			6
Nat.Sci. 7†	General Biology	3		2	4
	Electives				

Second Quarter

M.&M. 25	Calculus II: Integral	5	5		
Phys. 8	General Physics: Electricity	5	1	4	2
M.E. 12, 13, or 16	Materials and Processing II, III, or VI	2		2	3
M.E. 21	Kinematics	2			6
Nat.Sci. 8*†	General Biology	3		2	4
	Electives				

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5		
Phys. 9	General Physics: Sound and Light	5	1	4	2
M.E. 12, 13, or 16	Materials and Processing II, III, or VI (Two courses to be taken this quarter, 4 credits.)	2		2	3
Nat.Sci. 9*†	General Biology	4		2	4

* See page 92 for alternate sequences which may be substituted as a unit.

† It is recommended that students in industrial engineering substitute Psy. 1-2-3 (3 cred. per quarter) for Nat.Sci. 7-8-9.

THIRD YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.E. 14 or 17	Materials and Processing IV or VII	2	.....	2	3
M.E. 22	Mechanisms	3	2	.....	3
M.E. 70	Mechanical Technology	1	.....	2	.....
M.E. 131	Thermodynamics	3	3	.....	2
Econ. 8	General Economics	3	3	.....	.....
	Elective				

Second Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	1	.....	.....	2
M.E. 14, 15, or 17	Materials and Processing IV, V, or VII	2	.....	2	3
M.E. 33	Mechanical Laboratory I	2	.....	1	3
M.E. 132	Thermodynamics	3	3	.....	.....
Econ. 9	General Economics	3	3	.....	.....
	Elective				

Third Quarter

M.&M. 130	Fluid Mechanics	5	5	.....	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
M.E. 15 or 17	Materials and Processing V or VII	2	.....	2	3
M.E. 27	Machine Design	3	.....	2	3
M.E. 34	Mechanical Laboratory II	2	.....	1	3
Econ. 161	Labor Problems and Trade Unionism	3	3	.....	.....
	Elective				

FOURTH YEAR

First Quarter

I.E. 150	Elements of Industrial Engineering and Management	3	3	.....	.....
M.&M. 132	Industrial Statistics	3	3	.....	.....
M.E. 141	Heat Power Engineering (1 of 4 courses)	3	3	.....	.....
M.E. 150	Internal Combustion Engines (1 of 4 courses)	4	3	.....	3
M.E. 160	Heating and Ventilation (3 or 4 credits)	3	3	.....	.....
M.E. 180	Refrigeration (3 or 4 credits)	3	3	.....	.....
Econ. 22	Principles of Accounting	4	3	1	.....
Hum. 21*	American Life I	3	.....	3	.....
	Electives				

Second Quarter

I.E. 153	Methods Analysis and Development	3	2	.....	3
M.&M. 133	Industrial Statistics	3	3	.....	.....
M.E. 141	Heat Power Engineering (1 of 4 courses)	3	3	.....	.....
M.E. 150	Internal Combustion Engines (1 of 4 courses)	4	3	.....	3
M.E. 160	Heating and Ventilation (3 or 4 credits)	3	3	.....	.....
M.E. 180	Refrigeration (3 or 4 credits)	3	3	.....	.....
Econ. 23	Principles of Accounting	4	3	1	.....
Hum. 22*	American Life II	3	.....	3	.....
	Electives				

* See page 92 for alternate sequences which may be substituted as a unit.

Third Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
I.E. 154	Work Measurement and Production Standards	3	2	.....	3
I.E. 170	Production Planning and Control (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 171	Quality Control (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 180	Elements of Supervision (1 of 3 courses 3 credits)	3	3	.....	.....
M.E. 141	Heat Power Engineering (2 or 4 courses 6 or 7 credits)	3	3	.....	.....
M.E. 150	Internal Combustion Engines (2 or 4 courses 6 or 7 credits)	4	3	.....	3
M.E. 160	Heating and Ventilation (2 or 4 courses 6 or 7 credits)	3	3	.....	.....
M.E. 180	Refrigeration (2 or 4 courses 6 or 7 credits)	3	3	.....	.....
B.A. 130	Cost Accounting Survey	3	3	.....	.....
Hum. 23*	American Life III	3	.....	3	.....

FIFTH YEAR

First Quarter

I.E. 165	Industrial Plants	3	2	.....	3
I.E. 170	Production Planning and Control (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 171	Quality Control (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 180	Elements of Supervision (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 190	Industrial Engineering Seminar	1	1	.....	.....
E.E. 36	Electrical Engineering Survey	3	2	.....	2
B.A. 133	Standard Costs	3	3	.....	.....
B.A. 167**	Introduction to Industrial Relations	3	3	.....	.....
Engl. 85	Advanced Technical Communication	3	3	.....	.....

Second Quarter

I.E. 173	Engineering Economic Analysis and Cost Control	3	3	.....	.....
I.E. 170	Production Planning and Control (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 171	Quality Control (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 180	Elements of Supervision (1 of 3 courses 3 credits)	3	3	.....	.....
I.E. 191	Industrial Engineering Seminar	1	1	.....	.....
E.E. 37	Electrical Engineering Survey	3	2	.....	2
Engl. 86	Advanced Technical Communication	3	3	.....	.....
	Electives				

Third Quarter

I.E. 194	Applied Production Engineering and Management	3	2	.....	3
I.E. 192	Industrial Engineering Seminar	1	1	.....	.....
I.E. 193	Inspection Trip	1	.....	.....	.....
E.E. 38	Electrical Engineering Survey	3	2	.....	2
G.E. 103	Professional Problems	1	.....	1	.....
	Electives				

The following electives which may be applied toward the requirement of 37 credits in the social-humanistic area as described on page 92 are particularly recommended to students in industrial engineering: Economics 164, Political Science 1-2-3 or 5, 25, Psychology 130, 160.

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* See page 92 for alternate sequences which may be substituted as a unit.

** Econ. 164 together with Psy. 130 or Psy. 160 may be substituted for B.A. 167. These three courses are accepted as electives toward the requirement of 37 credits in the social-humanistic area as outlined on page 92.

Mechanical Engineering

A five-year curriculum is offered which leads to the degree of bachelor of mechanical engineering, B.M.E.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of at least 253 credits for graduation.

The mechanical engineering 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, ventilating, and air conditioning; refrigeration; mechanical research and development; sales engineering; the general field of management; wood utilization; and flour milling engineering. A student may specialize in any of these divisions by taking senior design courses, senior laboratory courses, and electives in the desired division.

Students with an honor point ratio of 1.50 or better may petition for admission to the combined course with Business Administration which is described on page 49. In this curriculum, business courses may be substituted for Natural Science 7-8-9, Social Science 1-2-3, Humanities 1-2-3, English 85-86 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
M.E. 11	Materials and Processing I	2	.....	2	.....
M.E. 20	Elementary Machine Design	2	.....	.....	6
Nat.Sci. 7*	General Biology	3	.....	2	4
	Electives				

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
M.E. 12, 13, or 16	Materials and Processing II, III, or VI	2	.....	2	3
M.E. 21	Kinematics	2	.....	.....	6
Nat.Sci. 8*	General Biology	3	.....	2	4
	Electives				

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
M.E. 12, 13, or 16	Materials and Processing II, III, or VI	2	.....	2	3
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Nat.Sci. 9*	General Biology	4	.....	2	4

* See page 92 for alternate sequences which may be substituted as a unit.

THIRD YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.E. 12, 13, or 16	Materials and Processing II, III, or VI	2	.....	2	3
M.E. 22	Mechanism	3	2	.....	3
M.E. 70	Mechanical Technology	1	.....	2	.....
M.E. 131	Thermodynamics	3	3	.....	2
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	1	.....	.....	2
M.E. 14 or 17	Materials and Processing IV or VII	2	.....	2	3
M.E. 33	Mechanical Laboratory I	2	.....	.....	6
M.E. 132	Thermodynamics	3	3	.....	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....
	Electives				

Third Quarter

M.&M. 130	Fluid Mechanics	5	5	.....	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
M.E. 23	Dynamics of Machine Design	3	.....	2	3
M.E. 34	Mechanical Laboratory II	2	.....	.....	6
M.E. 14, 15, or 17	Materials and Processing IV, V, or VII	2	.....	2	3
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

FOURTH YEAR

First Quarter

Met. 156††	Metallography for Mechanical, Mining, and Petroleum Engineers	3	.....	2	2
M.E. 15 or 17	Materials and Processing V or VII	2	.....	2	3
M.E. 24	Elements of Machine Design	3	2	.....	3
M.E. 35	Mechanical Laboratory III	2	.....	.....	6
M.E. 141§	Heat Power Engineering	3	3	.....	.....
M.E. 150§	Internal Combustion Engines	4	3	.....	3
M.E. 160§	Heating and Ventilation	3	3	.....	.....
I.E. 150§	Elements of Industrial Engineering and Management	3	3	.....	.....
M.E. 180§	Refrigeration	3	3	.....	.....
Hum. 1*	Humanities in the Modern World I	5	.....	5	.....

(M.E. 141§ through M.E. 180§: 1 or 2 of five courses; 3 to 7 credits)

Second Quarter

M.E. 121	General Engineering Design	2	.....	.....	6
M.E. 141§	Heat Power Engineering	3	3	.....	.....
M.E. 150§	Internal Combustion Engines	4	3	.....	3
M.E. 160§	Heating and Ventilation	3	3	.....	.....
I.E. 150§	Elements of Industrial Engineering and Management	3	3	.....	.....
M.E. 180§	Refrigeration	3	3	.....	.....
Hum. 2*	Humanities in the Modern World II	5	.....	5	.....
	Elective				

(M.E. 141§ through M.E. 180§: 1 or 2 of five courses; 3 to 7 credits)

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* See page 92 for alternate sequences which may be substituted as a unit.

§ The entire five courses must be completed during the year.

†† Ch.E. 31 may be substituted for Met. 156.

Third Quarter

COURSE NO.	TITLE		CREDITS	REC.	LECT.	LAB.
M.E.¶	Engineering Design		0 to 2			
M.E. 141§	Heat Power Engineering	1 or 2 of five courses 3 to 7 credits	3	3	.....	.....
M.E. 150§	Internal Combustion Engines		4	3	.....	3
M.E. 160§	Heating and Ventilation		3	3	.....	.....
I.E. 150§	Elements of Industrial Engineering and Management		3	3	.....	.....
M.E. 180§	Refrigeration		3	3	.....	.....
Hum. 3*	Humanities in the Modern World III		5	.....	5	.....
	Elective					

FIFTH YEAR

First Quarter

E.E. 36**	Electrical Engineering Survey	3	2	.....	2
M.E. 190	Seminar	1	1	.....	.....
M.E.†	Mechanical Engineering Senior Laboratory	2	.....	.....	4 or 6
Engl. 85	Advanced Technical Communication	3	3	.....	.....
M.E.¶	Engineering Design	0 or 2			
	Elective				

Second Quarter

E.E. 37**	Electrical Engineering Survey	3	2	.....	2
M.E. 191	Seminar	1	1	.....	.....
M.E. †	Mechanical Engineering Senior Laboratory	2	.....	.....	4 or 6
Engl. 86	Advanced Technical Communication	3	3	.....	.....
M.E.¶	Engineering Design	0 or 2			
	Elective				

Third Quarter

E.E. 38**	Electrical Engineering Survey	3	2	.....	2
G.E. 103	Professional Problems	1	.....	1	.....
M.E. 192	Seminar	1	1	.....	.....
M.E. †	Mechanical Engineering Senior Laboratory	2	.....	.....	4 or 6
M.E.¶	Engineering Design	0 or 2			
M.E. 195	Inspection Trip	1			
	Elective				

Cooperative Work-Study Curriculum in Mechanical Engineering

A cooperative work-study curriculum is offered in cooperation with industry leading to the degree of bachelor of mechanical engineering. The awarding of the degree will require the satisfactory completion of all of the university work as outlined below plus 18 months of supervised industrial experience.

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* See page 92 for alternate sequences which may be substituted as a unit.

† Three of the seven laboratory courses M.E. 125, 149, 159, 169, 189, 198, and I.E. 155 must be taken in the three quarters and not more than two in any one quarter.

§ The entire five courses must be completed during the year.

¶ A minimum of 4 credits of engineering design must be completed in addition to M.E. 121. The following courses are accepted for this requirement: M.E. 122, 123, 147, 148, 154, 155, 161, 162, 170, 182, C.E. 37, and I.E. 166.

** E.E. 36, 37, and 38 may be taken in the fourth year if it is desired to take additional electrical engineering work in the fifth year.

This curriculum is designed to provide both theoretical and practical training in engineering work over a period of five years and is the equivalent of the regular five-year mechanical curriculum.

Applications will be accepted from freshmen in the spring quarter of the freshman year. Candidates will be selected on the basis of scholastic ability, personal qualifications and fitness for work.

For freshman year, see page 15.

SECTION I

SECOND YEAR

Fall Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
M.E. 11	Materials and Processing I	2	.....	2	.....
M.E. 12	Materials and Processing II	2	.....	2	3
M.E. 20	Elementary Machine Design	2	.....	.....	6
Psy. 1*	General Psychology	3	.....	3	.....

Winter Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
M.E. 13	Materials and Processing III	2	.....	2	3
M.E. 21	Kinematics	2	.....	.....	6
M.E. 33	Mechanical Laboratory I	2	.....	.....	6
Psy. 2*	General Psychology	3	.....	3	.....

Spring Quarter

Industrial Assignment I

Summer Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
M.E. 14	Materials and Processing IV	2	.....	2	3
M.E. 16	Materials and Processing VI	2	.....	2	3
M.E. 22	Mechanisms	3	2	.....	3
M.E. 34	Mechanical Laboratory II	2	.....	.....	6

THIRD YEAR

Fall Quarter

Industrial Assignment II

Winter Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
M.E. 17	Materials and Processing VII	2	.....	2	3
M.E. 23	Dynamics of Machine Design	3	.....	2	3
M.E. 131	Thermodynamics	3	3	.....	2
Econ. 8*	General Economics	3	3	.....	.....

Spring Quarter

Industrial Assignment III

* Alternate sequences in the Social-Humanistic Area may be selected as a unit.

Summer Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	1	.....	.....	2
M.E. 132	Thermodynamics	3	3	.....	.....
I.E. 150	Elements of Industrial Engineering and Management	3	3	.....	.....
Econ. 9*	General Economics	3	3	.....	.....
Pol.Sci. 1*	American Government and Politics	3	.....	3	.....

FOURTH YEAR

Fall Quarter

Industrial Assignment IV

Winter Quarter

M.&M. 130	Fluid Mechanics	5	5	.....	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
M.E. 24	Elements of Machine Design	3	2	.....	3
M.E. 150	Internal Combustion Engines	4	3	.....	3
M.E. 160	Heating and Ventilating	3	3	.....	.....
Pol.Sci. 2*	American Government and Politics	3	.....	3	.....

Spring Quarter

Industrial Assignment V

Summer Quarter

E.E. 36	Electrical Engineering Survey	3	2	.....	2
M.E. 121	General Engineering Design	2	.....	.....	6
M.E. 141	Heat Power Engineering	3	3	.....	.....
M.E. 190	Seminar	1	1	.....	.....
Hum. 21*	American Life I	3	.....	3	.....
	Elective	6			

FIFTH YEAR

Fall Quarter

Industrial Assignment VI

Winter Quarter

E.E. 37	Electrical Engineering Survey	3	2	.....	2
Engl. 85	Advanced Technical Communication	3	3	.....	.....
M.E. 180	Refrigeration	3	3	.....	.....
M.E. 191	Seminar	1	1	.....	.....
M.E.†	Engineering Design	2	.....	.....	.....
Hum. 22*	American Life II	3	.....	3	.....
	Elective	3			

Spring Quarter

E.E. 38	Electrical Engineering Survey	3	2	.....	2
Engl. 86	Advanced Technical Communication	3	3	.....	.....
G.E. 103	Professional Problems	1	.....	1	.....
M.E. 192	Seminar	1	1	.....	.....
M.E.†	Engineering Design	2	.....	.....	.....
Hum. 23*	American Life III	3	.....	3	.....
	Elective	3			

* Alternate sequences in the Social-Humanistic Area may be selected as a unit.

† M.E. Engineering Design. A minimum of 4 credits of engineering design must be completed in addition to M.E. 121. The following courses are accepted for this requirement: M.E. 122-123, 147, 148, 154-155, 161, 162, 170, 182, and I.E. 166.

SECTION II

SECOND YEAR

Fall Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
M.E. 11	Materials and Processing I	2	.....	2	.....
M.E. 12	Materials and Processing II	2	.....	2	3
M.E. 20	Elementary Machine Design	2	.....	.....	6
Psy. 1*	General Psychology	3	.....	3	.....

Winter Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
M.E. 13	Materials and Processing III	2	.....	2	3
M.E. 21	Kinematics	2	.....	.....	6
M.E. 33	Mechanical Laboratory I	2	.....	.....	6
Psy. 2*	General Psychology	3	.....	3	.....

Spring Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
M.E. 14	Materials and Processing IV	2	.....	2	3
M.E. 16	Materials and Processing VI	2	.....	2	3
M.E. 22	Mechanisms	3	2	.....	3
M.E. 34	Mechanical Laboratory II	2	.....	.....	6

Summer Quarter

Industrial Assignment I

THIRD YEAR

Fall Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
M.E. 17	Materials and Processing VII	2	.....	2	3
M.E. 23	Dynamics of Machine Design	3	.....	2	3
M.E. 131	Thermodynamics	3	3	.....	2
Econ. 8*	General Economics	3	3	.....	.....

Winter Quarter

Industrial Assignment II

Spring Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	1	.....	.....	2
M.E. 132	Thermodynamics	3	3	.....	.....
I.E. 150	Elements of Industrial Engineering and Management	3	3	.....	.....
Econ. 9*	General Economics	3	3	.....	.....
Pol.Sci. 1*	American Government and Politics	3	.....	3	.....

Summer Quarter

Industrial Assignment III

* Alternate sequences in the Social-Humanistic Area may be selected as a unit.

FOURTH YEAR

Fall Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 130	Fluid Mechanics	5	5	.....	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
M.E. 24	Elements of Machine Design	3	2	.....	3
M.E. 150	Internal Combustion Engines	4	3	.....	3
M.E. 160	Heating and Ventilating	3	3	.....	.....
Pol.Sci. 2*	American Government and Politics	3	.....	3	.....

Winter Quarter

Industrial Assignment IV

Spring Quarter

E.E. 36	Electrical Engineering Survey	3	2	.....	2
M.E. 121	General Engineering Design	2	.....	.....	6
M.E. 141	Heat Power Engineering	3	3	.....	.....
M.E. 190	Seminar	1	1	.....	.....
Hum. 21*	American Life I	3	.....	3	.....
	Elective	6			

Summer Quarter

Industrial Assignment V

FIFTH YEAR

Fall Quarter

E.E. 37	Electrical Engineering Survey	3	2	.....	2
Engl. 85	Advanced Technical Communication	3	3	.....	.....
M.E. 180	Refrigeration	3	3	.....	.....
M.E. 191	Seminar	1	1	.....	.....
M.E.†	Engineering Design	2	.....	.....	.....
Hum. 22*	American Life II	3	.....	3	.....
	Elective	3			

Winter Quarter

Industrial Assignment VI

Spring Quarter

E.E. 38	Electrical Engineering Survey	3	2	.....	2
Engl. 86	Advanced Technical Communication	3	3	.....	.....
G.E. 103	Professional Problems	1	.....	1	.....
M.E. 192	Seminar	1	1	.....	.....
M.E.†	Engineering Design	2	.....	.....	.....
Hum. 23*	American Life III	3	.....	3	.....
	Elective	3			

Milling Engineering Specialization in Mechanical Engineering

A milling engineering specialization in mechanical engineering has been established with the sponsorship and financial assistance of the Millers' National Federation, national organization of wheat flour milling companies. The purpose of this specialization is to provide graduates well grounded in basic mechanical engineering with specialized training in milling engineering subjects and related branches of

* Alternate sequences in the Social-Humanistic Area may be selected as a unit.

† M.E. Engineering Design. A minimum of 4 credits of engineering design must be completed in addition to M.E. 121. The following courses are accepted for this requirement: M.E. 122, 123, 147, 148, 154, 155, 161, 162, 170, 182, and I.E. 166.

the agricultural sciences. It leads to the degree of bachelor of mechanical engineering, B.M.E.

Application for admission to this specialization should be made by petition to the Students' Work Committee in the College of Engineering.

For freshman year, see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
M.E. 11	Materials and Processing I	2	.....	2	.....
M.E. 20	Elementary Machine Design	2	.....	.....	6
Nat.Sci. 7	General Biology	3	.....	2	4

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
M.E. 12	Materials and Processing II	2	.....	2	3
M.E. 21	Kinematics	2	.....	.....	6
Nat.Sci. 8	General Biology	3	.....	2	4

Third Quarter

M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
M.E. 13	Materials and Processing III	2	.....	2	3
M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Nat.Sci. 9	General Biology	4	.....	2	4

THIRD YEAR

First Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.E. 16	Materials and Processing VI	2	.....	2	3
M.E. 22	Mechanism	3	2	.....	3
M.E. 70	Mechanical Technology	1	.....	2	.....
M.E. 131	Thermodynamics	3	3	.....	2
Econ. 8	General Economics	3	3	.....	.....

Second Quarter

M.&M. 128	Strength of Materials	5	5	.....	.....
M.&M. 141	Materials Laboratory	1	.....	.....	2
M.E. 14	Materials and Processing IV	2	.....	2	3
M.E. 33	Mechanical Laboratory I	2	.....	.....	6
M.E. 132	Thermodynamics	3	3	.....	.....
Econ. 9	General Economics	3	3	.....	.....

Third Quarter

M.&M. 130	Fluid Mechanics	5	5	.....	.....
M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
M.E. 23	Dynamics of Machine Design	3	.....	2	3
M.E. 34	Mechanical Laboratory II	2	.....	.....	6
M.E. 15	Materials and Processing	2	.....	2	3
Econ. 161	Labor Problems and Trade Unionism	3	3	.....	.....

FOURTH YEAR

First Quarter

M.E. 17	Materials and Processing VII	2	.....	2	3
M.E. 24	Elements of Machine Design	3	2	.....	3
M.E. 35	Mechanical Laboratory III	2	.....	.....	6
M.E. 150	Internal Combustion Engines	4	4	.....	.....
Agron. 52	Production and Grading of Cereal Crops	4	.....	.....	.....
Hum. 21	American Life I	3	.....	3	.....

Second Quarter

M.E. 100	Milling I	3	.....	3	.....
M.E. 103	Milling Laboratory I	2	.....	.....	6
M.E. 121	General Engineering Design	2	.....	.....	6
M.E. 141	Heat Power Engineering	3	3	.....	.....
M.E. 160	Heating and Ventilating	3	2	1	.....
Pl.Path. 9	Seed Technology and Testing	3	.....	.....	.....
Hum. 22	American Life II	3	.....	3	.....

Third Quarter

Ent. 57	Mill Pests and Their Control	5	.....	.....	.....
M.E. 101	Milling II	3	.....	3	.....
M.E. 105	Milling Design I	2	.....	.....	6
I.E. 150	Elements of Industrial Engineering and Management	3	3	.....	.....
M.E. 180	Refrigeration	3	3	.....	.....
Hum. 23	American Life III	3	3	3	.....

FIFTH YEAR

First Quarter

M.E. 102	Milling III	3	.....	3	.....
M.E. 104	Milling Laboratory II	2	.....	.....	6
M.E. 190	Seminar	1	1	.....	.....
E.E. 36	Electrical Engineering Survey	3	2	.....	2
Engl. 85	Advanced Technical Communication	3	3	.....	.....
Agr.Biochem. 52	Biochemistry and Microbiology of Cereal Grains	3	.....	.....	.....
	Electives				

Second Quarter

E.E. 37	Electrical Engineering Survey	3	2	.....	2
M.E. 106	Milling Design II	2	.....	.....	6
M.E. 191	Seminar	1	1	.....	.....
Engl. 86	Advanced Technical Communication	3	3	.....	.....
G.E. 103	Professional Problems	1	.....	.....	.....
	Electives				

Third Quarter

E.E. 38	Electrical Engineering Survey	3	2	.....	2
M.E. 107	Packaging and Handling of Materials	3	.....	3	.....
M.E. 192	Seminar	1	1	.....	.....
M.E.†	Mechanical Engineering Senior Laboratory	2	.....	.....	4 or 6
M.E. 195	Inspection Trip	1	.....	1	.....
Econ. 164	Labor Legislation and Social Insurance	3	.....	3	.....
	Electives				

† One of the six laboratory courses M.E. 149, 159, 169, 189, 198, or I.E. 155 must be taken.

Metallurgical Engineering

A five-year curriculum is offered which leads to the degree of bachelor of metallurgical engineering, B.Met.E.

In addition to the prescribed courses and exclusive of the summer field trips, a total of 255 credits is required for graduation.

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.

Lectures cover the construction and operation of mineral dressing and concentrating machinery, together with typical combinations of mineral 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.

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.

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.

Students taking the combined course with business administration may substitute business courses for Natural Science 7-8-9, Social Science 1-2-3, Humanities 21-22-23 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 23	Mineralogy	5	1	3	4
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Nat.Sci. 7*	General Biology	3	.....	2	4
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2

* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 24	Mineralogy	5	1	3	4
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Nat.Sci. 8*	General Biology	3	.....	2	4
Phys. 8	General Physics: Electricity	5	1	4	2

Third Quarter

Geol. 11	General Geology (Physical and Historical)	5	.....	5	.....
Met. 1	Assaying	3	.....	3	4
Nat.Sci. 9*	General Biology	4	.....	2	4
Phys. 9	General Physics: Sound and Light	5	1	4	2
	Elective in the Institute of Technology	2			

THIRD YEAR

First Quarter

Geol. 106	Petrography	3	1	1	4
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
M.E. 12	Materials and Processing II	2	.....	2	3
Met. 11	Metallurgy of Pig Iron	3	.....	3	.....
Met. 106	Nonferrous Metallurgy	3	.....	3	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

Anal.Chem. 9	Quantitative Analysis	3	1	1	6
M.&M. 128	Strength of Materials	5	5	.....	.....
M.E. 13	Materials and Processing III	2	.....	2	3
Met. 107	Nonferrous Metallurgy	3	.....	3	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....

Third Quarter

E.E. 41	Electrical Engineering Survey	3	.....	2	3
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
M.E. 6	Machine Shop Practice	2	.....	2	3
Met. 12	Metallurgy of Steel	3	.....	3	.....
Met. 108	Nonferrous Metallurgy	3	.....	3	.....
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

FOURTH YEAR

First Quarter

Met. 110	Mineral Dressing	3	.....	2	3
Met. 153	Metallography	4	.....	3	4
Phys.Chem. 101	Physical Chemistry	3	1	3	.....
Hum. 21*	American Life I	3	.....	3	.....
	Electives in S.L.&A.	3			

Second Quarter

Met. 111	Mineral Dressing	3	.....	2	3
Met. 133	Electrometallurgy	3	.....	3	.....
Met. 154	Metallography	4	.....	3	4
Phys.Chem. 102	Physical Chemistry	3	1	3	.....
Hum. 22*	American Life II	3	.....	3	.....

Third Quarter

Met. 112	Mineral Dressing	3	.....	2	3
Met. 155	Metallography	4	.....	3	4
Phys.Chem. 103	Physical Chemistry	3	1	3	.....
Hum. 23*	American Life III	3	.....	3	.....

* See page 92 for alternate sequences which may be substituted as a unit.

Summer Field Trip

Met. 175	Study of metallurgical operations in important iron and steel centers	3

FIFTH YEAR

First Quarter

Engl. 85	Advanced Technical Communication	3	3	.....	.....
Met. 121	Ore Testing	2	.....	1	3
Met. 134	Advanced Metallurgy	4	.....	3	4
Met. 163	Advanced Metallography	3	.....	3	.....
	Electives in the Institute of Technology	3			
	Electives in S.L.&A.	3			

Second Quarter

Engl. 86	Advanced Technical Communication	3	3	.....	.....
Met. 122	Advanced Mineral Dressing	3	1	2	.....
Met. 135	Advanced Metallurgy	4	.....	3	4
Met. 164	Advanced Metallography	3	.....	3	.....
	Electives in the Institute of Technology	3			

Third Quarter

Met. 123	Advanced Mineral Dressing	3	1	2	.....
Met. 136	Advanced Metallurgy	4	.....	3	4
Met. 165	Advanced Metallography	3	.....	3	.....
G.E. 103	Professional Problems	1	.....	1	.....
	Electives in the Institute of Technology	3			
	Electives in S.L.&A.	2			

Mining Engineering

A five-year curriculum is offered which leads to the degree of bachelor of mining engineering, B.Min.E.

In addition to the prescribed courses and exclusive of summer field trips, a total of 255 credits is required for graduation.

The curriculum 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 mineral dressing and be able to determine whether separation of the minerals in the ore may be made at a profit. The basic training must, therefore, include thorough 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, mineral dressing, and ore testing.

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.

Geophysics courses are recommended to supplement this curriculum. Geophysics aids in geological interpretations, provides knowledge of the earth's crust, and is used in the discovery of mineral deposits and petroleum. Geophysics courses may be substituted for electives to be chosen from courses offered by the College of Science, Literature, and the Arts or, with approval, for prescribed credits.

Students taking the combined curriculum with business administration may substitute business courses for Natural Science 7-8-9, Social Science 1-2-3, Humanities 21-22-23 and electives.

For freshman year see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 23	Mineralogy	5	1	3	4
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Nat.Sci. 7*	General Biology	3	.....	2	4
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2

* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 24	Mineralogy	5	1	3	4
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Nat.Sci. 8*	General Biology	3	.....	2	4
Phys. 8	General Physics: Electricity	5	1	4	2

Third Quarter

Geol. 11	General Geology (Physical and Historical)	5	.....	5	.....
Geol. 25	Rock Study	2	1	1	2
Met. 1	Assaying	3	.....	3	4
Nat.Sci. 9*	General Biology	4	.....	2	4
Phys. 9	General Physics: Sound and Light	5	1	4	2

THIRD YEAR

First Quarter

Geol. 125	Structural Geology	3	.....	3	.....
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Met. 11	Metallurgy of Pig Iron	3	.....	3	.....
Min. 11	Surveying	3	1	3	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

Anal.Chem. 9	Quantitative Analysis	3	1	1	6
M.&M. 128	Strength of Materials	5	5	.....	.....
Min. 12	Surveying	3	1	3	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....
	Electives in S.L.&A.	3			

Third Quarter

M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Min. 13	Surveying	2	1	2	.....
Min. 14	Surveying Field Work	5	.....	.....	20
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

Summer Field Trips

Min. 15	Field work in surveying on the iron ranges of Minnesota	6
Geol. 100	Field work in geology on the iron ranges of Minnesota	3

FOURTH YEAR

First Quarter

M.E. 131	Thermodynamics	3	.....	3	.....
Met. 106	Nonferrous Metallurgy	3	.....	3	.....
Met. 110	Mineral Dressing	3	.....	2	3
Min. 111	Elements of Mining	3	.....	4	.....
Hum. 21*	American Life I	3	.....	3	.....

Second Quarter

Met. 107	Nonferrous Metallurgy	3	.....	3	.....
Met. 111	Mineral Dressing	3	.....	2	3
Min. 106	Mine Mapping	2	.....	.....	8
Min. 112	Elements of Mining	3	.....	4	.....
Min. 121	Mine Plant	2	.....	.....	6
Hum. 22*	American Life II	3	.....	3	.....

* See page 92 for alternate sequences which may be substituted as a unit.

Third Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
E.E. 41	Electrical Engineering Survey	3	.....	2	3
M.&M. 129	Fluid Mechanics	4	4	.....	.....
Met. 112	Mineral Dressing	3	.....	2	3
Min. 113	Elements of Mining	3	.....	4	.....
Min. 122	Mine Plant	2	.....	.....	6
Hum. 23*	American Life III	3	.....	3	.....

Summer Field Trip

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

FIFTH YEAR

First Quarter

Engl. 85	Advanced Technical Communication	3	3	.....	.....
Geol. 110	Economic Geology	3	.....	3	.....
Met. 121	Ore Testing	2	.....	1	3
Met. 156	Metallography	3	.....	2	3
Min. 123	Mine Plant	2	.....	.....	6
Min. 126	Engineering Construction	3	.....	.....	8
Min. 141	Examination and Valuation	3	.....	4	.....

Second Quarter

Engl. 86	Advanced Technical Communication	3	3	.....	.....
Geol. 111	Economic Geology	3	.....	3	.....
M.E. 138	General Laboratory	2	.....	.....	4
Min. 127	Engineering Construction	3	.....	.....	8
Min. 142	Open Pits, Quarries, Placers, and Mining Law	3	.....	4	.....
Min. 144	Advanced Mining	2	.....	.....	6

Third Quarter

Min. 143	Industrial Minerals and Coal	3	.....	4	.....
Min. 145	Advanced Mining	4	.....	.....	10
G.E. 103	Professional Problems	1	.....	1	.....
Geophys. 110	Introduction to Exploration Geophysics	3	.....	3	.....
	Electives in the Institute of Technology	2			
	Electives in S.L.&A.	3			

* See page 92 for alternate sequences which may be substituted as a unit.

Petroleum Engineering

A five-year curriculum is offered which leads to the degree of bachelor of petroleum engineering, B.Pet.E.

In addition to the prescribed courses and exclusive of summer field trips, a total of 255 credits is required for graduation.

The curriculum 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 principles of pumping, with both gas lift and mechanical pumps, and the methods of gasoline recovery to be used in connection with these methods.

The basic training must, therefore, include thorough courses in mathematics, drafting, chemistry, physics, and geology, including in particular, a thorough knowledge of sedimentary deposits. It must also include surveying and mapping.

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.

Geophysics courses are recommended to supplement this curriculum. Geophysics aids in geological interpretations, provides knowledge of the earth's crust, and is used in the discovery of mineral deposits and petroleum. Geophysics courses may be substituted for electives to be chosen from courses offered by the College of Science, Literature, and the Arts or, with approval, for prescribed credits.

Students taking the combined curriculum with business administration may substitute business courses for Natural Science 7-8-9, Social Science 1-2-3, Humanities 21-22-23 and electives.

For freshman year, see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 23	Mineralogy	5	1	3	4
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Nat. Sci. 7*	General Biology	3	. .	2	4
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2

* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 24	Mineralogy	5	1	3	4
M.&M. 25	Calculus II: Integral	5	5	.....	.....
Nat.Sci. 8*	General Biology	3	.....	2	4
Phys. 8	General Physics: Electricity	5	1	4	2

Third Quarter

Geol. 11	General Geology (Physical and Historical)	5	.....	5	.....
Geol. 25	Rock Study	2	1	1	2
Met. 1§	Assaying	3	.....	3	4
Nat.Sci. 9*	General Biology	4	.....	2	4
Phys. 9	General Physics: Sound and Light	5	1	4	2

THIRD YEAR

First Quarter

Geol. 106	Petrography	3	1	1	4
Geol. 107	Invertebrate Paleontology	3	.....	1	4
Geol. 125	Structural Geology	3	.....	3	.....
Min. 11	Surveying	3	1	3	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

Anal.Chem. 9	Quantitative Analysis	3	1	1	6
Geol. 144	Geologic Maps	3	.....	.....	6
Geol. 151	Stratigraphy	3	.....	3	.....
Min. 12	Surveying	3	1	3	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....

Third Quarter

Geol. 112	Petroleum Geology	3	.....	3	.....
Min. 13	Surveying	2	1	2	.....
Min. 14	Surveying Field Work	5	.....	.....	20
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....
	Electives in S.L.&A.	3			

Summer Field Trips

Min. 15†	Field work in surveying on the iron ranges of Minnesota	6
Geol. 100†	Field work in geology on the iron ranges of Minnesota	3
Geol. 115†	Field work in geology in southeastern Minnesota	3
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

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* See page 92 for alternate sequences which may be substituted as a unit.

† One of the following must be taken: Min. 15, Geol. 100, Min. 107; Min. 15, Geol. 115, Min. 107; or Geol. 150. One credit in Min. 107 may be used to satisfy Institute of Technology elective requirements.

§ Permissible substitute allowed for petroleum engineers.

FOURTH YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Geol. 101	Sedimentation	3	.....	3	.....
M.&M. 26	Technical Mechanics: Statics	5	5	.....	.....
Pet. 111	Oil Field Development	3	.....	4	.....
Hum. 21*	American Life I	3	.....	3	.....
	Electives in S.L.&A.	3			

Second Quarter

Geol. 131	Petrology	4	1	2	4
M.&M. 128	Strength of Materials	5	5	.....	.....
Pet. 112	Oil Field Production	3	.....	4	.....
Hum. 22*	American Life II	3	.....	3	.....

Third Quarter

E.E. 41	Electrical Engineering Survey	3	.....	2	3
M.&M. 127	Technical Mechanics: Dynamics	5	5	.....	.....
Pet. 131	Petroleum Refining	2	.....	2	.....
Pet. 138	Oil Field Mapping	2	.....	.....	6
Hum. 23*	American Life III	3	.....	3	.....

Summer Field Trip

Pet. 135	Study of oil well drilling and production methods and refining practice in one or more oil fields	3			

FIFTH YEAR

First Quarter

Engl. 85	Advanced Technical Communication	3	3	.....	.....
Geol. 153	Subsurface Stratigraphy	3	.....	1	4
Met. 156	Metallography	3	.....	2	2
Min. 126	Engineering Construction	3	.....	.....	8
Min. 141	Examination and Valuation	3	.....	4	.....
Pet. 152	Petroleum Production Technology	3	.....	1	6

Second Quarter

Engl. 86	Advanced Technical Communication	3	3	.....	.....
M.&M. 129	Fluid Mechanics	4	4	.....	.....
M.E. 131	Thermodynamics	3	.....	3	.....
Pet. 144	Advanced Petroleum Engineering	2	.....	.....	6
Pet. 153	Petroleum Production Technology	3	.....	1	6
	Electives in the Institute of Technology	4			

Third Quarter

M.&M. 143	Hydraulics Laboratory	1	.....	.....	2
Min. 122	Mine Plant	2	.....	.....	6
Pet. 134	Petroleum Plant	2	.....	2	.....
Pet. 145	Advanced Petroleum Engineering	4	.....	.....	10
Pet. 154	Petroleum Production Technology	3	.....	1	6
G.E. 103	Professional Problems	1	.....	1	.....
Geophys. 110	Introduction to Exploration Physics	3	.....	3	.....
	Electives in the Institute of Technology	3			

* See page 92 for alternate sequences which may be substituted as a unit.

Physics

A five-year curriculum is offered which leads to the degree, bachelor of physics, B.Phys.

In addition to the prescribed courses, sufficient approved electives must be taken to complete a total of 255 credits for graduation.

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 below may be modified on petition.

A student entering this course may take the freshman program outlined for the first year in the Institute of Technology. Those who maintain a C average 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 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 this course should consult the chairman of the department.

For freshman year, see page 15.

SECOND YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 24	Calculus I: Differential	5	5	.....	.....
Phys. 7	General Physics: Mechanics and Heat	5	1	4	2
Org.Chem. 61	Elementary Organic Chemistry	4	2	3	4
Nat.Sci. 7*	General Biology	3	.....	2	4

Second Quarter

M.&M. 25	Calculus II: Integral	5	5	.....	.....
Phys. 8	General Physics: Electricity	5	1	4	2
Org.Chem. 62	Elementary Organic Chemistry	4	2	3	4
Nat.Sci. 8*	General Biology	3	.....	2	4

Third Quarter

M.&M. 80	Elementary Differential Equations	3	3	.....	.....
Phys. 9	General Physics: Sound and Light	5	1	4	2
Anal.Chem. 7	Quantitative Analysis	4	1	1	8
E.E. 11	Elements of Electrical Engineering	3	2	1	.....
Nat.Sci. 9*	General Biology	4	.....	2	4

* See page 92 for alternate sequences which may be substituted as a unit.

THIRD YEAR

First Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
M.&M. 150	Calculus III: Intermediate Calculus	3	3	.....	.....
Phys. 101	Theoretical Physics	5	5	.....	.....
Phys. 107	Modern Physics	3	.....	3	.....
Soc.Sci. 1*	Introduction to Social Science	4	.....	4	.....

Second Quarter

M.&M. 152	Calculus IV: Special Topics in Advanced Calculus	3	3	.....	.....
Phys. 103	Theoretical Physics	5	5	.....	.....
Phys. 109	Modern Physics	3	.....	3	.....
Soc.Sci. 2*	Introduction to Social Science	4	.....	4	.....

Third Quarter

M.&M. 153	Calculus V: Special Topics in Advanced Calculus	3	3	.....	.....
Phys. 105	Theoretical Physics	5	5	.....	.....
Phys. 111	Modern Physics	3	.....	3	.....
Phys. 144	Electrical Measurements	3	.....	3	4
Soc.Sci. 3*	Introduction to Social Science	4	.....	4	.....

FOURTH YEAR

First Quarter

Phys.Chem. 101	Physical Chemistry	3	1	3	.....
Phys. 134	Experimental Optics	3	.....	3	3
Hum. 1*	Humanities in the Modern World I	5	.....	5	.....

Second Quarter

Phys.Chem. 102	Physical Chemistry	3	1	3	.....
E.E. 117	Engineering Electronics	3	3	.....	.....
E.E. 118	Engineering Electronics Laboratory	1	.....	.....	2
Phys. 110	Modern Experimental Physics	3	.....	.....	6
Hum. 2*	Humanities in the Modern World II	5	.....	5	.....

Third Quarter

Phys.Chem. 103	Physical Chemistry	3	1	3	.....
E.E. 119	Engineering Electronics	3	3	.....	.....
E.E. 120	Engineering Electronics Laboratory	1	.....	.....	2
Phys. 112	Modern Experimental Physics	3	.....	.....	6
or Phys. 136	Spectrum Analysis	3	.....	3	3
Hum. 3*	Humanities in the Modern World III	5	.....	5	.....

FIFTH YEAR

First Quarter

Engl. 85	Advanced Technical Communication	3	3	.....	.....
Phys. 181	Atomistics and Elementary Quantum Mechanics	3	3	.....	.....
or Phys. 191	Mathematical Physics	3	3	.....	.....
	Electives				

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* See page 92 for alternate sequences which may be substituted as a unit.

Second Quarter

COURSE NO.	TITLE	CREDITS	REC.	LECT.	LAB.
Engl. 86	Advanced Technical Communication	3	3	.....	.....
Phys. 183	Atomistics and Elementary Quantum Mechanics	3	3	.....	.....
or Phys. 192	Mathematical Physics	3	3	.....	.....
	Electives				

Third Quarter

Phys. 185	Atomistics and Elementary Quantum Mechanics	3	3	.....	.....
or Phys. 193	Mathematical Physics	3	3	.....	.....
G.E. 103	Professional Problems	1	.....	1	.....
	Electives				

Acceptable electives may be taken in Astronomy, Chemistry, Economics, Engineering, English, Geology, History, Languages, Mathematics, Philosophy, Political Science, Psychology, or the biological sciences.

Two-Year Technical Aid Curricula

Two-year technical aid curricula are offered leading to certificates of technical aid.

These programs provide post–high school technological training for students who desire to prepare for positions in industry requiring more responsibility and preparation than normally required of skilled craftsmen but less than needed by graduate engineers.

High school graduation including two years of mathematics (elementary algebra and plane geometry or unified mathematics) are prerequisite for admission. Students who have been registered in the Institute of Technology or who have attended any accredited college or university may transfer into this program. Some advanced standing credit may be received for previous college work, but it will normally take two years to finish the balance of the requirements. Because of the sequence nature of the courses, admission may normally be obtained for the fall quarter only.

It may be possible to transfer into a regular engineering curriculum from the technical aid program if a high scholastic average has been maintained. However, because of the lack of similarity between the two programs, normal progress toward an engineering degree cannot be made while registered in technical aid.

Engineering Drafting

This course is planned to give a thorough training in engineering drafting, a grounding in practical mathematics and shop operations. It also includes courses in English so that the student can make out reports, handle correspondence, and be able to read and understand technical literature.

FIRST YEAR

First Quarter

COURSE NO.	TITLE	QUARTER CREDITS	CONTRACT HOURS PER WEEK
T.A. 11	Engineering Drafting	5	15
T.A. 21	Applied Mathematics	6	10
T.A. 16	Alphabets	2	6
T.A. 34	English (Technical Writing)	3	3

Second Quarter

T.A. 12	Engineering Drafting	5	15
T.A. 22	Applied Mathematics	6	10
T.A. 35	English (Technical Writing)	3	3
T.A. 81	Shop (General Shop)	2	6

Third Quarter

COURSE NO.	TITLE	QUARTER CREDITS	CONTRACT HOURS PER WEEK
T.A. 13	Engineering Drafting (Applied Descriptive Geometry)	5	15
T.A. 23	Applied Mathematics	6	10
T.A. 36	English (Composition)	3	3
T.A. 82	Shop (Machine Tool Utilization)	2	6

SECOND YEAR

Fourth Quarter

T.A. 14	Engineering Drafting (Structural Detailing)	5	15
T.A. 24	Applied Mathematics	6	10
T.A. 37	English (Oral Composition)	3	3
T.A. 83	Shop (Metal Processing)	2	6

Fifth Quarter

T.A. 41	Engineering Drafting (Architectural Drawing)	5	15
T.A. 25	Applied Mathematics	6	10
T.A. 84	Shop (Machine Shop)	2	6
T.A. 42	Engineering Materials (Building Materials)	2	2
T.A. 17	Slide Rule	1	1

Sixth Quarter

T.A. 15	Engineering Drafting (Production Illustration)	5	15
T.A. 26	Applied Mathematics	6	10
T.A. 85	Engineering Materials	2	2
T.A. 27	Engineering Problems (Use of Handbooks)	3	3

Total Credits 96

Industrial Technician

This course is planned to give a thorough training in laboratory technique and procedure, the setting up and the reading of measuring devices of all kinds, the development of skills in wood and metal working. It will include training in reading drawings, and a grounding in practical mathematics. It also includes courses in English so that the student can make out reports, handle correspondence, and be able to read and understand technical literature.

FIRST YEAR

First Quarter

COURSE NO.	TITLE	QUARTER CREDITS	CONTRACT HOURS PER WEEK
T.A. 18	Engineering Drawing	2	6
T.A. 21	Applied Mathematics	6	10
T.A. 34	Technical Writing	3	3
T.A. 80A	Shop Practice, Tools and Fittings	2	6
T.A. 80B	Laboratory Practice	3	5

Second Quarter

T.A. 19	Engineering Drawing	3	8
T.A. 22	Applied Mathematics	6	10
T.A. 35	Technical Writing	3	3
T.A. 81A	Shop Practice, Wood Working	2	6
T.A. 81B	Laboratory Practice	2	6

Third Quarter

COURSE NO.	TITLE	QUARTER CREDITS	CONTRACT HOURS PER WEEK
T.A. 23	Applied Mathematics	6	10
T.A. 36	English Composition	3	3
T.A. 82A	Shop Practice, Foundry	3	6
T.A. 82B	Laboratory Practice, Standard Procedures	3	6
T.A. 85	Engineering Materials	2	2

SECOND YEAR

Fourth Quarter

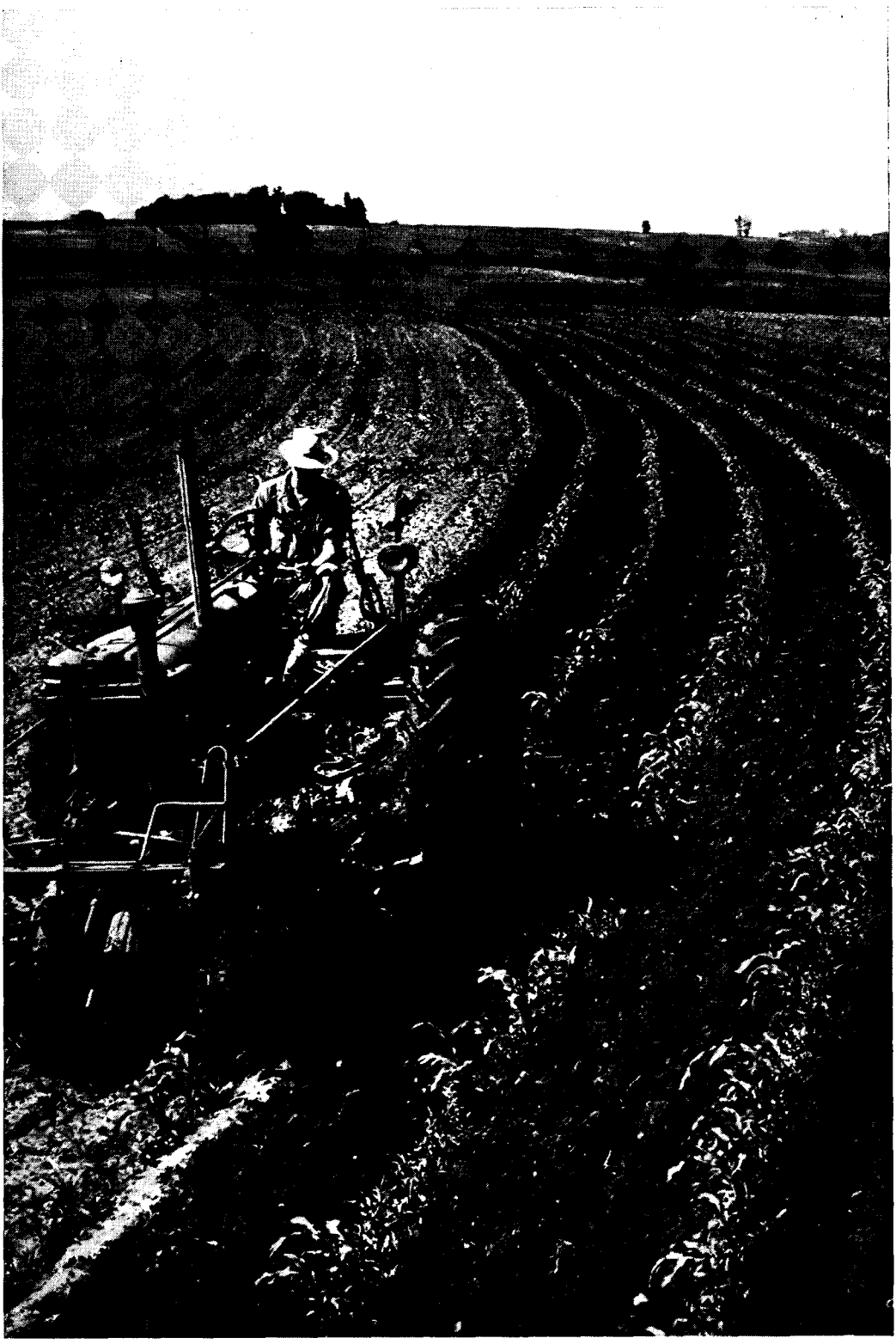
T.A. 24	Applied Mathematics	6	10
T.A. 71	Direct Current Circuits, Machinery and Equipment	3	3
T.A. 72	Direct Current Laboratory	2	4
T.A. 83A	Shop Practice, Forging and Heat Treating	2	6
T.A. 37	Oral Composition	3	3

Fifth Quarter

T.A. 25	Applied Mathematics	6	10
T.A. 73	Alternating Current Circuits Machinery and Equipment	3	3
T.A. 74	Alternating Current Laboratory	2	4
T.A. 84A	Shop Practice, Machine Shop	2	6
T.A. 86	Elements of Production	3	3

Sixth Quarter

T.A. 26	Applied Mathematics	6	10
T.A. 75	Industrial Electronics	3	3
T.A. 76	Industrial Electronic Laboratory	2	4
T.A. 87	Industrial and Supervisory Relations	3	3
T.A. 85A	Shop Practice, Machine Shop	2	6
	Total Credits	96	



Additional Course Information

Requirements in the Social-Humanistic Area

A minimum of 54 credits in life science, social science, and the humanities is specified in the social-humanistic area of the regular curricula. This includes 15 credits in English 4-5-6, 85-86; 2 credits in Personal Health 3; and 37 credits in Natural Science 7-8-9, Social Science 1-2-3, and Humanities 1-2-3, or 21-22-23.

In order to provide for greater flexibility, one of the alternate sequences from Group I may be substituted for Natural Science 7-8-9, one of the alternate sequences from Group II for Social Science 1-2-3, and one of the alternate sequences from Group III for Humanities 1-2-3, or 21-22-23 if the curriculum in which the student is registered so permits.

In the event the total number of credits completed in Groups I, II, and III is less than 37, sufficient electives from the departments listed below must be taken to make a total of 37 credits.

GROUP I—*One of the following sequences may be substituted in the second year for Natural Science 7-8-9:*

1. Botany 1-2-3 (6 or more cred.)
2. Psychology 1-2-3 (6 or more cred.)
3. Zoology 1-2-3 (10 cred.)

GROUP II—*One of the following sequences may be substituted in the third year for Social Science 1-2-3:*

4. Economics 8-9 or 6-7 or 62-63—may be followed by Econ. 161, 164 (6 or more cred.)
5. Political Science 1-2, 25 or A-B-C, 25—may be followed by Political Science 123 or 124-125 or 155 or 161 (6 or more cred.)
6. Sociology 1-2, 14 or 1-2, 104 (6 or more cred.)

GROUP III—*One of the following sequences may be substituted in the fourth year for Humanities 1-2-3 or 21-22-23:*

7. Humanities (6 or more cred.)
8. English 37-38-39 (6 or more cred.)
9. History (6 or more cred.)
10. Philosophy (6 or more cred.)

Electives may be chosen from the following departments:

Anthropology	Fine Arts	Languages	Speech
Astronomy	Geography	Music	Social Science
Botany	Geology	Philosophy	Sociology
Classics	History	Political Science	Zoology
English	Humanities	Psychology	

Students registered in NROTC may substitute 27 credits in naval science for an equivalent number of credits in the social-humanities area. At least 12 credits must be taken in two of the three groups above, 6 credits per sequence in two sequences. The balance of NROTC credits may be used as electives.

Students registered in Air ROTC or ROTC may substitute 15 credits in air or military science for 15 credits in the social-humanities area. At least 24 credits are required from Groups I, II, and III above with at least 6 credits within a single sequence in each group. The balance of ROTC credits may be used as electives.

Substitutions

The courses listed in the right-hand column may be substituted for the corresponding courses in the left-hand column by petition to the Students' Work Committee. The excess credits may be applied as elective credits.

COURSE	SUBSTITUTE COURSE
Aero.E. 115 (3 cred.)	M.&M. 180 (3 cred.)
Anal.Chem. 132 (3 cred.)	Anal.Chem. 105 (3 cred.)
Arch. 104 (3 cred.)	Arch. 106 (3 cred.)
Draw. 7 (3 cred.)	Draw. 1 (3 cred.)
Draw. 8 (3 cred.)	Draw. 2 (3 cred.)
Draw. 21 (2 cred.)	Draw. 26 (2 cred.) or Draw. 28 (2 cred.)
Draw. 26 (2 cred.)	Draw. 28 (2 cred.) or Draw. 21 (2 cred.)
Draw. 28 (2 cred.)	Draw. 26 (2 cred.) or Draw. 21 (2 cred.)
M.&M. 84 (5 cred.)	M.&M. 26 and 127 (10 cred.)
M.&M. 85 (3 cred.)	M.&M. 128 (5 cred.)
M.&M. 86 (3 cred.)	M.&M. 129 (4 cred.)
M.&M. 86 (3 cred.)	M.&M. 130 (5 cred.)
M.&M. 87 (1 cred.)	M.&M. 141 (1 cred.)
M.&M. 91 (4 cred.)	M.&M. 24 and 25 (10 cred.)
M.&M. 92 (4 cred.)	M.&M. 26 (5 cred.)
M.&M. 92 (4 cred.)	M.&M. 84 (5 cred.)
M.&M. 93 (4 cred.)	M.&M. 85 (3 cred.)
M.&M. 93 (4 cred.)	M.&M. 128 (5 cred.)
M.&M. 129 (4 cred.)	M.&M. 130 (5 cred.)

Extension Courses

Credits will be accepted from the General Extension Division toward a degree in the Institute of Technology for the following types of courses:

1. Elective courses approved by the Students' Work Committees and such other courses as have been approved by the department concerned and by the dean.

2. Correspondence Study Courses:

COURSE	TITLE	CREDITS
Civil Engineering 1c	Elementary Structural Steel Design	3
Civil Engineering 2c	Steel Bridge Design	3
Civil Engineering 5c	Steel Building Design	3
Civil Engineering 46c	Plain Concrete	3
Civil Engineering 49c	Advanced Reinforced Concrete Design	3
Drawing 1	Engineering Drawing	3
Drawing 2	Engineering Drawing	3
Drawing 4	Engineering Drawing	1
General Engineering 70	The Slide Rule	1
Mathematics and Mechanics 9	Higher Algebra	0
Mathematics and Mechanics 11	College Algebra	5
Mathematics and Mechanics 12	Trigonometry	5
Mathematics and Mechanics 13	Analytic Geometry	5
Mathematics and Mechanics 24	Differential Calculus	5
Mathematics and Mechanics 25	Integral Calculus	5
Mathematics and Mechanics 26	Technical Mechanics: Statics	5
Mathematics and Mechanics 127	Technical Mechanics: Dynamics	5
Mathematics and Mechanics 128	Strength of Materials	5

3. Evening Courses:

Inorganic Chemistry 6	General Chemistry	5

COURSE	TITLE	CREDITS
Inorganic Chemistry 7	General Chemistry	5
Inorganic Chemistry 12	Semimicro Qualitative Analysis	5
Analytical Chemistry 1	Quantitative Analysis	5
Analytical Chemistry 2	Quantitative Analysis	5
Analytical Chemistry 7	Quantitative Analysis	4
Analytical Chemistry 123	Advanced Analytical Chemistry	3
Civil Engineering 12	Surveying	3
Civil Engineering 31	Stress Analysis	2
Civil Engineering 32	Stress Analysis	2
Civil Engineering 141	Reinforced Concrete and Design	3
Civil Engineering 142	Reinforced Concrete and Design	3
Drawing 1	Engineering Drawing	3
Drawing 2	Engineering Drawing	3
Drawing 3	Descriptive Geometry	3
Drawing 10	Solid Geometry	0
Drawing 29	Drafting	2
Drawing 38	Reading Drawings	2
Electrical Engineering 11-12	Elements of Electrical Engineering	4
Electrical Engineering 13-14	Elements of Electrical Engineering	4
Mathematics and Mechanics 9	Higher Algebra	0
Mathematics and Mechanics 11	College Algebra	5
Mathematics and Mechanics 12	Trigonometry	5
Mathematics and Mechanics 13	Analytic Geometry	5
Mathematics and Mechanics 24	Differential Calculus	5
Mathematics and Mechanics 25	Integral Calculus	5
Mathematics and Mechanics 26	Statics	5
Mathematics and Mechanics 80	Differential Equations	3
Mathematics and Mechanics 127	Dynamics	5
Mathematics and Mechanics 128	Strength of Materials	5
Mathematics and Mechanics 129	Hydraulics	4

Course Fees

The following courses described in this bulletin require payment of course fees as indicated:

Aeronautical Engineering laboratory fee, required of all sophomores, juniors, and seniors in aeronautical engineering	$ 3.00 per quarter
20, Flying (payable at the University Airport)	4.50 per solo hour
	7.50 per dual hour
46, Orientation Course in Link Flying. No fee for Aero Engineers; other students	42.00 per quarter
Agricultural Engineering 21	1.00 per quarter
43	6.00 per quarter
Architecture AD I-II-III, Arch. 40	3.00 per quarter
AD IV	10.00 per quarter
Astronomy 20	1.00 per quarter
Bacteriology 53, 103, 104, 113, 114, 123	3.00 per quarter
Botany 1, 2, 3	1.50 per quarter
4, 5	2.25 per quarter
Business Administration 65, 66, 74	2.00 per quarter
170, 171	1.00 per quarter
Civil Engineering 23	10.00 per quarter
51, 52, 53, 137, 146	2.00 per quarter
Electrical Engineering 12, 14, 112, 114, 116, 118, 120, 127, 128, 129	1.00 per quarter
16, 122, 124, 126, 164, 165, 166	2.00 per quarter
English 4 (Engineering English)	1.00 per quarter
Entomology 125, 142	1.50 per quarter
Geology A, B, 23 24	1.00 per quarter
100, 115, 150	10.00 per quarter
175	5.00 per quarter

Humanities 1, 11, 21, 51, 61, 71	1.00 per quarter
Mathematics and Mechanics 87, 141, 143	1.00 per quarter
Mechanical Engineering 1-8, 12-18, 33-35, 61, 110-114, 118, 149, 159, 169, 189, 198	2.00 per quarter
Natural Science 7, 8, 9	1.50 per quarter
Physical Education (Men) 1A-B-C, 2A-B-C	1.50 per credit
A towel fee and locker fee of $2.50 per quarter, payable at the department, is charged all students using physical education facilities for activity. Uniforms for class work or recreational activity are $2 per quarter.	
Physics 7-9, 110, 112, 134, 136, 144, 146	2.00 per quarter
Psychology 130	2.00 per quarter
Rhetoric 22	1.00 per quarter
Soils 108	2.00 per quarter
Technical Aid 80A, 80B, 81, 81A, 81B, 82A, 82B, 83A, 84, 84A, 85A	2.00 per quarter
Zoology 1, 2, 3, 14, 15, 155, 156, 157	1.50 per quarter

COURSES REQUIRING DEPOSIT CARDS

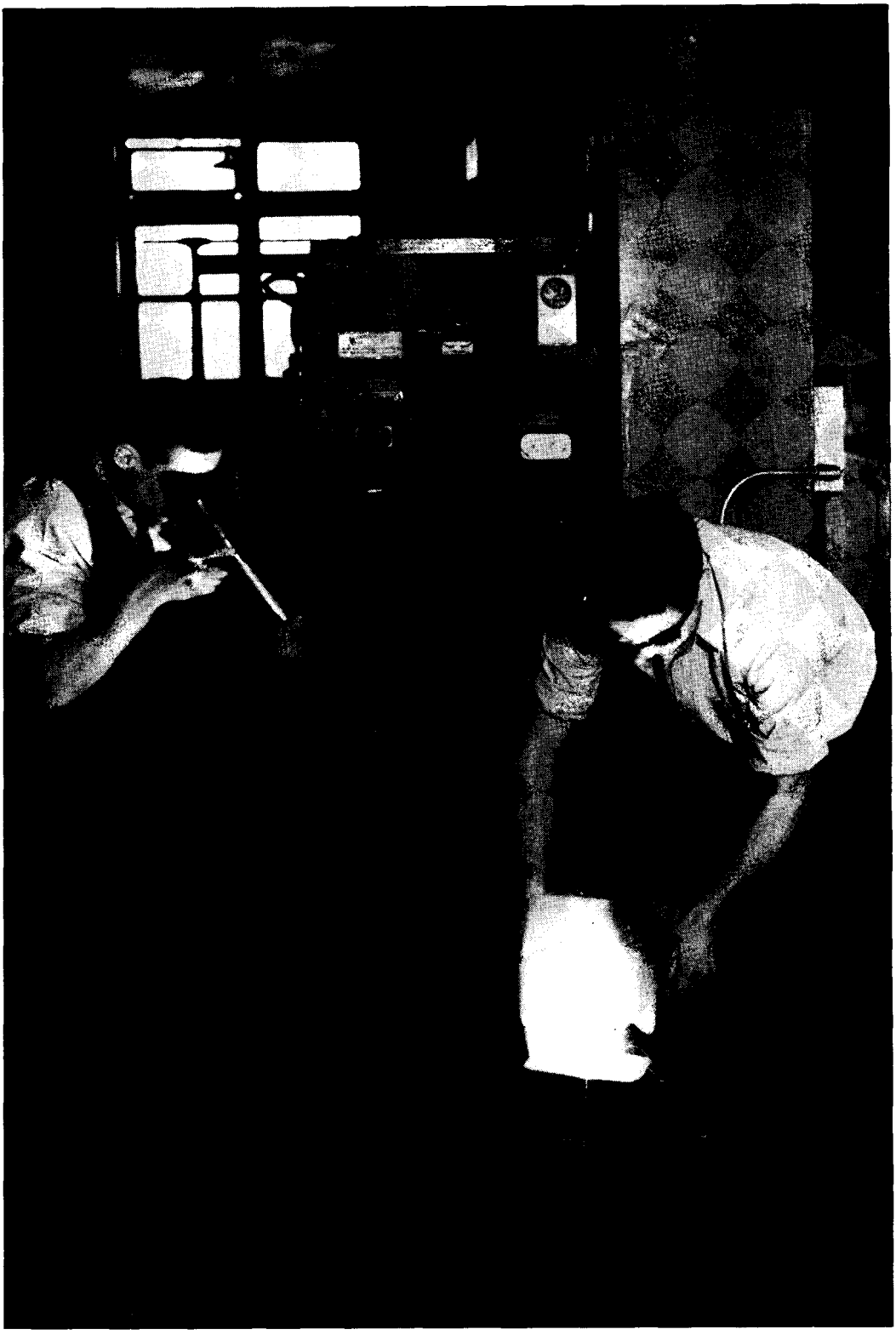
Nonveterans should purchase Agricultural Biochemistry or Chemistry deposit cards as appropriate. Chemistry cards may be purchased from the bursar, Administration Building, Minneapolis Campus. Agricultural Biochemistry cards may be purchased from the cashier, Administration Building, St. Paul Campus. Chemistry deposit cards are $10 each. Agricultural Biochemistry deposit cards are $5 each. Veterans will receive information from the instructor concerning cards and checking into laboratory. No student will be assigned a desk in the laboratory until he presents his card. The course fee, laboratory material, and breakage will be charged against the card. The unused balance will be credited to the student's matriculation deposit at the end of the course.

Agricultural Biochemistry 103, 110, 129, 130, 131, 132, 133	$ 5.00 per quarter
Analytical Chemistry 1, 2, 7, 9, 96, 97, 98, 101, 102, 103, 104, 105, 106, 107, 108, 109, 122, 123, 127, 131, 132, 134, 138, 140	3.00 per quarter
Chemical Engineering 105, 106, 111, 112, 113, 151, 152, 153, 154, 155, 156, 160, 176, 177, 179	3.00 per quarter
Inorganic Chemistry 1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 96, 97, 98, 102, 109, 110	3.00 per quarter
Organic Chemistry 61, 62, 64, 96, 97, 98, 102, 130	3.00 per quarter
110, 139	10.00 per quarter
Physical Chemistry 104, 105, 106, 107, 108, 110, 111, 112, 113, 132, 133, 134, 211, 212, 213, 231	3.00 per quarter

MICROSCOPE FEES

Students may obtain use of a microscope by purchasing a $3 microscope card from the bursar.

Bacteriology 53	$ 3.00 per quarter
Botany 4	3.00 per quarter



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 lect. hrs. per week. Kircher.

2—AIRCRAFT AND AUTO ENGINES. Principles and types of reciprocating, gas turbine, and jet propulsion engines. Principles of electrical systems, carburetor, lubrication, cooling, and fuels. Accessories. (Open only to aeronautical engineers or by petition.) 3 cred.; soph.; 3 lect. and 2 lab. hrs. per week.

20-21-22—FLYING: THEORY AND PRACTICE. Consists of 12 hours of ground instruction and 10 hours of flying each. 1 lect. hr. and average flying hrs. 1 per week. Laboratory fee by arrangement. Magnus.

46—ORIENTATION COURSE. Indoctrination course on Link instrument flying. 2 cred.; prereq. 4th, 5th yr. or graduate in Aeronautical Engineering or special permission of Aeronautical Engineering Department. Twelve 2-hour periods, lect. and practice. Magnus.

83—STRESSES IN SIMPLE STRUCTURES. Statically determinate trusses and beams. Graphic statics. Combined stresses. Short and long struts. Airplane structures. 4 cred.; prereq: M.&M. 128. 3 lect. and 2 lab. hrs. per week. Harris.

100-101-102—AERODYNAMICS. Atmospheric properties; fluid mechanics; Prandtl's wing theory. Dimensional analysis. Performance stability, propeller theory. Motion of body in fluids in three dimensions. 3 cred. per qtr.; prereq. Aero.E. 1 and M.&M. 25. Stolarik, Cronk.

103-104-105—ADVANCED AERODYNAMICS. Dynamic stability, advanced theoretical aerodynamics, flutter analysis. 3 cred. per qtr.; prereq. Aero.E. 102; 3 lect. hrs. per week. Stolarik, Cronk.

106—ADVANCED AERODYNAMICS. Compressible flow. Comparison of compressible and incompressible flow influences on aircraft. Airfoil analysis and design. Spanwise lift distribution. 3 cred.; prereq. Aero.E. 102; 3 lect. hrs. per week. Upson.

107—AERODYNAMICS OF VISCOUS FLUIDS. Viscosity effects in fluid flows, Navier-Stokes equation, laminar boundary layer theory. Application of boundary layer theory to aerodynamic design problems. Prereq. Aero.E. 102; 3 cred.; 3 lect. hrs. per week. Cronk.

110—VIBRATION AND FLUTTER. Free harmonic and forced vibrations. Spring constants. Critical frequency. Vibrating systems with several degrees of freedom. Vibration of aircraft. Tail and wing flutter. 3 cred.; prereq. Aero.E. 115 and M.&M. 80; 3 lect. hrs. per week. Werner, Kircher.

115—AIRPLANE STRESSES. Deflection of structures. Theory of statically indeterminate structures. Analysis of fuselage trusses, landing gear, wing beams. Structural details and connections. 3 cred.; prereq. Aero.E. 83. 2 lect. and 2 lab. hrs. per week. Harris.

116—ADVANCED AIRPLANE STRESSES. Frames, space frameworks, secondary stresses, beams, columns, curved beams, rings, multispar and unit wing construction, monocoque fuselages. 3 cred.; prereq. Aero.E. 115 or M.&M. 180; 3 lect. hrs. per week. Wise.

117—ADVANCED AIRPLANE STRESSES. Analysis of thin-shelled plates and membranes used in aircraft wings and fuselages. Local stresses and effects of discontinuities. Initial and thermal stresses, combined stresses, and theories of failure as applied to aircraft structures. 3 cred.; prereq. Aero.E. 115; 3 lect. hrs. per week. Wise.

118—STRESSES ON AIRCRAFT STRUCTURES. Theory of flexure of flat plates. Bucklings of plates. Combined bendings and axial stress in plates. Application and design of seaplane floats and hulls. 3 cred.; prereq. Aero.E. 115; 3 lect. hrs. per week. Wise.

119—TESTING OF AIRCRAFT STRUCTURES AND MODELS. Theory of model studies. Similitude. Maxwell theorem of reciprocal deflections. Begg's Deformeter. Strain gauges. Mechanical, optical, magnetic, and electrical resistance types. Interpretation of tests. Mohr's circles of stress and circles of strain. Measurement of deflection. 3 cred.; prereq. Aero.E. 115; 2 lect. and 3 lab. hrs. per week. Wise.

120-121-122—AIRPLANE DESIGN. Design and stress analysis of aircraft structures involving beam-columns, thin-web beams, multi-cell wings, closed frames. Sheet buckling and tension characteristics of sheet-stringer combinations. Shear, bending, and torsion in shell structures. 2 cred. per qtr.; prereq. Aero.E. 83, 102; 2 lect. hrs. per week. Upson, Harris.

123-124-125—ADVANCED AIRPLANE DESIGN. Problems in airplane design or development. 2 to 5 cred. per qtr.; prereq. Aero.E. 121. Akerman.

126—AIRSCREW PROPULSION. Study of the theory common to the propulsive and lifting airscrews. Theory of the helicopter performance. 3 cred.; prereq. Aero.E. 120. Stolarik.

127-128—ADVANCED PROBLEMS IN AIRSCREW DESIGN. 2 to 5 cred. per qtr.; prereq. Aero.E. 126. Stolarik.

130—AERODYNAMIC DESIGN LABORATORY. Preliminary airplane design. Reg. in Aero.E. 120. 2 cred.; 6 lab. hrs. per week. Stolarik and staff.

131-132—AIRPLANE DESIGN LABORATORY. Air loading analysis. Load factors. Structural design and analysis. 131 to be taken concurrently with Aero.E. 121. 132 to be taken concurrently with Aero.E. 122. 2 cred.; 6 lab. hrs. per week. Harris and staff.

135—AIRPLANE STATIC TESTING. Theory and use of electrical strain gauges as applied to aircraft structures. Tests of wing structures and aircraft components. 2 cred.; prereq. Aero.E. 142; 1 lect. and 3 lab. hrs. per week. Zimney and staff.

140—AERONAUTICAL LABORATORY. Study of airplane parts and construction. Fittings. Rigging. Inspection and maintenance. 4 cred.; prereq. Aero.E. 142; 3 lect. and 3 lab. hrs. per week. Zimney and staff.

141—AERODYNAMICS LABORATORY. Wind tunnel test procedure. Measurement of airflow. Calibration of wind tunnels, pitot tubes and anemometers. Pressure distribution. Wind tunnel testing of wings, propellers, and airplane models. 2 cred.; prereq. Aero.E. 101; 6 lab. hrs. per week. Cronk, Kircher.

142—AIRCRAFT INSTALLATION I. Installation and function of airplane components and accessories. 2 cred.; prereq. Aero.E. 1; 1 lect. and 3 lab. hrs. per week. Zimney and staff.

143—AIRCRAFT INSTALLATION II. 3 cred.; prereq. reg. in Aero.E. 130; 1 lect. and 6 lab. hrs. per week. Zimney and staff.

155—AERONAUTICAL CALCULATIONS. Special methods in practice. 2 cred.; prereq. sr.; 2 lect. hrs. per week. Cronk, Leadon.

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.; 2 lect. and 1 rec. hr. per week. Piccard.

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.)

164—PROBLEMS RELATING TO THE STRATOSPHERE. 3 cred.; prereq. Aero.E. 102; 3 lect. hrs. per week. Piccard.

165-166-167—ADVANCED AERONAUTICAL LABORATORY. Research problems in aeronautical engineering requiring laboratory of field research facilities. 2-4 cred.; prereq. Aero.E. 141 or permission of instructor; 1 lect. and 3 lab. hrs. per week. Akerman.

173—INTRODUCTORY METEOROLOGY. Survey of meteorological phenomena and the related physical principles; atmospheric statics; atmospheric thermodynamics; the equations for simple atmospheric motions. The laboratory work consists of problems designed to illustrate the physical principles involved. 3 cred.; prereq. jr. or sr.; 2 lect. and 3 lab. hrs. per week. Mantis.

174—APPLIED METEOROLOGY. Meteorological observations; the collection and dissemination of meteorological data. Elementary weather analysis and the interpretation of weather charts. 4 cred.; prereq. Aero.E. 173; 1 lect. and 6 lab. hrs. per week. Mantis.

175—ADVANCED METEOROLOGY. Physical meteorology. Atmospheric stability; heat balance; the equations of hydrodynamics as applied to the atmosphere; the structure and mechanism of cyclones and anticyclones. 4 cred.; prereq. Aero.E. 173; 3 lect. and 3 lab. hrs. per week. Mantis.

180—INSTRUMENTATION AND TECHNIQUES FOR SUPERSONIC FLOW. Principles, uses and limitations of measuring devices used in supersonic flow. Static and dynamic pressure orifices. Mach cones and wedges; shadowgraph and Schlieren apparatus; interferometer; and hot wire anemometer; temperature measuring devices and methods; specific conditions and problems. 2 cred.; prereq. Aero.E. 106 or M.E. 134; 1 lect. and 2 lab. hrs. per week. Bradfield.

190-191-192—SEMINAR. Readings, reports, conferences, and discussions. 1 cred. per qtr.; prereq. Aero.E. 101; 1 rec. hr. per week. Piccard.

193-194-195—ADVANCED PROBLEMS IN AERONAUTICAL ENGINEERING. 2 to 5 cred. per qtr.; prereq. sr. or grad. in aeronautical engineering. Staff.

201-202-203—AERODYNAMICS OF COMPRESSIBLE FLUID. Equations of motion in a compressible fluid. Thermodynamic considerations. Isentropic channel flow. Method of characteristics. Application of aerodynamic design. The small pertubation method. The Busemann first and higher order approximations to pressure coefficient on aerodynamic surfaces. Aerodynamic characteristics of two dimensional supersonic profiles. Extension of foregoing techniques to three dimensions. Finite wing theory. Conical flow. Applications to supersonic aircraft design. 3 cred. per qtr.; prereq. Aero.E. 106 or special permission. 3 lect hrs. a week. Bradfield, Braithwaite.

204—SUPERSONIC AERODYNAMICS LABORATORY. A laboratory course in supersonic wind tunnel operations, technique and instrumentation. Flow study and model testing for static and dynamic characteristics in three supersonic wind tunnels at Rosemount Research Laboratory. 3 cred.; prereq. registration in Aero.E. 201 or M.E. 134. 2 lect. and 3 lab. hrs. per week. Akerman, Anderson.

220—HIGH SPEED PERFORMANCE AND DESIGN. General principles of designing for performance. Compressibility corrections at subsonic speeds. Transonic effect. Supersonic possibilities and requirements. 3 cred.; prereq. Aero.E. 202 or special permission. 3 lect. hrs. per week. Upson.

240—DYNAMICS OF AIRCRAFT STRUCTURES. Fundamental principles of vibrations of springs supported masses, beams, trusses, and other structural forms; response of structures to suddenly applied forces and impulses; strength of structures under impactive and repeated forces; application to vibration and flutter of aircraft structures and components, and their response to blast or explosion, jet reaction, gust loads, landing loads, and similar dynamic forces. 3 to 5 cred. Wise.

241—DYNAMICS OF AIRCRAFT STRUCTURES. 3 cred.; prereq. Aero.E. 240. Wise.

272-273-274—RESEARCH IN AERONAUTICAL ENGINEERING. 2 to 5 cred. per qtr.; prereq. permission of instructor. Graduate staff.

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.; prereq. permission of instructor. Graduate staff.

For additional courses available to aeronautical engineers in:

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

Electrical Engineering Survey and Aeronautical Radio, see Electrical Engineering 46-47.

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

Agricultural Biochemistry

(College of Agriculture, Forestry, Home Economics and Veterinary Medicine)

1—INTRODUCTION TO ORGANIC CHEMISTRY. An introduction to the chemistry of carbon compounds directed toward an understanding of the principles underlying the classification, structure, and general properties of those which are of biological importance. 5 cred.; soph., jr., sr.; prereq. 8 cred. in inorg. chem.

52*†—BIOCHEMISTRY AND MICROBIOLOGY OF CEREAL GRAINS. Physical properties and chemical composition of cereal grains and their mill products; micro-organisms associated with cereal grains and their products; the biochemistry and microbiology of grain storage, milling, malt production and breadmaking. 3 cred.; jr., sr.; prereq. 5 cred. in elem. org. chem. and 9 cred. in gen. biol.

103—DAIRY CHEMISTRY. Lectures and laboratory work on the physical, colloidal, and chemical properties of milk and dairy products, the chemistry of the various constituents of milk and of the process involved in the manufacture of dairy products. 6 cred.; prereq. Ag.Biochem. 2 and 6 or equiv. Jenness.

* Same as Plant Pathology and Botany 52.

† Open only to students in Mechanical Engineering (Milling option).

108—CHEMISTRY OF WHEAT AND WHEAT PRODUCTS. A lecture course, with collateral library reference work, on the chemical technology of the production and milling of wheat and the conversion of its products into human food. 3 cred.; prereq. Ag.Biochem. 5. Geddes.

110—FLOUR LABORATORY METHODS. A laboratory course in methods of analysis of wheat and its products; milling tests of wheat, baking, and special tests of flour. Designed to train students for research and control work in the cereal industry. 3 to 5 cred.; prereq. Ag.Biochem. 2 and parallel Course 108, or equiv. Geddes, Bottomley.

119—COLLOIDS. Lectures and assigned readings dealing with the colloidal state of matter, the preparation and properties of colloidal systems, and the relation of these to biochemical processes. 3 cred.; prereq. Ag.Biochem. 3 or 8 cred. in org. chem., Phys. 9 advised. Briggs.

120—PROTEINS—Lectures and assigned readings on composition, structure, chemical and physical properties, and the functions of proteins and amino acids. 3 cred.; prereq. Ag.Biochem. 119 or permission of instructor. Sandstrom.

121—CARBOHYDRATES. Lectures and assigned readings on the composition, structure, chemical and physical properties, and the functions of the carbohydrates. 3 cred.; prereq. Ag.Biochem. 119 or permission of instructor. Smith.

122—LIPIDES. Lectures and assigned readings on the composition, structure, chemical and physical properties, and the functions of the fats and fat-like compounds. 3 cred.; prereq. Ag.Biochem. 119 or permission of instructor. Briggs.

123—ENZYMES. Lectures and assigned readings on enzyme action, including the methods of preparation and investigation of enzymes and their function in biological and industrial processes. 3 cred.; prereq. Ag.Biochem. 119 or permission of instructor. Boyer.

129—COLLOIDS LABORATORY. Methods for the preparation and purification of and study of the physico-chemical properties of inorganic and biocolloid systems. 2 cred.; jr., sr., grad.; prereq. Ag.Biochem. 2, parallel Course 119.

130—PROTEINS LABORATORY. Preparation, identification, and analysis of proteins and their hydrolytic products. 2 cred.; sr., grad.; prereq. Ag.Biochem. 2 or equiv. and parallel Course 108.

131—CARBOHYDRATES LABORATORY. Preparation, identification, and analysis of sugars and polysaccharides. 2 cred.; sr., grad.; prereq. Ag.Biochem. 2 or equiv. and parallel Course 121.

132—LIPIDES LABORATORY. Preparation, identification, and analysis of the lipides. 2 cred.; sr., grad.; prereq. Ag.Biochem. 2 or equiv. and parallel Course 122.

133—ENZYMES LABORATORY. Preparation and measurement of enzymes and for the study of their properties. 2 cred.; sr.; grad.; prereq. Ag.Biochem. 2 or equiv. and parallel Course 123.

Agricultural Economics

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

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., grad.; prereq. Ag.Econ. 2 or Econ. 8, 9; 3 rec. hrs. per week. Pond.

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

144—COOPERATIVE ORGANIZATION. Development of cooperation in agriculture in the United States and foreign countries. Analysis of economic problems peculiar to cooperative organization, especially of marketing agencies. 3 cred.; jr., sr., grad.; prereq. Course 40. Jesness.

Agricultural Engineering

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

AGRICULTURAL PHYSICS AND RURAL ELECTRIFICATION: Ag.E. 125, 131-132-133, 172.

FARM POWER AND MACHINERY: Ag.E. 18, 43, 52, 73, 121-122-123, 126, 150, 171, 221-222-223.

FARM STRUCTURES: Ag.E. 36, 53, 63, 111-112-113, 167, 211-212-213.

SOIL AND WATER CONSERVATION: Ag.E. 21, 51, 61, 101-102-103, 105, 106, 201-202-203.

18—AGRICULTURAL AUTOMOTIVES. Principles of internal combustion engines and tractors including ignition, lubrication, carburetion, cooling, real gas cycles, transmission systems, and drive members. 3 cred.; prereq. M.E. 131; 2 lect. and 3 lab. hrs. per week. Strait, Torrance.

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 earthwork, and adjustments of instruments. 5 cred.; prereq. Draw. 3, M.&M. 12; 1 lect. and 12 lab. hrs. per week. Manson.

36—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. Allred.

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

51—SOIL AND WATER CONSERVATION. Principles and practices of land drainage, soil erosion control, and water conservation in relation to plant growth, farm operation, land development, and community interest. 3 cred.; prereq. Ag.E. 21, Soils 4, M.&M. 129 or reg. in M.&M. 129; 3 lect. hrs. per week. Manson.

52—ELEMENTS OF FARM MACHINERY. Principles of design, construction, and economics of agricultural machines. Drawbar power. 3 cred.; prereq. M.E. 24; 1 lect., 1 rec., and 3 lab. hrs. per week. Schwantes, Johnson.

53—FARM STRUCTURES. Planning and economics of farm buildings. Functional and structural requirements. 3 cred.; prereq. C.E. 37 or reg. in C.E. 37, M.&M. 128, Econ. 9; 1 lect., 1 rec., and 3 lab. hrs. per week. Otis.

61—IRRIGATION. Principles and practices of irrigation in arid and humid regions in relation to plant growth. Design, cost, and construction of irrigation systems of all types. 3 cred.; prereq. Ag.E. 51; 3 lect. hrs. per week. Allred.

63—FARM STRUCTURES LABORATORY. Materials and construction methods used in farm buildings. Tests of materials and assemblies. 3 cred.; prereq. 53 or reg. in 53, M.&M. 141; 6 lab. hrs. per week. Otis.

73—STEAM BOILERS AND HEAT ENGINES. Steam boilers and heat engines in their applications to agriculture. A study of steam equipment, internal combusion engines, and refrigeration including properties of vapors, thermodynamics of theoretical and real cycles, heat transfer, operating principles, and performance characteristics. 3 cred.; prereq. Ag.E. 18 and M.E. 131; 2 lect. and 3 lab. hrs. per week. Strait.

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. Ag.E. 61. Manson, Allred.

105—DRAINAGE, IRRIGATION, AND SOIL EROSION CONTROL DESIGN. Design and field layout of drainage, erosion control, and irrigation systems for the control and conservation of soil and water in agriculture. 4 cred.; prereq. Ag.E. 61 and 106 or special arrangement. 2 lect. and 6 lab. hrs. per week. Manson, Allred, Larson.

106—AGRICULTURAL HYDROLOGY. Study of the hydrologic cycle and its component parts — precipitation, transpiration, evaporation, infiltration, and runoff. Measurement and estimation of runoff by various methods. Ground water hydrology. 3 cred.; prereq. Ag.E. 51 or special arrangement. 3 lect. hrs. per week. Manson, Larson.

111-112-113—FARM BUILDING PROBLEMS. Investigations in building materials, methods of construction, or building equipment. 2 to 6 cred. per qtr.; prereq. Ag.E. 167. Christopherson, Otis.

121-122-123—FARM POWER AND MACHINERY PROBLEMS. Special studies of farm machinery and mechanical power for the farm. Tests, designs, and adaptability. 2 to 6 cred. per qtr.; prereq. Ag.E. 171. Schwantes, Strait.

125—TOPICS IN AGRICULTURAL PHYSICS. An advanced study of the essential physical principles involved in the utilization of electricity in agriculture. 3 cred.; prereq. Phys. 9, or integral calculus and Ag.E. 25 or equiv. Open to sr. or grad. Hustrulid.

126—MANAGEMENT OF AGRICULTURAL MACHINERY. Principles of power and machinery management. 3 cred.; prereq. Ag.E. 171, Ag.Econ. 102; 2 lect. and 3 lab. hrs. per week. Schwantes.

131-132-133—RURAL ELECTRIFICATION PROBLEMS. Advanced studies dealing with the design, testing, and use of electrical equipment for farm applications. 2 to 6 cred. per qtr.; sr., grad.; prereq. Ag.E. 172. Hustrulid.

150—INSPECTION TRIP. During spring vacation of the senior year an inspection trip is made to observe activities, in agriculture and industry, that have agricultural engineering significance. Required of seniors in Agricultural Engineering; 1 cred.

167—ADVANCED FARM STRUCTURES. Design of structural members and assemblies for farm structures. Insulation and ventilation of animal shelters. Building equipment. 3 cred.; prereq. 63, M.E. 160, C.E. 146; 1 lect., 1 rec., and 3 lab. hrs. per week. Otis.

171—DESIGN OF AGRICULTURAL MACHINERY. Operating principles and problems in design of agricultural machines. 3 cred.; prereq. Ag.E. 52, and M.E. 121; 1 lect. and 6 lab. hrs. per week. Strait.

172—APPLIED ELECTRICITY. A study of topics important in the application of electric power to agriculture, including instruments, farmstead wiring, lighting, motors and controls, control circuits, and storage batteries. 3 cred.; prereq. E.E. 38 or reg. in E.E. 38; 2 lect. and 4 lab. hrs. per week. Hustrulid.

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. Ag.E. 101, 102, or 103 and one qtr. statistics. Manson, Allred.

211-212-213—FARM STRUCTURES RESEARCH. Investigations in performance of materials, methods of construction, or development of equipment for use in farm structures. 2 to 6 cred.; prereq. Course 167. Otis.

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. Ag.E. 171. Schwantes, Strait.

Agronomy and Plant Genetics

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

1—GENERAL FARM CROPS. Adaptation, distribution, production, and uses of the important field crops of the United States. 3 cred.; no prereq.

21—GRAIN CROPS. Production, improvement, and uses of corn, small grains, and flax. Lectures and laboratory work. 4 cred.; soph., jr., sr.; prereq. Agron. 1.

23—FORAGE CROPS. Distribution, characteristics, production, preservation, and uses of forage crops. Lectures and laboratory work. 4 cred.; soph., jr.; sr.; prereq. Agron. 1.

52—PRODUCTION AND GRADING OF CEREAL CROPS. Production, harvesting, and grading of cereal crops including soil management practices and fertilizers, selection of varieties and cultural methods; factors affecting quality and methods of harvesting; laboratory practice in grading small grains. 4 cred.; jr., sr.; open only to students registered in the mechanical engineering curriculum (milling option); prereq. general biol. 9 cred. or equiv. Same as Soils 52.

135—WEED CONTROL. Cultural and chemical methods of weed control; weed and seed laws pertaining to dissemination and control. Lectures, laboratory, and field work. 3 cred.; jr., sr., grad.; prereq. Agron. 1 and Pl.Path. 3. Same as Pl.Path. 135.

Air Science and Tactics (Air ROTC)

The Department of the Air Force will offer a four (4)-year program, consisting of Air Science I, II, III, IV, leading to a commission in the Air Force Reserve (USAFR). The program is offered as a university elective enabling students to qualify for an Air Force Reserve Commission concurrently with enrolment in any of the undergraduate courses offered by the University. Students accepted for the Air ROTC program must be enrolled in a four (4)-year or longer college course, and meet physical and age requirements established by the Air Force.

Air Science I consists of three (3) hours per week for three (3) consecutive quarters of subjects pertinent to the Air Force. Air Science II is devoted to administration of air power and the specialization in either Air Force Supply or Communications, the selection depending upon aptitude, prior training, major college in the University, and other factors.

Air Science III and IV (3rd and 4th years) consist of five (5) hours per week of continuing study in Air Force subjects with emphasis on field of specialization and one six-week summer camp between the two years. During these last two years, students are paid approximately $27 per month. A separate pay scale for the six-week summer camp provides travel pay and $75 per month for the camp period.

Air Science courses carry college credits of 1 credit per quarter for Air Science I and II, and 3 credits per quarter for Air Science III and IV.

Students enrolling in the program may be deferred from service under the Selective Service Act of 1948 until completion of their undergraduate college program within quotas established by the Air Force. Subsequent service would be performed in a commissioned officer grade.

Students may, upon completion of the course, apply for flight training in a commissioned officer grade provided they meet age and physical requirements.

Further information may be obtained from the professor of air science and tactics, Room 106, Armory.

Animal Husbandry

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

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. 4 cred.; jr., sr.; no prereq.; 3 lect. and 2 lab. hrs. per week. Harvey.

56—LIVESTOCK FEEDING I. The nutritional requirements of farm animals and the composition and characteristics of livestock feeds. Calculation of rations and a study of the different methods of feeding. 3 cred.; jr., sr.; prereq. An.Husb. 1. R. M. Anderson.

57—LIVESTOCK FEEDING II. The values of single feeds and of combinations of feeds for beef cattle, horses, sheep and swine. Economical rations for breeding animals and for market livestock. 3 cred.; jr., sr., prereq. 56. P. A. Anderson.

Architecture

HISTORY AND THEORY

1—INTRODUCTION TO ARCHITECTURE. Discussions and problems to inform prospective students of the nature of architecture as an art and a profession. 1 cred.; prereq. permission of instructor; 1 rec. hr. per week. McClure.

40—GRAPHIC REPRESENTATION. Projections, shades and shadows, perspective and other processes involved in architectural drawing. 6 cred.; prereq. solid geometry, soph. standing for Institute of Technology students and 3rd qtr. soph. standing for Science, Literature, and the Arts students; normally open only to students accepted as candidates for B.Arch. or B.A. (major in arch.) degrees. 3 lect. and 15 lab. hrs. per week. Heath.

51-52-53—HISTORY OF ARCHITECTURE. Significant architecture of the past, with particular reference to the geographic, social, and technical influences which produced it. 4 cred. per qtr.; prereq. soph. standing for Institute of Technology students, jr. standing for Science, Literature, and the Arts students. 4 lect. and conf. hrs. per week. Robertson.

57—BUILDING MATERIALS AND METHODS, PART I. Principles, methods, and materials involved in the standard types of building construction. 4 cred.; prereq. soph. standing for Institute of Technology students, jr. standing for Science, Literature, and the Arts students. 4 lect. hrs. per week. Robert Jones.

58-59—BUILDING MATERIALS AND METHODS, PART II. 4 cred. per qtr.; prereq. 57; 4 lect. hrs. per week. Robert Jones.

71-72-73—BUILDING EQUIPMENT. Mechanical, electrical, and sanitary equipment of buildings. 2 cred. per qtr.; prereq. jr. standing; 2 lect. and conf. hrs. per week. Close and associates.

101-102-103—TUTORIAL WORK IN HISTORY OF ARCHITECTURE. 2 cred. per qtr.; prereq. 53 and sr. or grad. standing; 1 conf. and 5 research hrs. per week. Robertson.

104—CITY PLANNING. Same as Econ. 111, Pol.Sci. 123, Soc. 106. 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. Robert Jones, Anderson, Chapin, Filipetti, Vaile, and associates.

105—PROFESSIONAL RELATIONS. Relations of the architect to clients, contractors, and fellow practitioners; procedures of architectural practice. 3 cred.; prereq. sr. standing; 2 two-hr. seminars per week. Roy Jones.

106—CITY PLANNING. Technical phases of modern city planning, with special reference to the architect's functions therein. 3 cred.; prereq. Arch. 104 and sr. or grad. standing. 3 conf. hrs. per week. Robert Jones.

For courses required of architectural students in applied mathematics, structural design, drawing, and painting see: M.&M. 91-92-93, Calculus, Mechanics, and Strength of Materials for Architects, in Department of Mathematics and Mechanics; C.E. 38-39-41, Structural Design for Architects, in Department of Civil Engineering; Art 20-21, 60-61-62, in Department of Art in College of Science, Literature, and the Arts.

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 objective 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 of which Mr. Roy Jones is chairman and Mr. McClure is secretary. See also *Statement Concerning Courses in Architectural Design* issued by the School of Architecture.

In addition to the prerequisites indicated below, enrolment in these courses is subject to specific approval by the School of Architecture, and to limitation by the work space and instructional facilities available.

Major critics: Roy Jones, Cerny, McClure, Nagle, Vivrett, Cavin, Graffunder, and associates. Consulting critics: Robert Jones (City Planning and Construction), Heath (Construction), Hopkins (Interior Design), Anderson (Structural Design), Close (Building Equipment), Robertson (Architectural History), and associates.

AD-I—ARCHITECTURAL DESIGN, GRADE I. 12 cred. (normally 6 cred. per qtr.); prereq. Arch. 40, soph. standing for Institute of Technology students, jr. standing for Science, Literature, and the Arts students; 18 lab. hrs. per week.

AD-II—ARCHITECTURAL DESIGN, GRADE II. 18 cred. (normally 6 cred. per qtr.); prereq. AD-I; 18 lab. hrs. per week.

AD-III—ARCHITECTURAL DESIGN, GRADE III. 45 cred. (normally 9 cred. per qtr.); prereq. AD-II; normally open only to students accepted as candidates for the B.Arch. degree; 27 lab. hrs. per week.

AD-IV—ARCHITECTURAL THESIS. 12 cred.; prereq. AD-III; 36 lab. hrs. per week.

Astronomy

(College of Science, Literature, and the Arts)

20—ASTRONOMY FOR CELESTIAL NAVIGATION. Deals with the principles and the practice of navigation of planes and ships by using the stars in the sky. Includes some dead reckoning. 5 cred.; no prereq.; 4 lect. and one 3 hr. lab. per week.

51—GENERAL ASTRONOMY. Fundamental facts and principles of astronomy. 3 cred.; prereq. M.&M. 12; 3 rec. hrs. per week. Luyten.

101*—CELESTIAL MECHANICS. A course dealing with Newton's law of gravitation and its application to astronomy, especially planetary motions. 3 cred.; prereq. M.&M. 25; 3 rec. hrs. per week. Luyten.

140*—METHODS 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. Astron. 51 or 11 and M.&M. 24. Luyten.

Bacteriology and Immunology

(Medical School)

53—GENERAL BACTERIOLOGY. Lectures, demonstrations, and laboratory exercises are employed for instruction in the morphology, physiology, taxonomy, and ecology of bacteria. The practical applications of these fundamental principles in other phases of science and industry are emphasized. 5 cred.; soph. with a C average in the prerequisite courses, jr., sr.; prereq. 10 cred. in chemistry and 4 cred. in biological sciences or permission of instructor. Staff.

103—SOIL MICROBIOLOGY. Methods for enumeration and study of microflora and microfauna. Biochemical activities of soil population. 4 cred.; jr., sr., grad.; prereq. Bact. 53 and 8 cred. in organic chemistry. Schmidt.

104—SANITARY BACTERIOLOGY. Standard and other methods for the bacteriological analysis of water, sewage, food and dairy products. Preparation of standard culture media, technic, and evaluation of results. Primarily for majors in bacteriology. Limited to 50 students. 4 cred.; prereq. Bact. 53 and 15 cred. in chemistry. Johansson.

113-114—FUNGI. Morphology, physiology, and taxonomy. Staining, isolation, culturing, identification. Special emphasis on fungi of importance in medicine and industry. 4 cred. per qtr.; jr., sr., grad.; prereq. Bact. 53, and 5 cred. in bacteriology or 4 cred. in plant pathology. Christensen, Roth.

121-122—PHYSIOLOGY OF BACTERIA. Growth; enzymes; metabolism; dormancy; death. 3 cred. per qtr.; prereq. Bact. 53 and 8 cred. in organic chemistry or biochemistry. Lones, Watson.

123—APPLIED BACTERIOLOGY. Industrial fermentations; bacteriology of water and sewage. 3 cred.; sr., grad.; prereq. Bact. 121-122. Halvorson.

Botany

(College of Science, Literature, and the Arts)

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.

4-5—GENERAL BOTANY. (See 1-2-3.) 3 lect. and 6 lab. hrs. per week. (Not offered.)

* Courses 101 and 140 are usually offered in alternate years, and only one will be given in each year, depending on the demand. No student should register for this course without first consulting the instructor.

12—PLANTS USEFUL TO MAN. Survey of the world's useful plants and plant products, their sources, characteristics, and uses. Demonstration of material. Plants and man; the origin and history of cultivated plants. Lectures, demonstration, and reference reading. 3 cred.; no prereq.; 3 lect. hrs. per week.

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, corrosion, etc. 2 cred.; prereq. Inorg.Chem. 11; 3 lect. hrs. per week. (Not open to chemical engineers.) Preckshot.

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. Preckshot.

89-90—CHEMICAL ENGINEERING SURVEY. Elementary study of the principles of the unit operations and application to inorganic and organic technology, stoichiometry and chemical engineering economics. Combined as a unit subject. 5 cred. per qtr.; prereq. Org.Chem. 61 and 62; 3 lect. and 2 rec. hrs. per week. (For chemists only.)

100—CHEMICAL ENGINEERING STOICHIOMETRY. 3 cred.; prereq. Anal. Chem. 1, 2, 3 lect. and rec. hrs. per week. Ceaglske, Bancroft.

101—UNIT OPERATIONS. Fundamental principles of unit operations, materials of construction, performance and uses of equipment. Crushing, grinding, size separation, and fluid flow. 3 cred.; prereq. Chem.E. 80, Anal.Chem. 1, 2; 2 lect. and 2 rec. hrs. per week. Amundson, Stoppel, Madden, Preckshot, Bond.

102—UNIT OPERATIONS. Continuation of Course 101 on filtration, heat transfer, evaporation, humidification, and air conditioning. Their applications and the solution of problems. 5 cred.; prereq. Chem.E. 101; 3 lect. and 3 rec. hrs. per week. Amundson, Stoppel, Madden, Preckshot, Bond.

103—UNIT OPERATIONS. Continuation of Courses 101 and 102 on drying, distillation, absorption, and extraction, with problems. 5 cred.; prereq. Chem.E. 102; 3 lect. and 2 rec. hrs. per week. Amundson, Stoppel, Madden, Preckshot, Bond.

104—UNIT OPERATIONS. An elective course primarily for undergraduates to include topics sparsely covered or not considered in Chem.E. 101-102-103. 3 cred.; 3 lect. and rec. hrs. per week. Preckshot.

105—FUELS AND COMBUSTION. The technology of solid, liquid, and gaseous fuels; analysis, combustion characteristics, specific uses, and furnaces. Calculation of heat and material balances. 2 cred.; prereq. Anal.Chem. 1-2; 2 lect. and rec. hrs. and 4 lab. hrs. per week. Chem.E. 100 and 105 must be taken by students in four-year curriculum. Ceaglske, Stoppel, Preckshot, Bancroft, Bond.

106—PETROLEUM AND PETROLEUM PRODUCTS. Technology and testing of petroleum products, principally gasoline, lubricating oils, and fuel oils. 3 cred.; prereq. Org.Chem. 61, or by permission; 3 lect. and 4 lab. hrs. per week. Stoppel.

107—PETROLEUM REFINERY ENGINEERING. Unit operations and chemical engineering design principles and calculations involved in the manufacture of the principal petroleum products. 3 cred.; prereq. Chem.E. 103 or by permission; 3 lect. hrs. per week. Amundson.

111—UNIT OPERATIONS LABORATORY. 1 cred.; prereq. Chem.E. 101; 4 lab. hrs. per week. Ceaglske, Stoppel, Bancroft, Bond.

112—UNIT OPERATIONS LABORATORY. 1 cred.; prereq. Chem.E. 102; 4 lab. hrs. per week. Ceaglske, Stoppel, Bancroft, Bond.

113—UNIT OPERATIONS LABORATORY. 1 cred.; prereq. Chem.E. 103; 4 lab. hrs. per week. Ceaglske, Stoppel, Bancroft, Bond.

117-118—CHEMICAL ENGINEERING EQUIPMENT DESIGN. Fundamental principles in the design of simple chemical engineering equipment. 3 cred.; prereq. Chem.E. 103, M.&M. 85 and 87; 3 rec. and 4 lab. hrs. per week. Bancroft.

119-120—CHEMICAL ENGINEERING THERMODYNAMICS. A study of the principles of the three fundamental laws of energy as applied to chemical engineering problems. 3 cred.; prereq. Chem.E. 103; 3 rec. hrs. per week. Ceaglske, Preckshot.

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. Chem.E. 131; 3 lect. hrs. per week.

125—REACTION KINETICS IN CHEMICAL ENGINEERING. Applications of the principles of reaction kinetics to chemical engineering process development. 3 cred.; prereq. permission of instructor; 3 lect. and rec. hrs. per week. (Offered in alternate years; not offered in 1950-51.)

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. 4 cred.; prereq. Chem.E. 102 for chemical engineers, Chem.E. 89-90 for chemists; 4 lect. and 1 rec. hr. per week. Madden.

132—ORGANIC TECHNOLOGY. Similar to Course 131 but covering the organic field. Destructive distillation of coal and wood, petroleum, organic processes, synthetic products, plastics, cellulose products, etc. 3 cred.; prereq. Chem.E. 103 and 132 for chemical engineers, Chem.E. 89-90 for chemists; 4 lect. and 1 rec. hr. per week.

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. 63; 3 lect. hrs. per week.

137-138—ADVANCED UNIT PROCESSES. An extension of Chem.E. 131-132. Recent technical developments in inorganic and organic technology. 3 cred. per qtr.; prereq. Chem.E. 131-132 or equiv.; 3 lect. and rec. hrs. per week. (Offered in alternate years; not offered in 1950-51.)

140—WATER AND SEWAGE TREATMENT. A discussion of the chemistry of water treatment and disposal of sewage and industrial waste. 3 cred.; prereq. jr. or by permission; 3 lect. and rec. hrs. per week. Stoppel.

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. Chem.E. 103, 131. Staff.

152*—CHEMICAL MANUFACTURE (ORGANIC). Similar to Course 151 but covering the unit organic processes. Laboratory. 3 or more cred.; prereq. Chem.E. 103, 132. Staff.

153-154-155-156—SPECIAL PROBLEMS. Investigations in chemical engineering. Library or laboratory research. 3 or more cred. per qtr.; 1 conf. hr. per week, lab. hrs. ar. Staff.

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

171-172—INSTRUMENTATION AND CONTROL. Theory and application of instrumentation and control with particular emphasis on application to the chemical industry, including some theory of servomechanisms. 3 cred.; prereq. by permission; 3 lect. and rec. hrs. per week. Ceaglske.

176-177—APPLIED ELECTROCHEMISTRY. Laws and phenomena of electrochemistry including batteries, electroplating, electric furnace operation, and electrochemical products. 4 cred. per qtr.; prereq. Phys.Chem. 103, or by permission; 3 lect. and 4 lab. hrs. per week. Madden.

187—INSPECTION TRIP. Various industrial plants in the Middle West are visited by the class on a trip which lasts about 6 days, during the spring vacation period. A written report covering the plants visited must be submitted. 2 cred.; prereq. Chem.E. 131 and 132. Required of seniors and fifth year chemical engineers. Staff.

191-192-193—SEMINAR. 1 cred. per qtr.; prereq. seniors or fifth year chemical engineers. Piret, Amundson.

201-202-203—SEMINAR. Presentation and discussion of papers concerning the newer developments in chemical engineering. 1 cred. per qtr.; prereq. grad. Piret, Amundson.

205-206-207—ADVANCED UNIT OPERATIONS. A study of basic principles and of new developments in the unit operations. Theory and applications to equipment and process design including economic balance problems. 3 cred. per qtr.; prereq. Chem.E. 103. Piret.

208-209-210—ADVANCED UNIT OPERATIONS. An extended study of the principles of chemical engineering and their applications to industrial problems. Survey of the literature. 3 cred.; prereq. Chem.E. 103. Piret, Madden. (Offered in alternate years; not offered in 1950-51.)

211-212-213—PROCESS AND PLANT DESIGN. Several phases of chemical engineering training including unit operations, reaction kinetics, economic balance and market survey are combined to develop from laboratory and literature data an economic and technically sound industrial process for a projected chemical product. Equipment and plant layout prepared. Cost analyses. 3 cred. per qtr.; prereq. Chem.E. 103; 6 lab. hrs. per week.

214-215-216—ADVANCED MATHEMATICS FOR CHEMICAL ENGINEERS AND CHEMISTS. Numerical analyses; ordinary and partial differential equations; Fourier series and special functions; finite difference equations; partial differentiation. Theory of heat conduction and diffusional operations. 3 cred.; prereq. differential equations; 3 lect. and rec. hrs. per week. Amundson.

220—ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS. An advanced course covering chemical engineering applications. 3 cred.; prereq. Phys.Chem. 201-202; 3 lect. and rec. hrs. per week. Amundson. (Offered in alternate years; not offered in 1950-51.)

225—FLUID FLOW AND RELATED TOPICS. A fundamental course covering advanced topics in viscous and turbulent fluid flow, eddy diffusion and heat transfer. 3 cred.; prereq. by permission; 3 lect. and rec. hrs. per week. Amundson. (Offered in alternate years; not offered in 1950-51.)

301-302-303—RESEARCH IN CHEMICAL ENGINEERING. Unit operations, applied unit processes, electrochemistry and electric furnace work, and chemical manufacture. Cred. ar. Ceaglske, Piret, Amundson, Stoppel, Madden.

Chemistry

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†—QUANTITATIVE 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 (for chemists), Inorg.Chem. 12 (for chem. eng.); 1 lect., 1 rec., 1 quiz, and 9 lab. hrs. per week. Meehan, Herr.

7—QUANTITATIVE ANALYSIS. (Premed.) Introductory course 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 or 12; 1 lect., 1 rec., 1 quiz, and 9 lab. hrs. per week. Meehan, O'Connor.

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 or 12, 1 lect., 1 rec., and 6 lab. hrs. per week. Meehan, O'Connor.

96-97-98—SENIOR THESIS. 5 cred. per qtr.; sr. Kolthoff, Sandell, Meehan.

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

103—QUANTITATIVE INORGANIC MICROANALYSIS. Representative methods of micro- and semi-microgravimetric, volumetric, and colorimetric analysis. 3 cred.; prereq. Anal.Chem. 1, 2; 1 lect. and 6 lab. hrs. per week. Class limited to 16 students. Sandell.

104—QUALITATIVE INORGANIC MICROANALYSIS. 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. Anal.Chem. 1, 2; 1 lect. and 6 lab. hrs. per week. Sandell.

105—POLARIZING MICROSCOPE. Its use and application to chemistry. Identification of substances. 3 cred.; prereq. Phys.Chem. 101; 1 lect. and lab. hr. ar. per week. Sandell.

106-107-108—GENERAL TECHNICAL ANALYSIS. Analysis of commercially important materials such as iron, steel, nonferrous alloys, ores, and glass; use of microscope in technical problems; quantitative analysis of heterogeneous mixtures, particle size determinations. 2 or 3 cred. per qtr.; prereq. Anal.Chem. 1, 2; 1 lect. and lab. hrs. ar. per week. Sandell.

109—ROCK ANALYSIS. Laboratory course covering the technique of rock analysis. 3 cred.; prereq. Anal.Chem. 1, 2 and permission of instructor. Peck.

122—ADVANCED ANALYTICAL CHEMISTRY. Condensed review of modern fundamentals of gravimetric and volumetric analysis. 2 cred.; prereq. Anal. Chem. 1, 2. 2 lect. hrs. per week. Meehan.

123—ADVANCED ANALYTICAL CHEMISTRY. Analysis of complex materials by modern methods. 3 cred.; prereq. Anal.Chem. 1, 2, or by permission; 1 lect. hr. per week, 6 lab. hrs. per week. Meehan.

127—OPTICAL METHODS IN ANALYTICAL CHEMISTRY. 2 cred.; prereq. Phys.Chem. 103; 2 lect. hrs. per week. Meehan.

131—APPLICATIONS OF INDICATORS IN NEUTRALIZATION REACTIONS AND *p*H DETERMINATIONS. 2 cred. without lab., 3 cred. with lab.; prereq. Anal.Chem. 1, 2, and Phys.Chem. 103; 2 lect. and 3 lab. hrs. per week. Kolthoff.

† Course 2 may precede 1 if necessary.

132*—ELECTROMETRIC MEASUREMENTS AND TITRATIONS. Application of potentiometric and conductometric methods in analytical work. 2 cred. without lab., 3 cred. with lab.; prereq. Anal.Chem. 1, 2, and Psys.Chem. 103; 2 lect. and 3 lab. hrs. per week. Kolthoff.

133—VOLTAMMETRY AND AMPEROMETRIC TITRATIONS. A lecture course. A discussion of the use of the dropping mercury electrode (polarograph) and the platinum microelectrode in pure and applied chemistry. 2 cred.; prereq. Anal.Chem. 1, 2 and Phys.Chem. 103; 2 lect. hrs. per week. Kolthoff.

134—VOLTAMMETRY AND AMPEROMETRIC TITRATIONS. A laboratory course. 2 cred.; prereq. cred. in, or registration in Anal.Chem. 133; 6 lab. hrs. Kolthoff.

135-136-137—SEMINAR: MODERN PROBLEMS IN ANALYTICAL CHEMISTRY. 1 cred. per qtr.; prereq. Anal.Chem. 1, 2, and Phys.Chem. 103; 1 lect. hr. per week. Kolthoff.

138—ADVANCED VOLUMETRIC ANALYSIS. 3 cred.; prereq. Anal.Chem. 131; 2 lect. and lab. hrs. ar. per week. Kolthoff.

140—WATER ANALYSIS. Analysis of potable water with interpretation of results. 2 cred.; prereq. Anal.Chem. 1, 2. Sandell.

201-202-203—SELECTED TOPICS IN ANALYTICAL CHEMISTRY. 3 cred. per qtr.; prereq. Anal.Chem. 1, 2, and 123. Kolthoff.

301-302-303—RESEARCH IN QUANTITATIVE ANALYSIS. Cred. ar. Kolthoff, Sandell, Meehan.

INORGANIC CHEMISTRY

1-2—GENERAL INORGANIC CHEMISTRY. (Agr., S.L.A., predent., premed., eng., and mines without high school chem.) Study of the general laws of chemistry and of the nonmetals and metals and their compounds. 4 cred. per qtr.; no prereq.; 3 lect., 1 quiz, and 4 lab. hrs. per week. Barber, Pervier, Pray.

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 4 lab. hrs. per week. (Students doing unsatisfactory work in this course will be required to take two additional hours per week.) Heisig, Maynard, Brasted, Johnson, Lindeke.

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.; 3 lect., 1 quiz, and 5 lab. hrs. per week. O'Brien, Johnson.

9**-10—GENERAL INORGANIC CHEMISTRY. Study of general laws of chemistry and of nonmetals, metals, and their compounds. 5 cred. per qtr.; prereq. one year of high school chemistry; 3 lect., 1 quiz, and 5 lab. hrs. per week. Sneed.

11—SEMIMICRO QUALITATIVE ANALYSIS. Laboratory work in systematic qualitative analysis of cations with lectures on solutions, ionization, chemical and physical equilibria, oxidation and reduction, etc. 4 cred.; prereq. Inorg. Chem. 2, 5, 7, or 10; 3 lect. and 4 lab. hrs. per week. Barber, Heisig, Pervier, Maynard, Brasted, Johnson, Lindeke.

12-13—SEMIMICRO QUALITATIVE ANALYSIS. Laboratory work in systematic qualitative analysis of the cations in 12 and of the anions in 13 with lectures on solutions, ionization, chemical and physical equilibria, oxidation and reduction, etc. 5 cred. per qtr.; prereq. Inorg.Chem. 2, 5, 7, or 10; 3 lect. and 6 lab. hrs. per week for Course 12; 2 lect., 1 quiz, and 8 lab. hrs. per week for Course 13. Sneed, Brasted, Heisig.

* For permissible substitute, see page 93.

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

52,53,54—SEMINAR: MODERN PROBLEMS IN INORGANIC CHEMISTRY. 1 cred. per qtr.; prereq. sr.

96-97-98—SENIOR THESIS. 5 cred. per qtr.

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. Barber.

103-104-105—ADVANCED INORGANIC CHEMISTRY. (Fall) Atomic structure and the properties of elements based thereon. (Winter) Chemistry of the more representative elements. (Spring) Coordination compounds. 3 cred. per qtr.; prereq. Anal.Chem. 1, 2, Org.Chem. 62; 3 lect. hrs. per week. O'Brien, Brasted, Maynard.

106-107—CHEMISTRY OF THE LESS FAMILIAR ELEMENTS. 3 cred. per qtr.; prereq. Anal.Chem. 1, 2, Org.Chem. 62; 3 lect hrs. per week. O'Brien.

108—NONAQUEOUS SYSTEMS. A study of the principal nonaqueous systems, both protonic and aprotonic systems. The theories of Bronsted, Lewis, and Usanovich are considered in detail. 3 cred.; prereq. Anal.Chem. 1, 2, Org. Chem. 62; 3 lect. hrs. per week. Pray.

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. 63; 2 lect. hrs. with lab. Heisig.

111—SILICON AND RELATED ELEMENTS. Review of current studies on boron, silicon, germanium, tin, and lead, with emphasis on recent silicon chemistry. 3 cred.; prereq. Anal. Chem. 1, 2, Org.Chem. 62; 3 lect. hrs. per week. Johnson.

134-135-136—SEMINAR: MODERN PROBLEMS IN INORGANIC CHEMISTRY. 1 cred. per qtr.; prereq. grad.

301-302-303—RESEARCH IN INORGANIC CHEMISTRY. Cred. ar. Sneed, Barber, Brasted, Heisig, Maynard, O'Brien, Johnson, Pray.

ORGANIC CHEMISTRY

61-62†—ELEMENTARY ORGANIC CHEMISTRY. (Chem., Chem.E., premed., predent., pharm.) Discussion of important classes of organic compounds, both aliphatic and aromatic together with some heterocyclic compounds. Laboratory work includes the preparation of typical substances. 4 cred. per qtr.; prereq. 12-15 cred. in chem.; 3 lect., 1 lab. conference, 1 quiz, and 4 lab. hrs. per week. Arnold, Koelsch, Dodson.

63—ELEMENTARY ORGANIC CHEMISTRY. Lecture course. Continuation of 61-62. This course is prerequisite to all other advanced courses in organic chemistry. 3 cred.; prereq. 62; 3 lect. and 1 quiz hr. per week. Parham.

64—ELEMENTARY ORGANIC CHEMISTRY LABORATORY. To accompany or follow Course 63. This course is prerequisite to all advanced courses in organic chemistry. 3 cred.; prereq. cred. or reg. in Course 63. 6 lab. hrs. and 1 conference hr. per week. Parham.

96-97-98—SENIOR THESIS. 5 cred. per qtr.; sr.; prereq. Org.Chem. 63 and 64. May be taken with any member of the staff of the Division of Organic Chemistry.

101—INTERMEDIATE ORGANIC CHEMISTRY. A survey course in which are considered important modern topics such as unusual types of aliphatic, aromatic, and heterocyclic compounds, natural products, and industrial processes. 3 cred.; prereq. 14 cred. in org. chem.; 3 lect. hrs. per week. Lauer.

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

102—CHARACTERIZATION OF ORGANIC COMPOUNDS. (Elementary course.) An introduction to the methods of organic qualitative analysis. 3 cred.; prereq. one year of org. chem.; 1 lect., 6 lab. hrs. per week. Lauer.

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. Org.Chem. 63 and 64 or equiv.; 3 lect. hrs. per week. Smith.

110—ADVANCED ORGANIC QUALITATIVE ANALYSIS. For graduate students. 3 cred.; prereq. Org.Chem 102 or equiv.; 9 lab. hrs. per week. Koelsch.

116—HETEROCYCLIC COMPOUNDS. Discussion of typical classes of heterocyclic compounds, their chemical and physical properties and uses, and the ring closures leading to heterocycles. 3 cred.; prereq. Org.Chem. 63 and 64 or equiv. Parham.

130—ORGANIC QUANTITATIVE ANALYSIS. Methods of proximate and ultimate analysis of organic compounds, with special attention to semimicro methods. 3 cred.; prereq. permission of instructor, Org.Chem. 63 and 64 and Anal.Chem. 1 and 2; 1 lect., 6 lab. hrs. per week. 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. Org.Chem. 63 and 64. 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. Org.Chem. 63 and 64; 3 lect. hrs. per week. Koelsch. (Offered in alternate years; not offered in 1950-51.)

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. Org.Chem. 63 and 64; 3 lect. hrs. per week. Koelsch.

142—THE CHEMISTRY OF NATURAL PRODUCTS. Discussion of the organic chemistry of important classes of natural products. 3 cred. per qtr.; prereq. 63 and 64; 3 lect. hrs. per week. Parham. (Offered in alternate years; not offered in 1950-51.)

151-152-153—ORGANIC CHEMISTRY SEMINAR. (For seniors.) 1 cred. per qtr.; 1 hr. per week. Staff.

201-202-203—ORGANIC CHEMISTRY SEMINAR. Required of all graduate students taking major work in organic chemistry. 1 cred. per qtr.; 1 hr. per week. Smith, Koelsch, Lauer, Arnold, Dodson, Parham.

205-206—THEORETICAL ORGANIC CHEMISTRY. Structure, reaction mechanisms, relation of physical properties to constitution, and other topics of a theoretical nature. Course 205 will center around a discussion of stereochemistry and stereochemical problems; Course 206 will center around a discussion of polymerization and high polymers. 3 cred. per qtr.; prereq. Org.Chem. 107. 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. Org.Chem. 107, Phys.Chem. 103, and calculus, or permission of instructor. Arnold.

301-302-303—RESEARCH IN ORGANIC CHEMISTRY. Cred. ar.; prereq. Org. Chem. 110 and permission of the division.

PHYSICAL CHEMISTRY

Candidates for an advanced degree in the Graduate School, who are not majoring in chemistry, may offer Physical Chemistry 101-102-103, 104-105-106, or 107-108 in partial or complete fulfillment of the course requirements for a minor in physical chemistry.

96-97-98—SENIOR THESIS. 5 cred. per qtr.

101-102-103—PHYSICAL CHEMISTRY. General survey of the subject. 3 cred. per qtr.; prereq. Anal.Chem. 1, 2 (or Anal.Chem. 7 for physicists), Physics 7, 8, 9, differential and integral calculus; 3 lect., 1 rec. hr. per week. Crawford, Lipscomb, Wertz.

104-105-106—PHYSICAL CHEMISTRY LABORATORY. 1 or 2 cred. per qtr. To accompany or follow 101-102-103; 1 rec., 5 lab. hrs. per week. Livingston, Wertz.

107-108—ELEMENTARY PHYSICAL CHEMISTRY. (Premed.) 3 cred. per qtr.; prereq. two years of college chem., one year of college phys., and Math. 15-16 or 6-7; 2 lect., 1 rec., 3 lab. hrs. per week. Lipscomb.

110—EXPERIMENTAL RESEARCH TECHNIQUES I. Physical manipulations, including the use of tools and machines as well as a course in glass blowing with demonstrations and practice by the student. 2 cred.; prereq. Phys.Chem. 103 and consent of instructor. Wertz.

111—EXPERIMENTAL RESEARCH TECHNIQUES II. Materials of research, high vacuum techniques, characteristics of thermionic tubes, rectifiers, amplifiers, oscillators, photocells. 2 cred.; prereq. Phys.Chem. 110. Wertz.

112—ADVANCED PHYSICOCHEMICAL EXPERIMENTS. Precise measurements in various fields such as thermochemistry, electromotive force, conductance, analysis of Raman spectra, surface tension, magnetic susceptibility, dielectric constant, characteristics of the photographic plate and ionization potentials of a gas. 2 cred.; prereq. Phys.Chem. 111. Wertz.

113—FUNDAMENTALS OF REACTION KINETICS. Empirical analysis of rate measurements, collision theory, transition state theory, chain reactions. 3 cred.; prereq. Phys.Chem. 103. Livingston.

114—KINEMATICS OF REACTIONS IN LIQUID AND HETEROGENEOUS SYSTEMS. Effect of solvents and electrolytes on reaction velocity; diffusion processes; induced reactions; homogeneous and heterogeneous catalysis. 3 cred.; prereq. Phys.Chem. 113; 3 lect. per week. Livingston. (Offered in alternate years; not offered in 1950-51.)

116—ADVANCED PHYSICAL CHEMISTRY. Thermodynamics. Designed to cover the fundamentals with applications to chemical problems. 3 cred.; prereq. Phys.Chem. 103; 3 lect. hrs. per week. Crawford.

117—ADVANCED PHYSICAL CHEMISTRY. Thermodynamics of electrolytic solutions. Phase rule and applications. 3 cred.; prereq. Phys.Chem. 116; 3 lect. hrs. per week. Livingston.

118—ADVANCED PHYSICAL CHEMISTRY. Elementary reaction kinetics. Methods of determining molecular structure with simple applications. Chemical and physical properties in terms of the nature of chemical bonds. 3 cred.; prereq. Phys.Chem. 117; 3 lect. hrs. per week.

120-121—INTRODUCTION TO MOLECULAR STRUCTURE. Elementary quantum mechanics and statistical mechanics will be discussed and applied to the problem of the chemical bond. 3 cred. per qtr.; prereq. Phys.Chem. 103; 3 lect. hrs. per week. Crawford.

122—CRYSTAL CHEMISTRY. Elementary survey of crystal chemistry. Crystals containing ionic, covalent, and metallic bonds. Relation between crystal structures and chemical and physical properties. Glasses, fibers, and liquids. 3 cred.; prereq. Phys.Chem. 103; 3 lect. hrs. per week. Lipscomb. (Offered in alternate years; not offered in 1950-51.)

123-124—CRYSTAL ANALYSIS. Theory and practice of X-ray crystallography. Methods and examples of structure determinations. 3 cred. per qtr.; prereq. Phys.Chem. 103; 3 lect. hrs. per week. Lipscomb.

128—COLLOID CHEMISTRY. The fundamental principles of colloid chemistry, surface chemistry, electrokinetic phenomena, lyophobic and lyophilic colloids. 3 cred.; prereq. Phys.Chem. 103; 3 lect. hrs. per week. Reyerson.

129—ADSORPTION AND CATALYSIS. The fundamental principles of adsorption at the different interfaces and the application of these principles to heterogeneous catalysis. 3 cred.; prereq. Phys.Chem. 128; 3 lect. hrs. per week. Reyerson.

130—COLLOIDS IN INDUSTRY. The important applications of colloid chemistry to many of the fields of chemical industry. 3 cred.; prereq. Phys.Chem. 128. 3 lect. hrs. per week. Reyerson.

131—COLLOIDAL PROCESSES. A survey of the important colloidal processes; coagulation, sol-gel transformation, thixotropy and dilatancy. 3 cred.; prereq. Phys.Chem. 128. Reyerson. (Offered in alternate years; not offered in 1950-51.)

132-133-134—COLLOID CHEMISTRY LABORATORY. 1 or 2 cred. per qtr.; prereq. cred. or reg. in Phys.Chem. 128; hrs. ar. Reyerson.

150-151-152—PHYSICAL CHEMISTRY SEMINAR FOR SENIORS. 1 cred. per qtr. Livingston.

161-162—NUCLEAR CHEMISTRY AND RADIOACTIVITY. The properties of nuclei, disintegration, properties of radiations; natural and artificial radioactivity; modern views of nuclear structure. 3 cred. per qtr.; prereq. Phys.Chem. 103; 3 lect. hrs. per week. O'Connor.

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. Phys.Chem. 103 and Phys. 9; 3 lect. hrs. per week. 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. Phys.Chem. 103 and calculus. 3 lect. hrs. per week. MacDougall. (Offered in alternate years; not offered in 1950-51.)

204-205-206—KINETIC THEORY AND ATOMISTICS. Kinetic theory of gases and liquids, atomic structure, quantum theory. 4 cred. per qtr.; prereq. Phys. Chem. 103 and calculus. 3 lect. hrs. per week. MacDougall.

209—ADVANCED CRYSTAL CHEMISTRY. Zone theory of solids. Conduction and bonding in metals. Electrical, magnetic, optical, and mechanical properties of solids in relation to their structure. 3 cred.; prereq. Phys.Chem. 103; 3 lect. hrs. per week. Lipscomb. (Offered in alternate years; not offered in 1950-51.)

211-212-213—ADVANCED PHYSICAL CHEMISTRY LABORATORY. To accompany or follow any of the advanced courses in physical chemistry. Cred. ar.; prereq. Phys.Chem. 103. MacDougall and staff.

221-222-223—COLLOID SEMINAR. 1 cred. per qtr. Reyerson.

231—RADIOACTIVITY LABORATORY. Use and standardization of electroscopes and Geiger-Muller tubes; radioactive measurements; chemistry of trace quantities. 1 or 2 cred.; must be preceded or accompanied by Phys.Chem. 161. O'Connor.

250-251-252—PHYSICAL CHEMISTRY SEMINAR. 1 cred. per qtr.; required of all graduate students majoring in physical chemistry. Livingston.

301-302-303—RESEARCH IN PHYSICAL CHEMISTRY. Thermodynamics, electrochemistry, photo- and radio-chemistry, reaction kinetics, molecular structure, colloids, adsorption, crystal structure. Cred. ar. MacDougall, Kolthoff, Livingston, Reyerson, Crawford, Lipscomb, O'Connor.

Seminars and Other Courses

Seminars or courses on the following topics may be offered when there is sufficient demand.

254—MOLECULAR VIBRATIONS. The dynamics of molecular vibrations will be discussed with the aid of group theory and the result applied to the interpretation of vibrational spectra. 3 cred. Crawford. (Offered in alternate years; not offered in 1950-51.)

255—QUANTITATIVE THEORY OF VALENCE. The basic method of both the atomic orbital and molecular orbital techniques will be discussed with quantitative applications. 3 cred. Crawford. (Offered in alternate years; not offered in 1950-51.)

256—IONS IN SOLUTION.

257—RESEARCH SEMINAR IN CRYSTAL STRUCTURE. Study of advanced techniques in the determination of crystal structures and evaluation of results of crystal structure investigations. Cred. ar. Lipscomb.

Civil Engineering

SURVEYING: C.E. 11, 12, 13, 14, 15, 16, 17, 23, 109, 112.

RAILROAD ENGINEERING: C.E. 21, 22, 121, 122, 123, 124.

STRUCTURAL ENGINEERING: C.E. 31, 32, 33, 37, 38, 39, 41, 130, 131, 132, 137, 140, 141, 142, 143, 147, 232, 233, 234-235, 236, 237-238-239, 240-241-242, 243-244, 245, 247-248-249.

HIGHWAY ENGINEERING AND SOIL MECHANICS: C.E. 51-52, 53, 146, 148-149-150, 151, 152, 153, 155, 156, 157, 158, 159, 251-252.

SANITARY ENGINEERING: C.E. 135, 162, 163, 165, 173, 174, 175, 179, 180-181-182, 261-262, 264, 276, 277.

GENERAL: C.E. 172, 176, 280-281-282.

HYDRAULIC ENGINEERING: C.E. 160, 161, 164, 166, 168, 263.

HYDRAULICS AND FLUID MECHANICS: C.E. 183, 184-185-186, 187, 190, 191, 192, 193, 194-195-196, 287, 290-291-292, 293-294-295, 296-297-298.

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. Staff.

12—SURVEYING. Lectures and drafting room. Platting of profiles, computation of earthwork volume and overhaul. Public land survey. Mapping and conventional signs. 3 cred.; prereq. M.&M. 12, Dr. 2; 1 lect. and 7 lab. hrs. per week. Staff.

13—SURVEYING. Lectures and field problems; differential and profile leveling; cross sections, circular curves, and adjustment of instruments. 3 cred.; prereq. C.E. 11; 1 lect. and 7 lab. hrs. per week. Staff.

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

15—SURVEYING. Theory and computations of astronomical observations for azimuth, latitude, longitude, and time; theory and use of the sextant; theory, methods and computation of stream discharge measurements and other hydrographic surveys. 2 cred.; prereq. C.E. 12; 1 lect. and 3 lab. hrs. per week. Fant.

16—SURVEYING. Theory, computation, and field problems in precise surveys of triangulation systems, base lines and level circuits; use of Plane Table in topographic surveys. 2 cred.; prereq. C.E. 14; 1 lect. and 4 lab. hrs. per week. Fant, Colcord.

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

21—ROUTE SURVEYING. An analysis of the methods of making surveys of proposed route locations including a study of grades, curvature, rise and fall, drainage, etc., and the economics of selecting alternate routes or structures. 2 cred.; prereq. C.E. 13; 1 lect. and 4 lab. hrs. per week. Klingel.

22—RAILWAY ENGINEERING. Study of the construction and maintenance of railway track and structures, compound and spiral curves, and turnouts. 2 cred.; prereq. C.E. 21; 1 lect. and 3 lab. hrs. per week. Klingel.

23—SUMMER CAMP. Six weeks immediately preceding the beginning of the fourth year. Extended railroad, topographic, hydrographic, and triangulation surveys. 9 cred.; prereq. C.E. 15, 16 and 22. Staff.

31—STRESSES IN STRUCTURES. Algebraic and graphical analysis of structural framework. Influence lines. Equivalent loads. 3 cred.; prereq. M.&M. 26; 3 lect. and 3 lab. hrs. per week. Cutts.

32—DESIGN IN STEEL. Design principles and methods of selecting members and connections. 3 cred.; prereq. C.E. 31, Draw. 23, M.&M. 128; 3 lect. and 3 lab. hrs. per week. Cutts.

33—DESIGN IN TIMBER. Design of timber members and connections. 3 cred.; prereq. Course 32; 3 lect. and 3 lab. hrs. per week. Cutts.

37—ELEMENTARY STRUCTURAL ENGINEERING. (Ag.E., M.E., E.E.) Elementary structural analysis and design in wood, steel, and reinforced concrete. 3 cred.; prereq. M.&M. 128; 2 lect. and 2 lab. hrs. per week. Graves.

38—ELEMENTARY STRUCTURAL DESIGN (STEEL). (Arch.) Elementary structural analysis and design of frame buildings. 3 cred.; prereq. M.&M. 93; 3 lect. hrs. per week. Graves.

39—ELEMENTARY STRUCTURAL DESIGN (STEEL AND TIMBER). (Arch.) Elementary structural analysis and design of timber frame buildings. 3 cred.; prereq. C.E. 38; 3 lect hrs. per week. Graves.

41—ELEMENTARY STRUCTURAL DESIGN (CONCRETE). (Arch.) Elementary structural analysis and design of reinforced concrete for buildings and foundations. 3 cred.; prereq. C.E. 39; 3 lect. hrs. per week. Graves.

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. reg. in M.&M. 128; 2 lect. and 3 lab. hrs. per week for Course 51; 2 lect. and 4 lab. hrs. per week for Course 52. Thomas and staff.

53—ELEMENTS OF SOIL MECHANICS. General characteristics of soils; soil classification; stresses in earth masses. Identification tests and shear tests. 3 cred; prereq. C.E. 52; 2 lect. and 3 lab. hrs. per week. Kersten and staff.

109—CADASTRAL SURVEYING. Study of the methods of accurate surveys of property with geodetic control and with coordinates of property monuments. 2 cred.; prereq. C.E. 16; 2 lect. hrs. per week.

112—AERIAL SURVEYING AND PHOTOGRAMMETRY. Theory and methods of making planemetric and topographic maps from aerial and terrestrial photographs. 3 cred.; prereq. C.E. 23; 1 lect. and 6 lab. hrs. per week. Fant.

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. C.E. 22 and M.&M. 127; 1 lect. and 6 lab. hrs. per week. Klingel.

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. C.E. 22. Klingel.

123—RAILWAY ENGINEERING. Design and construction of railroad buildings and structures; culverts, wooden trestles, switches, crossovers, crossing frogs, etc. 3 cred.; prereq. C.E. 22. Klingel.

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 amendments. Geographical, financial, and rate grouping of railways. Interstate Commerce Commission method of accounting and organization. 3 cred.; prereq. C.E. 22; 3 lect. hrs. per week. Klingel.

130—STATICALLY INDETERMINATE STRUCTURES. Method of moment area. Williot diagram. Slope-deflection method. 3 cred.; prereq. C.E. 33; 2 lect. and 2 lab. hrs. per week. Andersen.

131—STRUCTURAL ANALYSIS. Moment distribution method. 2 cred.; prereq. C.E. 130; 1 lect. and 3 lab. hrs. per week. Andersen.

132—STRUCTURAL DESIGN. Continuous structures of steel and concrete. 2 cred.; prereq. C.E. 131; 1 lect. and 3 lab. hrs. per week. Andersen.

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

140—ADVANCED STRUCTURAL LABORATORY. Continuation of C.E. 137. Calculated and experimental influence lines for framed structures including gabled bents. Secondary stresses for trusses. 3 cred.; prereq. C.E. 137; 2 lect. and 3 lab. hrs. per week. Wise.

141—REINFORCED CONCRETE. Principles of reinforced concrete. Theory of beams, slabs, and columns, and the application to simple structures. 3 cred.; prereq. C.E. 33; 2 lect. and 3 lab. hrs. per week. Wise.

142—REINFORCED CONCRETE DESIGN. Continuation of C.E. 141 with special emphasis on the practical features of the design of buildings, bridges, retaining walls, footings, etc. 3 cred.; prereq. C.E. 130, 141; 2 lect. and 2 lab. hrs. per week. Wise.

143—ARCH ANALYSIS AND DESIGN. Analysis and design of reinforced concrete and steel arches and rigid frame bridges. 3 cred.; prereq. C.E. 131 and 142. Andersen.

146—CONCRETE AND CONCRETE MATERIALS. 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. Thomas and staff.

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. 3 cred.; prereq. C.E. 33 and 141; 3 lect. hrs. per week. Andersen.

148-149-150—ADVANCED CONCRETE. Short research problems in concrete. 2 cred. per qtr.; prereq. C.E. 146. Thomas.

151—ADVANCED HIGHWAY LABORATORY. Special experimental studies of highway materials. 3 cred.; prereq. C.E. 52. Thomas.

152—HIGHWAY DESIGN. Study of the basis for design, design of intersections, street grades, pavement design, plans and specifications. 3 cred.; prereq. C.E. 52. Thomas.

153—SOILS IN HIGHWAY ENGINEERING. Classification, soil maps, surveys, physical tests, compaction, design of graded mixes, and soil stabilization. 3 cred.; prereq. C.E. 53. Kersten.

155—FIELD SOIL STUDIES. Soil classification and mapping, analysis of soil conditions where road failures have occurred. 2 cred.; prereq. C.E. 53. Kersten.

156—HIGHWAY TRAFFIC ENGINEERING. Traffic surveys, highway safety, highway commercial transportation as related to other forms of transportation. 3 cred.; prereq. C.E. 52.

157—HIGHWAY ECONOMICS. Annual highway costs, effect of highway location and design on motor vehicle operating costs. Economical significance of highway accidents. Allocation of 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 cred.; prereq. C.E. 52. Kersten.

159—SOIL MECHANICS. Seepage, consolidation, strength theory. Settlement analysis; stability of slopes; bearing capacity. 3 cred.; prereq. C.E. 53; 3 lect. hrs.

160—APPLIED HYDRAULICS. Pipes and pipe systems, control of water in open channels, automatic control devices, hydraulic turbines, pumping machinery, hydraulic transmission and storage of energy, hydroelectric applications. 3 cred.; prereq. M.&M. 129 and 143; 2 lect. and 4 lab. hrs. per week. Cornell.

161—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; 2 lect. and 4 lab. hrs. per week. Cornell, L. A. Johnson.

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. C.E. 161, M.&M. 129; 2 lect. and 4 lab. hrs. per week. Schroepfer, Johnson, and Ziemke.

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. C.E. 162; 2 lect. and 4 lab. hrs. per week. Schroepfer, Johnson, and Ziemke.

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. C.E. 161, or equiv., or by permission.

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.

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. C.E. 161; 2 lect. and 4 lab. hrs. per week. Recommended for seniors in sanitary engineering. Cornell.

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. C.E. 161; 2 lect. and 3 lab. hrs. per week.

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. C.E. 52.

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. C.E. 162; 3 lect. hrs. per week. Schroepfer.

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. C.E. 163; 3 lect. hrs. per week. Schroepfer.

175—INDUSTRIAL WASTE DISPOSAL. Investigation of quality of various types of industrial wastes and of methods of disposal. Economic studies. 3 cred.; prereq. C.E. 163; 3 lect. hrs. per week. Schroepfer.

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. C.E. 52.

179—SANITARY LABORATORY. The biological, bacteriological, physical, and chemical analyses of water, sewage, air, coagulant chemicals, disinfectants, sewage sludge, etc. 3 cred.; prereq. sr.; 8 lab. hrs. per week. Ziemke.

180-181-182—SANITARY ENGINEERING SEMINAR. Required of sr. and grad. students in sanitary option. 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. Schroepfer.

183—OPEN CHANNEL FLOW. Theory of uniform and varied flow in open channels, with practical applications to the design of hydraulic structures, computations of draw-down curves, backwater curves, hydraulic jump, measuring flumes, submerged weirs, etc. 3 cred.; prereq. M.&M. 86 or 129 or 130 and 143; 3 rec. hrs. per week. Straub.

184-185-186—ADVANCED HYDRAULIC PROBLEMS. Special problems in hydraulic design. 2 cred. per qtr.; prereq. C.E. 183 or reg. in C.E. 183; 6 lab. hrs. per week. Straub and staff. (Offered by individual arrangement.)

187—INTERMEDIATE FLUID MECHANICS. One- and two-dimensional flow of an ideal fluid, energy and momentum relations, fluid forces, boundary layer theory, separation and cavitation, hydrofoils. Prereq.: M.&M. 86 or 129 or 130 and 143. 3 cred.

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. M.&M. 127, 128, and 86 or 129 or 130 or permission of instructor. 3 rec. hrs. per week. Straub, Anderson.

191—HYDRAULIC MOTORS AND PUMPS. Study of the mechanics of turbomachines, including impulse, reaction, and propeller turbines and radial, mixed, and axial flow pumps. Hydraulic transmissions. Torque converters. Miscellaneous pumping devices. 3 cred.; prereq. C.E. 187 or permission of instructor; 3 rec. hrs. per week. Ripken.

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. C.E. 183 or permission; 3 rec. hrs. per week. Straub, Anderson.

193—HYDRAULIC MEASUREMENTS. Detailed study of laboratory and field, methods and instruments for measurement of hydraulic pressure, velocity and discharge. 3 cred.; prereq. C.E. 187 or permission of instructor; 3 rec. hrs. per week. Ripken.

194-195-196—ADVANCED HYDRAULICS LABORATORY. Special experimental studies concerning the characteristics of turbines, pumps, etc. Hydraulic models. 2 cred. per qtr.; prereq. M.&M. 129 and 143; 6 lab. hrs. per week. Straub and staff. Offered by individual arrangement.

232—ADVANCED STRUCTURAL PROBLEMS IN SANITARY ENGINEERING. Theory of domes, tanks, dams, culverts, and elliptical sewer sections. 3 cred.; prereq. C.E. 132. Andersen.

233—ADVANCED FOUNDATIONS. Advanced problems in earth pressure, pile foundations, cofferdams, and caissons. 3 cred.; prereq. C.E. 132 and 147. Andersen.

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. Courses 132, 142. Andersen, Wise.

236—ADVANCED STRUCTURAL DESIGN. Effect of shrinkage and plastic flow. Eccentrically loaded concrete sections. Nonsymmetrical bending. Lateral earth pressure theories. 3 to 5 cred.; prereq. Courses 131, 147. Andersen.

237-238-239—STRUCTURAL MODEL ANALYSIS. Analysis of indeterminate structures by use of models; methods of mechanical analysis; principles of similitude. 3 cred.; prereq. C.E. 137. Staff.

240-241-242—ADVANCED STRUCTURAL LABORATORY. Experimental determination of principal strains by use of three or four intersecting gauge lines; plastic flow and shrinkage; prestressed reinforced concrete; moment redistribution; theory of limit design; theory of similitude; statistical data. Vierendell trusses. 3 to 5 cred. per qtr.; prereq. C.E. 140. Staff.

243—DYNAMICS OF STRUCTURES. Vibrations of beams, trusses, and frameworks. Impact, and effect of suddenly applied forces. Forces on structures due to earthquakes, shocks, and explosions. Fatigue of materials. 3 cred.; prereq. C.E. 132. Wise.

244—DYNAMICS OF STRUCTURES LABORATORY. Laboratory work in vibrations of beams and trusses. 3 cred.; prereq. C.E. 243. Wise.

245—ADVANCED PROBLEMS IN BRIDGE DESIGN. Selection of type and span. Secondary stresses and problems associated with rigidity of joints. 3 cred.; prereq. C.E. 132. Cutts.

247-248-249—SEMINAR. Special topics in the theory of structures. 3 to 6 cred. per qtr.; prereq. C.E. 131 and 142. Staff.

251-252—ADVANCED SOIL MECHANICS LABORATORY. Consolidation; permeability; direct shear; triaxial compression; California bearing ratio; and other special laboratory problems in soil mechanics. 3 cred. per qtr.; prereq. C.E. 159 or reg. in 159.

261-262—WATER AND SEWAGE PLANT DESIGN. Design of water purification and sewage treatment works. 3 to 5 cred. per qtr.; prereq. C.E. 173 or 174. Schroepfer.

263—ADVANCED HYDRAULIC ENGINEERING PROBLEMS. Special hydraulic problems in laboratory, drafting room, and field. 3 to 5 cred.; prereq. C.E. 183, 190 and 192 or equivalent.

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, handling of material, drying, incineration, and digestion. 3 cred.; prereq. grad.; 1 lect. and 6 lab. hrs. per week. Schroepfer.

276—ADVANCED SANITARY ENGINEERING (WATER). Principles of water collection, distribution, and purification. Inspections and investigations of water works systems. Advanced study of certain phases of purifications. 3 to 5 cred.; prereq. C.E. 173. Schroepfer.

277—ADVANCED SANITARY ENGINEERING (SEWAGE AND INDUSTRIAL WASTE). Principles of sewage collection and treatment, and of industrial waste disposal. Inspection and investigation of sewage works. Advanced study of certain phases of sewage treatment. 3 to 5 cred.; prereq. C.E. 174. Schroepfer.

280-281-282—CIVIL ENGINEERING RESEARCH. Original work in concrete, structural steel, hydraulics, municipal, sanitary, or transportation problems. Investigations, reports, tests, designs. 5 cred. per qtr.; prereq. by permission. Staff.

287—FLUID TURBULENCE. Quantitative description of turbulence; momentum and vorticity transfer theories; statistical theory of turbulence. Phenomena of turbulence diffusion energy dissipation. Turbulence in wind-tunnels, rivers, and the atmosphere. 3 cred.; prereq. basic training in fluid mechanics and consent of the instructor. (Not offered 1950-51.)

290-291-292—ADVANCED FLUID MECHANICS. 3 cred. per qtr.; prereq. C.E. 190; 3 rec. hrs. per week. (Not offered 1950-51.)

293-294-295—HYDRODYNAMICS. Equations of motion, irrational flow, potential theory, two-dimensional motion, complex potentials, three-dimensional motion, solids in a fluid, vortex motion, waves, compressibility, viscous flow. 3 cred. per qtr.; prereq. C.E. 187 and differential equations or advanced calculus, or permission of instructor. 3 rec. hrs. per week. Silberman.

296-297-298—ADVANCED HYDRODYNAMICS. 3 cred. per qtr.; prereq. C.E. 295; 3 rec. hrs. per week. Silberman. (Not offered 1950-51.)

Dairy Husbandry

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

1—ELEMENTS OF DAIRYING. Lectures and demonstrations with opportunity for laboratory practice. The history and development of the dairy industry. The origin and classification of domesticated cattle. History and characteristics of the dairy breeds of cattle. Milk, its composition, food value, chemical and physical properties with relation to the handling of milk, sanitary milk production, and the manufacture of milk products. Dairy arithmetic. 3 cred.; prereq. entrance cred. in chem. or In.Ch. 1 or 4; 3 lect. hrs. per week. Combs.

3—TESTING DAIRY PRODUCTS. The use of the Babcock test and other tests common to dairy products plants. 2 cred.; prereq. Course 1.

101—MILK PRODUCTION. Problems of the dairy farmer, such as characteristics and adaptation of dairy breeds; selection and management of dairy herd and sires; calf raising, dairy barns. 3 cred.; prereq. Course 1.

103—DAIRY STOCK FEEDING. Application of principles of nutrition to feeding dairy animals. Feeding standards; characteristics of various feeding stuffs; formulation of rations. 3 cred.; prereq. Course 101, An.Husb. 56.

110—DAIRY PRODUCTS: ICE CREAM AND FROZEN DESSERTS. The manufacture of ice cream with special reference to the chemical and physical processes involved. Organization, construction, equipment, and operation of such factories. Lab. and lect. 3 cred.; prereq. Courses 1, 3.

114—MILK BY-PRODUCTS. The manufacture of condensed milk, dry milk, and other milk by-products with special reference to the physical processes involved. Lab. and lect. 3 cred.; prereq. Courses 1, 3.

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, and tracing. 3 cred.; prereq. solid geometry; 8 lect. and lab. hrs. per week. Schuck and others.

2—ENGINEERING DRAWING. A continuation of Course 1 including fastenings, sectional views, auxiliary projections, and blue printing. 3 cred.; prereq. Draw. 1; 8 lect. and lab. hrs. per week. Schuck and others.

3—DESCRIPTIVE GEOMETRY. Elementary course in the graphic solutions of space problems, correlated in part with algebraic solutions, lectures, demonstrations, and drafting. 3 cred.; prereq. Draw. 2, M.&M. 11; 8 lect. and lab. hrs. per week. Eggers and others.

7—ENGINEERING DRAWING. (Chem. and Chem.E.) An abbreviated course in methods of graphical representation including lettering, freehand sketching, theory of orthogonal projection, dimensioning, sectional views and pictorial drawings. 3 cred.; prereq. solid geometry; 8 lect. and lab. hrs. per week. Schuck and others.

8—ENGINEERING DRAWING. (Chem. and Chem.E.) A continuation of Course 7 with particular emphasis on space problems, fastening devices, piping, and working drawings. 3 cred.; prereq. Draw. 7; 8 lect. and lab. hrs. per week. Schuck and others.

10—SOLID GEOMETRY. Lines and planes in space, dihedral and polyhedral angles, polyhedrons, surfaces, cylinders, cones, and spheres. Numerical exercises in areas, volumes, weights. No cred.; prereq. plane geometry; 3 lect., rec., and quiz hrs. per week. Eggers and others.

21—DRAFTING. (C.E.) Application of descriptive geometry to drafting room problems including working drawings. 2 cred.; prereq. Draw. 3; 6 lab. hrs. per week. Myers and others.

22—STRUCTURAL DETAILING. (C.E.) Detail, assembly, and construction drawing of steel members and simple structures. Standards and conventions. 2 cred.; prereq. Draw. 21; 6 lab. hrs. per week. Myers and others.

23—STRUCTURAL DETAILING. (C.E.) Drafting problems in general construction work including earthwork, wood, steel, and concrete. 2 cred.; prereq. Draw. 22; 6 lab. hrs. per week. Myers and others.

26—DRAFTING. (E.E.) Applications of descriptive geometry to drafting room problems. Working drawings including limit dimensioning. 2 cred.; prereq. Draw. 3; 6 lect. and lab. hrs. per week. Myers and others.

28—DRAFTING. (Aero.E.) Applications of descriptive geometry to drafting room problems. Working drawings. 2 cred.; prereq. Draw. 3; 6 lect. and lab. hrs. per week. Myers and others.

29—DRAFTING. (Aero.E.) Detail, assembly, and layout drawings. Standard practices in the aircraft industry. Army and Navy standards and specifications; limit dimensioning. 2 cred.; prereq. Draw. 28; 6 lect. and lab. hrs. per week. Myers and others.

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

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. Draw. 2; 2 lect. and rec. hrs. per week. Potter and others.

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. Draw. 2; 2 lect. and rec. hrs. per week. Potter and others.

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

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. Draw. 44; 2 lect. and rec. hrs. per week. Potter.

50—DIAGRAMS AND CHARTS. Elementary course dealing with the construction of simple diagrams and charts. 2 cred.; prereq. Draw. 1; 2 lect. and rec. hrs. per week. Potter and others.

51—GRAPHIC REPRESENTATION AND COMPUTATION. Types of charts and applications to the solution of problems and equations. 3 cred.; prereq. Draw. 2, M.&M. 11; 3 lect. and rec. hrs. per week. Potter and others.

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. Draw. 2, M.&M. 12; 3 lect. and rec. hrs. per week. Potter and others.

55—PRODUCTION ILLUSTRATION. Detail and assembly drawing by use of isometric, oblique, axonometric freehand, and mechanical perspective. Shaded drawings suitable for reproduction. 2 cred.; prereq. Draw. 3; 6 lect. and lab. hrs. per week. Potter and others.

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. Draw. 3, M.&M. 25; 3 lect. and rec. hrs. per week. Eggers and others.

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. Draw. 3, M.&M. 25; 3 lect. and rec. hrs. per week. Eggers and others.

118—SHORT COURSE IN CURVE FITTING. Derivation of formulas to fit experimental data. Combination of graphic and algebraic methods. 3 cred.; prereq. Draw. 3, M.&M. 25, or permission of instructor; 3 lect. and rec. hrs. per week. Eggers and others.

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 coordinates. Use of determinants for the construction of alignment charts. Special rules. 3 cred. per qtr.; prereq.

Draw. 52 or equiv., M.&M. 25; 3 lect. and rec. hrs. per week. Eggers and others.

157-158-159—GRAPHICAL MATHEMATICS. Graphical calculus. Polar diagram method of stress analysis. 2 cred. per qtr.; prereq. Draw. 3, M.&M. 26; 2 lect. and rec. hrs. per week. Eggers and others.

Economics and Business Administration

(School of 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. 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. Kozelka and others.

6-7†—PRINCIPLES OF ECONOMICS. A course in the fundamental principles of economics intended to serve as a foundation for advanced courses in business administration and economics. 5 cred. per qtr.; prereq. soph., jr., sr.; 2 lect. and 3 rec. hrs. per week. Smith 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.; prereq. soph., jr., sr.; 3 rec. hrs. per week. Filipetti and others.

28§—BUSINESS LAW. A practical course on the law of contacts, agency, partnership, corporations, negotiable instruments, real estate, deeds, mortgages, fixtures, leases, mechanics' liens, workmen's compensation. 3 cred.; soph., jr., with 6 cred. in econ., or seniors without econ. cred.; 3 rec. hrs. per week. Palmer.

50—INSURANCE PRINCIPLES. An introductory course dealing with the nature and measurement of risk and the development and uses of personal, property, and liability insurance. Forms of protection; policy contracts; social insurance and government regulation. 3 cred.; jr., sr.; prereq. Econ. 6-7 or equiv.

54-55—ELEMENTARY ACCOUNTING—COMBINED COURSE. A combination of Econ. 24, 25, 26 for engineering students in the combined engineering business curricula. 4 cred. per qtr.; no prereq.; 4 rec. hrs. per week. Heilman and others.

62¶—COMPETITION AND MONOPOLY IN MODERN INDUSTRY. Economics 62 and 63 or nontechnical analytical courses for Senior College students, with special emphasis on questions of economic policy. The first quarter is devoted to national income, the pattern of consumption, the effects of competition and monopoly on prices and the allocation of resources, and labor unions. 3 cred.; jr., sr.; prereq. 6-7 or equiv.

63¶—MONEY, CYCLES, AND TAXATION. The money and banking system, fluctuations in business and proposed remedies; government expenditures and revenues. 3 cred.; prereq. Econ. 62.

* Not open to students who have received credit in Soc. 45 or B.A. 70.

† The entire course must be completed before credit is received for any quarter.

§ Credit may not be received for both Econ. 28 and B.A. 51.

¶ Not open to students who have received credit for Econ. 6-7 or equivalent.

64—THE ECONOMICS OF MONEY AND BANKING. A second course in money and banking. Banking policy viewed from the social standpoint with primary reference to the problems of the Federal Reserve System. Selected problems in monetary policy; monetary reconstruction and monetary reform. 3 cred.; jr., sr.; prereq. Econ. 3 and 7 or equiv.

73—MANPOWER ECONOMICS AND PROBLEMS. This course deals with: (1) the marketing of manpower resources; (2) the institutional structure of labor markets; (3) economic and social problems arising out of labor marketing processes; (4) methods, procedures, and proposals for solving these problems. 3 cred.; jr., sr.; prereq. Econ. 7 or equiv.

75—CORPORATION FINANCE. The corporation in comparison with other types of business units. Attention is given to such subjects as organization and capital structure, raising fixed and circulating capital, treatment of corporate earnings, incentives to and forms of combination, and trusteeship and reorganization. 3 cred.; jr., sr.; prereq. Econ. 3 and 7 or equiv.

80-81**—INTERMEDIATE ECONOMIC ANALYSIS. The development and the application of methods of economic analysis to problems of price and production under conditions of competition, monopoly, and monopolistic or imperfect competition. 3 cred. per qtr.; prereq. 20 cred. in social science including Econ. 6-7 or equiv. (20 cred. in social science not required for I.T. students); 3 rec. hrs. per week. Papandreou and others.

85—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 practice"; positive assistance to industrial groups. 3 cred.; jr., sr., grad.; prereq. 20 cred. in social science including Econ. 6-7 or equiv. (20 cred. in social science not required for I.T. students); 3 rec. hrs. per week. Papandreou and others.

103-104**—ADVANCED ECONOMIC THEORY. An advanced course in general economic theory with special emphasis on the systematic development of the tools of modern economic analysis. 3 cred. per qtr.; jr., sr., by special permission, grad.; prereq. 20 cred. in social science including Econ. 6-7 or equiv. (20 cred. in social science not required for I.T. students.)

121-122-123—THEORY OF STATISTICS. An advanced course in statistical analysis. The first quarter is designed to acquaint the student with modern statistical tools and their uses in the analysis and interpretation of data and does not stress mathematical developments. Emphasis is upon basic logic of procedures. Later quarters add consideration of origins and deviations, and more mathematical preparation is then desirable. 9 cred.; jr., sr., grad.; prereq. Econ. 5 or equiv.

142—MONETARY AND BANKING POLICY. An advanced course in money and banking policy viewed from the social standpoint with primary reference to the problems of the Federal Reserve system. Selected problems in monetary policy; monetary reconstruction and monetary reform. 3 cred.; jr., sr., grad.; prereq. Econ. 3 and either Econ. 6-7 or equiv.; 3 rec. hrs. per week. Myers, Upgren.

149—BUSINESS CYCLES. Analysis of factors involved in business fluctuations. Comparison of theories of their causes. Examination of proposals for the stabilization of employment, production and capital formation. Introduction to the statistical data and methods of business forecasting. 3 cred.; sr., grad.; prereq. Econ. 64 or consent of instructor.

** No credit may be received for both Econ. 80-81 and Econ. 103-104.

155—THE MODERN CORPORATION. Incorporation. The various types of corporate securities and their uses. Financial plans for industrial, utility, and other types of corporations. Financial affairs of an established business. General financial problems of the holding company, consolidations, mergers, and reorganizations. 3 cred.; jr., sr., grad.; prereq. Econ. 3 and 6-7 or equiv.; 3 rec. hrs. per week. Stehman and others.

161—GENERAL MANPOWER ECONOMICS. This course deals with: (1) the marketing of manpower resources; (2) the institutional structure of labor markets; (3) economic and social problems arising out of labor marketing processes; (4) methods procedures and proposals for solving these problems. This course includes the basic materials of Econ. 73 plus advanced discussion and special assignments. 3 cred.; jr., sr. with consent, grad.; prereq. Econ. 7 or equiv.

164—LABOR LEGISLATION AND SOCIAL INSURANCE. Course dealing with the economic aspects of labor legislation, including minimum wage laws; hours legislation; factory acts; accident, health, old age, and unemployment compensation; mothers' pension. 3 cred.; jr., sr., grad.; prereq. Econ. 73 or 161; 3 rec. hrs. per week. Yoder and others.

172—ECONOMICS OF TRANSPORTATION. An analysis of the economics of the agencies of modern transportation, including rail, water, highway, air, and pipe line. Relative advantage of each agency, national transportation policy, regulation, rate-making, taxation, coordination of services. 3 cred.; jr., sr., grad.; prereq. 20 cred. in social science, including Econ. 7 or equiv. (20 cred. in social science not required for I.T. students.)

185††—ECONOMICS OF MARKETING. A course dealing with (1) the role of market distribution in our total economy; (2) the costs of market distribution; (3) regional specialization and market distribution; (4) public, quasi-public, and corporate control of market distribution; (5) the role of the consumer in market distribution. 3 cred.; jr., sr., grad.; prereq. Econ. 6-7 or equiv.

189§§—PRINCIPLES OF PUBLIC FINANCE. Public expenditures, revenues, debts, fiscal policy, and financial administration. Special attention is given to tax principles, practices, and burdens. 3 cred.; jr., sr., grad.; prereq. Econ. 6-7 or equiv.

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 B.A. 51, Econ. 8 and 9, for 52 and 53, B.A. 51; 3 rec. hrs. per week.

58§—ELEMENTS OF PUBLIC FINANCE. Public expenditures, revenues, debts, fiscal policy and financial administration. Special attention is given to tax principles, practices, and burdens. This is a condensed course given especially for School of Business Administration students. 3 cred.; jr., sr.; prereq. Econ. 6-7 or equiv.

65—ANALYSIS OF FINANCIAL STATEMENTS. Interpretation and analysis of financial statements, credit, investment, and managerial analysis of financial statements. Final analysis and consolidated statements. Industrial, public utility, railroad statements. 3 cred.; jr., sr., grad.; prereq. Econ. 26 or equiv.; 3 rec. hrs. per week. Heilman and others.

* Credit may not be received for both B.A. 51 and Econ. 28.
† To receive credit, a student must complete B.A. 51 and either B.A. 52 or B.A. 53.
§ Credit may not be received for B.A. 58 and either Econ. 189 or Econ. 191-192.
†† Credit may not be received for both Econ. 185 and B.A. 77.
§§ Credit may not be received for both Econ. 189 and either B.A. 58 or Econ. 191-192.

66¶—COST ACCOUNTING SURVEY. A general survey of cost accounting from the point of view of the executive who must use cost information in the conduct of his business. 3 cred.; jr., sr., grad.; prereq. Econ. 26 or equiv.; 3 rec. hrs. per week. Wheeler, Anderson.

70**—STATISTICS SURVEY. A survey of elementary statistical tools used in business administration and economic analysis, including averages, variation, sampling, graphics, correlation, and index numbers. Emphasis is placed on the logical interpretation and limitations of statistical data. 3 cred.; jr., sr.; prereq. Econ. 6-7 or equiv.; 3 rec. hrs. per week.

71—TRANSPORTATION: SERVICES AND CHARGES I. Survey and economic aspects of national transportation policy, rail, highway, air, and water transportation facilities, services, rates, regulation, and current transportation problems. 3 cred.; prereq. Econ. 6-7 or equiv.; 3 rec. hrs. per week. Nightingale.

74—BUSINESS STATISTICS. Explanation and criticism of statistical techniques for dealing with time series; measurements of trend, seasonals, cycles; index numbers. Statistical control of quality in manufacturing operations. 3 cred.; jr., sr., grad.; prereq. Econ. 5 or equiv. 3 rec. hrs. per week. Mudgett, Gaumnitz, and others.

77††—SURVEY IN MARKETING. Survey course including descriptive analysis of (1) marketing institutions and their control; (2) market areas; (3) marketing costs; (4) the operation of supply and demand in marketing. 3 cred.; jr., sr.; prereq. Econ. 6-7 or equiv.; 2 rec. and 1 lect. hr. per week. Vaile and others.

89—PRODUCTION MANAGEMENT. Location and layout of industrial plants; types of operating organizations; shop personnel; standards of operation; purchasing and inventory control; routing, scheduling, and dispatching of product; scientific management; practical problems in production control. 3 cred.; jr., sr.; prereq. Econ. 6-7 or equiv.; 3 rec. hrs. per week. Filipetti.

91—TABULATING EQUIPMENT LABORATORY. The basic functions of tabulating equipment; illustrations of its use in special accounting, statistical, and production analysis; and its use for general accounting, and statistical control of business operations. 1 cred.; jr., sr.; prereq. Econ. 26 and Econ. 5 or equiv.; 1 lect. and 1 lab. hr. per week.

112—TIME SERIES ANALYSIS AND QUALITY CONTROL. An intermediate course dealing with (a) the explanation and criticism of statistical techniques applied to time series analysis including measurements of trend and seasonal and cyclical movements, (b) index numbers, and (c) statistical control of quality in manufacturing operations. 3 cred.; jr., sr. with consent, grad.; prereq. Econ. 5 or equiv.

116—FIRE AND MARINE INSURANCE. The fire risk and fire prevention. Fire insurance and insurance carriers. The standard policy. Methods of rate making. State regulation and supervision. Marine risks and insurance. 3 cred.; jr., sr.; prereq. Econ. 50.

117—CASUALTY INSURANCE. A detailed study of the risks, insurance coverages, and policy provisions in the more important lines of casualty insurance. Accident and health insurance; employers' liability and workmen's compensation; automobile; robbery and theft; plate glass; miscellaneous liability and damage types of insurance. 3 cred.; prereq. Econ. 50.

133—STANDARD COSTS. The methods of standard costs. The meaning of standards. The setting of standards for materials, labor, and overhead. The analysis of and accounting for variations. The development and application of stand-

¶ Credit may not be received for both B.A. 66 and B.A. 152.

** Not open to students who have received credit in Econ. 5.

†† Credit may not be received for both B.A. 77 and Econ. 185.

ards to distribution as well as to production activities. 3 cred.; jr., sr., grad.; prereq. B.A. 153; 3 rec. hrs. per week.

152**-153—COST ACCOUNTING. Cost accounting practices and procedures. 6 cred.; jr., sr., grad.; prereq. Econ. 23 or equiv.

156—FINANCE MANAGEMENT. The duties of the financial manager of a modern business. The various sources from which capital may be secured, the best use of a company's funds, and special financial problems which arise in the typical business. 3 cred.; jr., sr., grad.; prereq. Econ. 75 or 155.

167—INTRODUCTION TO INDUSTRIAL RELATIONS. An elementary survey of policy and practice in the management of manpower. The course seeks to provide a professional point of view toward, and an introduction to, the major functions of manpower management, including the formulation of policy, determination of labor needs, job analysis and classification, methods of recruiting employees, selective devices, training and safety programs, service rating, employment stabilization, collective bargaining, and wage and salary administration. 3 cred.; jr., sr., grad.; prereq. Econ. 73 or 161; 3 rec. hrs. per week. Yoder and others.

170—MOTION ECONOMY. Methods analysis and work measurement. Process and operation analysis, work simplification, motion study principles and applications. 3 cred.; jr., sr., grad.; prereq. B.A. 89 or equiv.

171—MOTION STUDY APPLICATIONS. Laboratory projects selected from, and contributory to improvement of, basic clerical, office practice, and merchandising procedures, emphasizing application of motion economy principles. Final report required for each project. 3 cred.; jr., sr., grad.; prereq. B.A. 170.

173—MARKET ANALYSIS AND RESEARCH. A systematic survey of the techniques used in market research. Selected problems in the analysis of sales records, sales forecasting, estimating sales potentials, sampling consumer demand, determining the factors which influence demand for specific goods, and so on. 3 cred.; sr., grad.; prereq. Econ. 5 and B.A. 77 or equiv.

174—TRANSPORTATION: SERVICES AND CHARGES II. Principles of traffic management and their application within the individual plant. Analysis of the principles relating to construction, interpretation, and application of rail, water, express, and air freight classifications and tariffs. Analysis of railway freight structures. Problems relating to the determination of charges on typical movements within and between major railway freight-rate territories. 3 cred.; jr., sr.; prereq. B.A. 71 or Econ. 172; 3 rec. hrs. per week. Nightingale.

180C—SENIOR TOPICS: MARKETING. Selected topics in management problems concerning market price and price policies. 3 cred. per qtr.; prereq. B.A. 77.

180-181-182G—SENIOR TOPICS: PRODUCTION MANAGEMENT. Selected problems in management; studies in the technique of executive control in manufacturing enterprises; field research and surveys in the organization and methods of management of Northwest industrial concerns. 3 cred. per qtr.; sr., grad; open only to students in the factory management or industrial management sequences and others with consent of instructor; prereq. B.A. 89 or equiv.; 3 rec. hrs. per week. Filipetti.

184—SCIENTIFIC MANAGEMENT IN INDUSTRY. A study of the origin and development of the movement to apply the methods of science to the management of industrial enterprises; the effects upon individual plant management and the influence upon "rationalization" in industrial society. 3 cred.; sr., grad.; prereq. B.A. 89, 187 or equiv.; 3 rec. hrs. per week. Filipetti.

** Credit may not be received for both B.A. 66 and B.A. 152.

Electrical Engineering

ELECTRICAL ENGINEERING, BASIC REQUIRED COURSES:
Year 2—E.E. 11, 12, 13, 14, 15, 16.
Year 3—E.E. 109, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120.
Year 4—E.E. 121, 122, 123, 124, 125, 126, 161, 162, 163.
Year 5—E.E. 127, 128, 129.

COMMUNICATION ENGINEERING: E.E. 161, 162, 163, 164, 165, 166, 167, 168, 169, 171, 172, 181, 183, 184, 185, 187, 188, 189, 211, 212, 213, 261, 262, 263, 264, 265, 266, 267, 268, 269, 272, 273, 274, 287, 288 and 289.

ELECTRONICS: E.E. 117, 118, 119, 120, 131, 133, 135, 157, 158, 159, 171, 172, 183, 184, 185, 201, 202, 203, 287, 288, 289, 291, 292 and 293.

ILLUMINATION: E.E. 151.

INSPECTION TRIP: E.E. 100.

MEASUREMENT: E.E. 81, 173, 174, 175, 181, 183, 184 and 185.

POWER AND CENTRAL STATION ENGINEERING: E.E. 121, 122, 123, 124, 125, 132, 134, 136, 138, 139, 140, 141, 142, 171, 172, 173, 174, 175, 183, 184, 185, 191, 192, 193, 197, 198, 199, 227, 228, 229, 251, 255, 256, 257, 275, 276 and 277.

RESEARCH: E.E. 171, 172.

SEMINAR: E.E. 93, 187, 188, 189, 191, 192, 193, 262, 264, 266, 291, 292 and 293.

SURVEY OF ELECTRICAL ENGINEERING: (For nonelectrical engineering students) E.E. 36, 37, 38, 41, 42, 43, 44, 45, 46, 47 and 48.

11-13-15—ELEMENTS OF ELECTRICAL ENGINEERING. Introduction to the development, principles, materials, safety, general applications of electrical engineering, and direct current machinery. 3 cred. per qtr.; prereq. M.&M. 24 or reg. in M.&M. 24 for 11; reg. in M.&M. 25 for 13; 3 rec. hrs. per week. Cartwright, Angland, Weiner, and others.

12-14-16—ELEMENTS OF ELECTRICAL ENGINEERING LABORATORY. Taken with Course E.E. 11, 13, 15. 1 cred. for 12 and 14; 2 cred. for 16; prereq. for 12, E.E. 11 or reg. in 11; for 14, 13 or reg. in 13; for 16, E.E. 14 and reg. in 14; 2 lab. hrs. per week for 12 and 14; 4 lab. hrs. per week for 16. Cartwright, Angland, Weiner, and others.

36-37-38—ELECTRICAL ENGINEERING SURVEY. Elementary study of the principles of electrical engineering with applications. 3 cred. per qtr.; sr. M.E.; prereq. Phys. 9; 2 lect. and 2 lab. hrs. per week. Kuhlmann, Pidcock, and others.

41—ELECTRICAL ENGINEERING SURVEY. 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. Pidcock and others.

42—ELECTRICAL ENGINEERING SURVEY. Similar to E.E. 41. 3 cred.; sr. C.E.; prereq. Phys. 8; 3 rec. hrs. per week. Pidcock and others.

43-44-45—ELECTRICAL ENGINEERING SURVEY. 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—ELECTRICAL ENGINEERING SURVEY AND AERONAUTICAL RADIO. Fundamentals of direct current and alternating current circuits, tubes, direction finding, and blind landing. 3 cred. per qtr.; sr. Aero.E.; prereq. Phys. 9; 2 rec. and 2 lab. hrs. per week. Pidcock and others.

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. E.E. 47 or by permission; 2 rec. hrs. per week.

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, re-

sistance, inductance, mutual inductance, capacity. 3 cred.; prereq. E.E. 111; 2 lect. and 2 lab. hrs. per week.

93—SEMINAR. Weekly discussion of current engineering periodicals and reports on assigned topics. 1 cred.; no prereq.; jr. E.E.

100—INSPECTION TRIP. Inspection of selected industrial plants made in the spring vacation period. 2 cred.; required of sr. E.E. (subject to cancellation).

109—ELECTRIC AND MAGNETIC FIELDS. Basic static and quasi-static electric and magnetic field theory including the dynamics of charged particles in these fields. 3 cred. per qtr.; prereq. E.E. 15, 16; 3 rec. hrs. per week.

111—ELECTRICAL ENGINEERING. Alternating current circuits. 3 cred.; prereq. E.E. 15, 16. Anderson, Hartman, and others.

112—ELECTRICAL ENGINEERING LABORATORY. Experimental study of alternating current circuits. 1 cred.; prereq. reg. in E.E. 111; 2 lab. hrs. per week. Anderson, Hartman, and others.

113-115—ELECTRICAL ENGINEERING. Alternating current circuits. 3 cred. per qtr.; prereq. E.E. 111, E.E. 112 for 113, and E.E. 113, E.E. 114 for 115; Anderson, Hartman, and others.

114-116—ELECTRICAL ENGINEERING LABORATORY. Experimental study of alternating current circuits. 1 cred. per qtr.; prereq. reg. in E.E. 113-115; 2 lab. hrs. per week. Anderson, Hartman, and others.

117-119—ENGINEERING ELECTRONICS. Fundamental theory of electronic devices. 3 cred. per qtr.; prereq. E.E. 111, 112 for 117, and E.E. 117 for 119; 3 rec. hrs. per week. Muckenhirn and others.

118-120—ENGINEERING ELECTRONICS LABORATORY. 1 cred. per qtr.; prereq. for E.E. 118 reg. in E.E. 117; for E.E. 120 reg. in E.E. 119; 2 lab. hrs. per week. Muckenhirn and others.

121-123-125—ELECTRICAL ENGINEERING. Theory of alternating current machinery. 3 cred. per qtr.; prereq. E.E. 115, 116, and 119. Kuhlmann, Caverley, and others.

122-124-126—ELECTRICAL ENGINEERING LABORATORY. Operating characteristics of alternating current machinery. 2 cred. per qtr.; prereq. E.E. 116 and reg. in 121-123-125; 4 lab. hrs. per week. Kuhlmann, Caverley, and others.

127-128-129—TRANSIENT ELECTRICAL PHENOMENA. Mathematical study of electric circuits during sudden changes of conditions. Classical and Laplace transform 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. M.&M. 80; 2 lect. and 2 lab. hrs. per week.

131-133-135—ELECTRONIC CIRCUIT DESIGN. Study of practical circuits and components for design of industrial electronic applications, amplifiers, oscillators, power rectifiers, etc. 3 cred. per qtr.; prereq. E.E. 163; 2 rec. and 2 lab. hrs. per week. Anderson and others.

132-134-136—ELECTRIC DESIGN. Design of direct current generators and motors, alternating current transformers, generators, and synchronous motors. 3 cred. per qtr.; prereq. for E.E. 132, E.E. 125; 3 rec. hrs. per week. Kuhlmann and others.

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. E.E. 125; 3 rec. hrs. per week. Caverley, Cartwright, and others.

141—CENTRAL STATIONS. Electric power generating stations and distributions systems. Economic considerations. Cost, load curves, plant location, selection of prime movers, station equipment. 3 cred.; prereq. E.E. 125; 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. E.E. 125; 3 rec. hrs. per week.

151—ILLUMINATING ENGINEERING. Light and vision. Principles of illumination. Photometry. Sources of light and their characteristics. Lighting equipment. Illumination requirements and calculation for various fields of use. 3 cred. per qtr.; prereq. reg. in E.E. 121. Johnson.

157-158-159—INDUSTRIAL ELECTRONICS. Theoretical and laboratory study; applications to X ray, dielectric heating, precipitation, servo-mechanisms, etc. 3 cred per qtr.; prereq. E.E. 163; 2 rec. and 2 lab. hrs. per week. Larson, Miller, and others.

161-162-163—ELECTRIC COMMUNICATION. Theoretical and laboratory study of communication circuits and apparatus. 4 cred. per qtr.; prereq. E.E. 119; 3 rec. and 2 lab. hrs. per week. Shepherd, Becklund, and others.

164-165-166—COMMUNICATION CIRCUITS. Theoretical and laboratory study of circuits having distributed constants. Use of hyperbolic functions. Wave filters, balancing networks, equalizers, repeaters. 3 cred. per qtr.; prereq. reg. in E.E. 163; 2 rec. and 2 lab. hrs. per week. Becklund, Miller, and others.

167-168-169—RADIO COMMUNICATION. Maxwell's equations. U.H. frequency transmission and reception, micro-waves, waves guides, velocity modulation. Klystrons and magnetrons. 3 cred. per qtr.; prereq. E.E. 163; 2 lect. and 2 lab. hrs. per week. Shepherd, Becklund, and others.

171-172—UNDERGRADUATE THESIS. Investigation of some approved problems in electrical engineering. 3 to 6 cred. per qtr.; prereq. E.E. 121.

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.

181—COMMUNICATION FREQUENCY MEASUREMENTS. Bridge circuits for measuring of resistance, inductance, and capacity at audio and radio frequencies. 2 cred.; prereq. E.E. 126.

183-184-185—SPECIAL ELECTRICAL LABORATORY. Efficiency tests and special problems. 1 to 3 cred. per qtr.; prereq. jr., sr., grad. by permission.

187-188-189—COMMUNICATION SEMINAR. Study and discussion of current articles on communication or allied topics. 1 cred. per qtr.; prereq. permission of instructor. Hartig.

191-192-193—GRADUATE SEMINAR. Discussions of problems in power circuits and machinery. 1 cred. per qtr.; prereq. permission of instructor. Caverley.

197-198-199—ADVANCED ELECTRICAL DESIGN. A study of the methods and procedures for the design of standard equipment for specific performance characteristics and for the design of special apparatus. Special problems in rotating machinery design including study of harmonics in air gap flux wave and their effect upon performance; study of starting of synchronous motors. Transformers for control and electronic applications including audio-transformers. 3 cred. per qtr.; prereq. Course 132-134-136. Kuhlmann.

201-202-203—ADVANCED INDUSTRIAL ELECTRONICS. Continuation of Course 157-158-159. 3 cred. per qtr. Staff.

211-212-213—ADVANCED NETWORK ANALYSIS. The study of networks by advanced methods. Particular emphasis is placed on active networks, feedback, stability, and physical realizability, topics in design of impedance functions. Applications of general theorems to design of equalizers, input and output circuits, and interstage networks, applications to servo-mechanisms. 3 cred. per qtr.; prereq. by permission. Hartig.

227-228-229—STABILITY OF A.C. POWER SYSTEMS. A study of A.C. power systems, including the system design factors which affect the problem of stability. The relation of both steady state and transient conditions to stable operation of power distribution systems. 3 cred. per qtr.; prereq. Course 138-139-140. Caverley.

251—HIGH VOLTAGE ENGINEERING. Study of insulation and generating equipment for high voltage; measurements of electrical quantities at high voltage; surges and surge-proof equipment. 2 or 3 cred. per qtr.; prereq. Course 121-123-125. Caverley.

255-256-257—ANALYSIS OF A.C. POWER-SYSTEMS CIRCUITS. Application of specialized network theorems and equivalent circuits to the study of A.C. generators, motors, transformers, and transmission lines. The study of the behavior of A.C. equipment under unbalanced conditions by the use of symmetrical components. Transients in machines and associated circuits. 3 cred. per qtr.; prereq. Course 138-139-140. Caverley.

261-263-265—ADVANCED COMMUNICATION. Applications of basic electromagnetic theory to problems in electrical engineering. Studies of antennas, free space transmission including refraction and diffraction phenomena, wave guides, and circuits. Static electric and magnetic fields with applications to the motions of charged particles. Interaction of electromagnetic fields with electron streams. 3 cred. per qtr.; prereq. Phys. 101-103-105 or equiv. Shepherd.

262-264-266—COMMUNICATION SEMINAR. Study and discussion of current literature. 1 cred. per qtr.; prereq. permission of instructor. Shepherd.

267-268-269—THEORY OF COMMUNICATION. Theory of communication with special reference to amplitude, frequency, phase, time division, pulse code modulation. Conservation of frequency space. Advanced study of communication networks and their synthesis, filters, phase and amplitude corrective networks. 3 cred. per qtr.; prereq. permission of instructor. (Offered whenever demand warrants.)

272-273-274—ELECTROMECHANICAL VIBRATING SYSTEMS AND ENGINEERING ACOUSTICS. Theoretical discussion of the production of sound by electrically driven vibrating systems, sound transmission, reflection, absorption. Laboratory study of vibrating systems, pipes, horns, absorbing materials, sound pressure, articulation, reverberation, resonance, sound filters. 3 cred. per qtr.; prereq. M.&M. 151; grad. by permission. Hartig. (Alternates with 211-212-213. (Not offered in 1950-51.)

275-276-277—ADVANCED ELECTRICAL DESIGN. Special problems. 3 cred. per qtr.; prereq. Course 132-134-136. Kuhlmann.

287-288-289—ADVANCED VACUUM TUBE ANALYSIS. Theoretical and laboratory investigations of vacuum tubes used for communication purposes with particular emphasis on high frequency applications. Space charge control tubes, deflection control, electron multipliers, klystrons, magnetrons and traveling wave amplifiers, transit time effects and noise. 3 cred. per qtr.; prereq. permission of instructor. Shepherd.

291-292-293—ELECTRONICS SEMINAR. Study and discussion of current literture. 1 cred. per qtr.; prereq. permission of instructor. Van der Ziel.

English (Engineering)

4-5-6—WRITTEN AND SPOKEN COMMUNICATION. Elementary technical writing and speaking integrated with analytic reading in class and pleasure reading outside of class. 3 cred. per qtr.; prereq. placement test; 3 rec. hrs. per week. Guthrie, Haga, and others.

7—EXPLORATIONS IN LITERATURE. Masterpieces of world poetry, drama, or the literature of science as announced. Lectures; class and individual reading. 3 cred.; prereq. Engl. 6; 3 rec. hrs. per week.

8—NOVELS. Lectures; class and individual reading to survey the field. 3 cred.; prereq. Engl. 6; 3 rec. hrs. per week.

9—TECHNICAL DISCUSSIONS. (M.E.) An informal course including both prepared and extemporaneous talks. Limited to 25 students per section. 3 cred.; prereq. Engl. 6; 3 rec. hrs. per week. Haga, Lippert.

37-38-39—TWENTIETH-CENTURY LITERATURE. Readings in British and American literature since the 1890's, arranged by types of discourse. 37: The literature of opinion, biography, travel, etc. with some reading in the short story; 38: Poetry and drama; 39: The novel since Thomas Hardy. This course, as a general introduction to the intelligent reading of literature, is intended for students in all colleges, and not particularly for those meaning to specialize in English. 3 cred. per qtr.; prereq. Engl. 6; 3 rec. hrs. per week.

85-86—ADVANCED TECHNICAL COMMUNICATION. Upperclass English review with practice in adapting material to various audiences and situations. Speaking, writing, and outside reading. 3 cred.; prereq. Engl. 6; 3 rec. hrs. per week. Guthrie, Haga.

Entomology

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

57—MILL PESTS AND THEIR CONTROL. The life histories, habits, and methods of control of the insect and rodent pests of elevators, flour mills and warehouses. Laboratory work in the determination of the more important forms. 5 cred.; jr., sr.; prereq. General Biology 9 cred. or equivalent. (Open only to students in Mechanical Engineering Curriculum—Milling option.)

Forestry

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

3-4—DENDROLOGY. The forest trees of the United States; their classification, characteristics, and range. Lectures, assigned reading, laboratory. Course 3, 3 cred. and Course 4, 4 cred.; no prereq.

10—FARM FORESTRY. The place of forestry in land-use planning. The economic status of the farm woodlot. The establishment and care of woodlots and windbreaks. Forest influences with special reference to soil erosion control. The use of wood on the farm. Lecture and laboratory. 3 cred.; not open to students majoring in forestry; no prereq.

49—IDENTIFICATION OF COMMERCIAL WOODS. Structure, classification, and identification of domestic woods important to the woodworking industries. Lectures and laboratory. 2 cred.; soph., jr., sr.; not open to forestry students; no prereq.

53-54—WOOD STRUCTURE AND IDENTIFICATION. Structure, classification, and identification of the domestic commercial woods. Lectures, reading, laboratory. 6 cred.; jr., sr.; prereq. For. 3-4.

57—WOOD UTILIZATION. Production, distribution, qualities, amounts, manufacture and prices of wood products. Lectures, reading, reports. 3 cred.; sr.; prereq. For. 53-54.

113—WOOD PULP AND PAPER. A detailed study of production of wood pulp and paper products. Lectures, reading, reports. 3 cred.; jr., sr., grad.

125—WOOD PRESERVATION. Lectures and collateral reading of the history, development, and methods of wood preservation. Different systems now in use and preservatives used. 3 cred.; jr., sr., grad.; prereq. For. 53-54.

142—WOOD CHEMISTRY. The clinical composition, reaction, and analyses of wood components and derivatives. The chemical technology of wood and wood products. 3 cred.; jr., sr., grad.; prereq. org. chem., For. 53-54.

152—WOOD SEASONING. Theory and practice of air seasoning and kiln drying of wood. 3 cred.; jr., sr., grad.; prereq. For. 53-54.

General Engineering

21—ORIENTATION. Series of lectures designed to orient the student who has just begun his university course. 1 cred.; no prereq.; req. of all freshmen. 1 lect. hr. per week.

70—THE SLIDE RULE. Computation practice and theory. Design of special scales. 1 cred.; prereq. M.&M. 11 or reg. in M.&M. 11; 1 rec. hr. per week. French.

101—CONTRACTS AND SPECIFICATIONS. Engineering contracts. Specification essentials; approved methods of handling construction projects; trade practices, workman compensation acts. Powers and duties of engineer executive. 3 cred.; prereq. sr., grad.; 3 rec. hrs. per week. Fixen.

103—PROFESSIONAL PROBLEMS. Lectures covering some of the problems the engineer will meet upon entering his professional career. 1 cred.; req. of all seniors in the Institute of Technology. 1 lect. hr. per week.

Geography

(College of Science, Literature, and the Arts)

41—GEOGRAPHY OF COMMERCIAL PRODUCTION. An introductory course in economic geography with special emphasis on commodities of commercial significance. Particular attention is given to the world patterns of raw material occurrence and production, as well as to the associated centers of industrial fabrication. 5 cred.; no prereq. Weaver.

Geology and Mineralogy

(College of Science, Literature, and the Arts)

1-2—GENERAL GEOLOGY (PHYSICAL AND HISTORICAL). A study of geologic processes and of the materials on which they operate, together with a résumé 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. Bell, Swain.

A-B—GENERAL GEOLOGY LABORATORY (PHYSICAL AND HISTORICAL). The physical properties of common minerals and rocks. Determinative work and sight identification of rocks and fossils. Interpretation of land forms from maps and aerial photographs. 2 cred. per qtr.; with or after Geol. 1-2; 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 use of building stones, cements, clays, fuels, and road material. 3 cred. per qtr.; no prereq.; 3 lect hrs. per week. Zumberge.

8—EARTH FEATURES AND THEIR MEANING. An explanation of the natural landscape as produced by such agents as the atmosphere, water, glaciers, volcanoes, and mountain building forces acting on the materials of the earth. 5 cred.; no prereq.; 5 lect. hrs. per week. Thiel.

11—GENERAL GEOLOGY (PHYSICAL AND HISTORICAL). An introductory course including both physical and historical geology. For the School of Mines and Metallurgy. 5 cred.; no prereq.; 5 lect. hrs. per week. Swain.

23-24—MINERALOGY. The crystal systems; morphological, physical and chemical characters of minerals; classification and description of common minerals. Determinative work in laboratory, blowpipe analysis, sight identification. 5 cred. per qtr.; prereq. one term of college chemistry; 3 lect., 1 rec., and 4 lab. hrs. per week. Gruner.

25—ROCK STUDY. The occurrence and origin of rocks, their mineral and chemical composition and classification. 2 cred.; prereq. Geol. 24; 1 lect., and 1 rec., and 2 lab. hrs. per week. Goldich.

61—BLOWPIPE ANALYSIS. The determination of minerals by systematic blowpipe analysis. 3 cred.; prereq. Geol. 24; 6 lab. hrs. per week. Gruner.

70—GEOLOGIC FIELD METHODS. Application of the plane table, altimeter, hand level, and Brunton compass to actual problems in the field. 2 cred.; prereq. Geol. 25 and trigonometry; 4 hrs. per week. Goldich, Swain.

100—FIELD WORK IN GEOLOGY ON THE IRON RANGES OF MINNESOTA. July 15 to 30, approximately. Selected areas in the iron district of Minnesota. Involves preparation of geologic maps and written reports. 3 cred.; prereq. Geol. 25. Gruner, Thiel, Wright.

101—SEDIMENTATION. Environments of sedimentation. The origin of sedimentary rocks and their primary structures; lithologic associations. 3 cred.; prereq. Geol. 24; 3 lect. hrs. per week. Thiel.

102—METHODS OF STUDY OF SEDIMENTS. Methods used in the study of sediments and sedimentary rocks. Textural and mineralogical analyses of clastic and nonclastic materials. 3 cred.; prereq. Geol. 101 and 106; 1 lect., 4 lab. hrs. per week. Thiel.

103-104—MICROPALEONTOLOGY. The study and classification of Foraminifera, Ostracoda, and other small fossils and their use in stratigraphy. 3 cred. per qtr.; prereq. Geol. 107; 6 lab. hrs. per week. Swain.

106—PETROGRAPHY. Optical methods for identification of minerals in thin section and immersion media; introduction to microscopic work on rocks. 3 cred.; prereq. Geol. 25; 1 lect., 1 rec., and 4 lab. hrs. per week. Goldich.

107—INVERTEBRATE PALEONTOLOGY. Morphology and classification of important fossil groups other than Foraminifera and Ostracoda. 3 cred.; prereq. Geol. 25 or permission of instructor; 1 lect. and 4 lab. hrs. per week. Bell.

108-109—ADVANCED INVERTEBRATE PALEONTOLOGY. Procedures in taxonomy; international rules of zoological nomenclature; techniques and elements involved in preparation of a paleontologic report. 3 cred. per qtr.; prereq. Geol. 107; 6 lab hrs. per week. Bell.

110-111—ECONOMIC GEOLOGY. The nature, genesis, and distribution of mineral deposits; relation of mineral deposits to structure and surficial alteration. 3 cred. per qtr.; prereq. Geol 25; 3 lect. hrs. per week Schwartz.

112—PETROLEUM GEOLOGY. The composition and origin of petroleum, methods of exploration, and the geology of the important oil producing regions. 3 cred.; prereq. Geol. 125 and 151; 3 lect. hrs. per week. Swain.

114—GEOLOGY OF MINNESOTA AND ADJOINING AREAS. The stratigraphy, structure, and lithology of the rocks and their associated mineral resources. 3 cred.; prereq. Geol. 25; 3 lect. hrs. per week. Thiel.

115—FIELD WORK IN GEOLOGY IN SOUTHEASTERN MINNESOTA. July 15 to 30, approximately. Stratigraphic methods and principles as illustrated by study of Cambrian and Ordovician rocks. 3 cred.; prereq. Geol. 25. Bell.

118—PRINCIPLES OF GEOMORPHOLOGY. Origin and evolution of land forms in different climatic environments. Systematic study of geologic processes such as weathering, mass movement, running water, subsurface water, waves and currents, and diastrophism. Map study, library work, and field trips. 3 cred.; prereq. Geol. A and 2, or 11; 3 lect. hrs. per week. Wright.

119a—GEOMORPHOLOGY OF EASTERN UNITED STATES. General geology of the physiographic provinces east of the Great Plains, with emphasis on the land forms and the Cenozoic history. Map study. 3 cred.; prereq. Geol. 118 or 125; 3 lect hrs. per week. Wright. (Offered in alternate years; not offered in 1950-51.)

119b—GEOMORPHOLOGY OF WESTERN UNITED STATES. General geology of the physiographic provinces from the Great Plains westward, with emphasis on the land forms and the Cenozoic history. Complementary to Geol. 119a. Map study. 3 cred.; prereq. Geol. 118 or 125; 3 lect hrs. per week. Wright.

120—GLACIAL GEOLOGY. Origin of glaciers, mechanics of mountain and continental glaciers, stratigraphy, and chronology of the Pleistocene in glaciated and nonglaciated areas, causes of glaciation. Field trips. 3 cred.; prereq. Geol. A and 2, or 11; 3 lect. hrs. per week. Wright.

121—CRYSTALLOGRAPHY. The symmetry relations in the thirty-two crystal classes. Crystal drawings and measurements. Projections and mathematical calculations. 3 cred.; prereq. trigonometry and one year of college chemistry. Gruner.

124—METAMORPHIC GEOLOGY. Conditions, processes, and results of metamorphism. 3 cred.; prereq. Geol. 131; 3 lect. hrs. per week. Schwartz.

125—STRUCTURAL GEOLOGY. Primary and secondary structures of sedimentary, igneous, and metamorphic rocks; mechanics of rock deformation; use in field mapping and in interpretation of geologic history. 3 cred.; prereq. Geol. 25; 3 lect. hrs. per week. Wright.

131-132—PETROLOGY. Petrographic description of igneous, metamorphic, and sedimentary rocks; their mineral and chemical composition, classification, origin, and alteration. Laboratory methods; preparation of samples. 4 cred. per qtr.; prereq. Geol. 106; 2 lect., 1 rec., and 4 lab. hrs. per week. Goldich.

137—PRINCIPLES OF CHEMICAL GEOLOGY. A study of geochemical literature. Methods in geochemical research and application of chemical and physical chemical principles to geologic problems. 3 cred.; prereq. Geol. 25; 3 lect. hrs. per week. Gruner.

140-141—APPLIED PETROGRAPHY. Determination of ore and gangue minerals, microscopic studies of paragenesis of ores and other mineral associations. Practical problems in mining and geology. 3 cred. per qtr.; prereq. Geol. 131; 1 lect., and 4 lab. hrs. per week. Goldich.

144—GEOLOGIC MAPS. Laboratory problems on construction and interpretation of geologic maps, cross sections, structure contour maps, and mine maps. Fault problems and other three-dimensional analyses of geologic structures. 3 cred.; prereq. Geol. 125; 6 lab. hrs. per week. Wright.

145—AERIAL PHOTOGRAPHS. Elements of photogrammetry, construction of mosaics and of planimetric and topographic maps, stereovision, geologic and geomorphic interpretation, field use. 3 cred.; prereq. Geol. A and 2, or 11; 6 lab. hrs. per week. Wright.

146-147—SOIL MINERALOGY. The crystal systems; morphological, physical, and chemical characteristics of minerals; classification and description of common minerals. Determinative work in laboratory, blowpipe analyses, sight identification. 4 cred. per qtr.; prereq. one term of college chemistry; 3 lect., 1 rec., and 4 lab. hrs. per week. Gruner.

150—FIELD GEOLOGY. June 15-July 15. Detailed systematic work conforming with standards of official surveys. Preparation of geologic maps, structure sections, reports; paragensis of ores and their relations to geologic structures. Field, Black Hills, South Dakota. 6 cred.; prereq. Geol. 125. Gruner.

151-152—STRATIGRAPHY. Principles and methods illustrated by selected stratigraphic reports; stratigraphic history of United States; index fossils of each geologic period; term paper in Course 152. 3 cred. per qtr.; prereq. Geol. 107; 3 lect. hrs. per week. Bell.

153—SUBSURFACE STRATIGRAPHY. The application of sample logs, electrical logs, and other methods to the detailed stratigraphy of the subsurface in selected areas. 3 cred.; prereq. Geol. 151; 1 lect. and 4 lab. hrs. per week. Swain.

161—ADVANCED MINERALOGY. Use of X rays for identification of minerals. The crystalline state. Isomorphism and polymorphism. Phase rule applied to mineralogy. Structures of silicates. Synthesis of minerals. 3 cred.; prereq. Geol. 25 and 121 or permission of instructor; 3 lect. hrs. per week. Gruner.

166-167—MINERALOGRAPHY. Methods of studying opaque minerals and applications to problems in ore genesis and history. 3 cred. per qtr.; prereq. Geol. 111, 131; 6 lab. hrs. per week. Schwartz.

170—GEOLOGIC PROBLEMS. Individual research in laboratory or field problems at Senior College and graduate levels. Cred. ar.; prereq. permission of major adviser. Staff.

175—FIELD WORK IN GLACIAL GEOLOGY AND GEOMORPHOLOGY. Mapping of surficial deposits and land forms of a selected area in Minnesota. 3 cred.; prereq. Geol. 118 and 120. One day of field work each week. Wright.

Geophysics

108—INTRODUCTION TO GENERAL GEOPHYSICS. Physics of the earth. Intended for majors in geology, physics, engineering, mining and geophysics. Geophysical evidence and data on age of the earth, figure, internal constitution and temperatures, gravity and magnetic fields, tides, poles, structure of the crust, etc. 3 cred.; prereq. Phys. 7, 8, 9, Geol. 1, 2, or 11. Geol. 125 recommended but not required. 3 lect. hrs. per week. Mooney.

109—INTRODUCTION TO GENERAL GEOPHYSICS. Elementary seismology. Physics and geology of earthquakes. Causes, effects and geographical distribution of earthquakes, elementary theory of seismic waves, instrumental principles, geological implications. 3 cred.; prereq. Geophys. 108. 3 lect. hrs. per week. Mooney.

110—INTRODUCTION TO EXPLORATION GEOPHYSICS. Intended for majors in geology, physics, and mining. Principles of exploration by gravitational, magnetic, seismic, and electrical measurements. Types of geologic and mining problems suitable for these methods, instrumental principles, basis in physical laws, interpretation of data. 3 cred.; prereq. Phys. 7, 8, 9, Geol. 1, 2, or 11. Geol. 125 recommended but not required. 3 lect. hrs. per week. Mooney.

120—THEORETICAL SEISMOLOGY. Intended principally for geophysics majors. Theory of the propagation of seismic waves, introductory elasticity theory, body and surface waves, effect of discontinuities, principles of the seismograph. 2 cred.; prereq. Phys. 101, 103, 105, Geophys. 109, M.&M. 25. 2 lect. hrs. per week. Mooney. (Not offered 1950-51.)

125—PRINCIPLES OF SEISMIC EXPLORATION. Intended for geophysics majors. Cannot be taken for credit with Geophysics 110. Principles of reflection and refraction shooting, propagation of elastic waves, interpretation of results, dip and depth determination, velocity shooting. 2 cred.; prereq. Phys. 101, 103, 105, Geol. 125, M.&M. 25. 2 lect. and 2 lab. hrs. per week. Mooney. (Not offered 1950-51.)

126—PRINCIPLES OF GRAVITY AND MAGNETIC EXPLORATION. Physical principles, use in geologic and mining problems, techniques of interpretation, instrumental principles. Airborne magnetometer. 2 cred.; prereq. Geophys. 125. 2 lect. and 2 lab. hrs. per week. Mooney. (Not offered 1950-51.)

127—PRINCIPLES OF ELECTRICAL EXPLORATION. Self-potential, equipotential, potential-drop, resistivity, electromagnetic methods. Interpretation and instruments. Well-logging. 2 cred.; prereq. Geophys. 126. 2 lect. and 2 lab. hrs. per week. Mooney. (Not offered 1950-51.)

German

(College of Science, Literature, and the Arts)

24-25-26—CHEMICAL GERMAN. Grammatical fundamentals, vocabulary, 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 PROSE. Representative chemical prose. 3 cred. per qtr.; prereq. two years of high school German or one year of college German; 3 rec. hrs. per week.

41-42-43—READINGS FROM GERMAN CHEMICAL PERIODICALS. 2 cred. per qtr.; prereq. German 26 or the equiv.; 2 rec. hrs. per week.

History

(College of Science, Literature, and the Arts)

1-2-3—CIVILIZATION OF THE MODERN WORLD. 1: The rise of the European state system as the framework within which Western civilization developed; the economic, cultural, political, intellectual, and religious implications of the emerging system; 2: The struggle for control over the Western system, and the emergence of liberal democracy in the modern world; 3: The pact of industrialization upon Western and world civilization, the origins and background of the period of confusion that is the twentieth-century world. 3 cred. per qtr.; no prereq.; 1 rec. and 2 lect. hrs. per week.

17—MODERN ECONOMIC AND SOCIAL PROBLEMS. Historical survey of contemporary problems created by changes in the organization and the methods of production and trade, in class relationships, political institutions and ideas; and of the efforts made by farmers, manufacturers, bankers, wage-earners, consumers, voluntary associations, and governments to find conservative, reformist, or revolutionary solutions. 5 cred.; no prereq.; 3 lect. and 2 rec. hrs. per week.

84a—HISTORY OF ENGINEERING AND INDUSTRIAL TECHNOLOGY. 3 cred.; jr., sr.; no prereq. Heaton.

112-113-114—ECONOMIC HISTORY OF EUROPE. 112: Economic life in ancient and medieval times; 113: Economic developments in the early modern world; 114: Economic developments since 1750. 3 cred. per qtr.; prereq. jr., sr., grad. Heaton.

Horticulture

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

6—FRUIT GROWING. The fundamental principles of fruit growing. Sites, soils, nursery stock, planting and planting plans, tillage, fertilization, cover crops, pollination, frost avoidance, pruning, and thinning. Lectures and references. 3 cred.; no prereq. Brierley.

Humanities

(College of Science, Literature, and the Arts)

1—HUMANITIES IN THE MODERN WORLD I. The old regime, the revolution, and Napoleon. Period: from about 1770 to about 1830. Authors: Voltaire, Rosseau, Burke, Paine, Goethe, and the poets. One historical novel, Tolstoy's *War and Peace*. 5 cred.; no prereq.; 5 lect. hrs. per week.

2—HUMANITIES IN THE MODERN WORLD II. The industrial revolution and liberalism; socialism and imperialism. How these bulked large in the nineteenth century. Period: from about 1830 to about 1870. Authors: Carlyle, Mill, Marx, Ibsen, Zola, Dostoevski, and the poets. 5 cred.; prereq. Hum. 1; 5 lect. hrs. per week.

3—HUMANITIES IN THE MODERN WORLD III. The impact of evolution, religion, and morals in a changing world. Period: from about 1870 to about 1914. Authors: Huxley, Arnold, Turgeneff, Nietzsche, Shaw, Mann, and the poets. 5 cred.; prereq. Hum. 2; 5 lect. hrs. per week.

4—HUMANITIES IN THE MODERN WORLD IV. An introduction to the study of humanities since World War I. The authors studied include Freud, Lenin, Malraux, Koestler, T. S. Eliot, and others. The background topics include civilization between two wars, the impact of psychoanalysis, communism versus fascism, etc. 5 cred.; prereq. Hum. 1 or 2 or 3; 5 lect. hrs. per week.

11—THE GREEK HERITAGE. The heroic age of legend—"Men like gods"; the golden age of Athens—tragedy, the concepts of goodness and beauty, the struggle for the state; the age of reason—the concepts of reason, justice, order. Selected readings in the historians and Aristotle; longer readings in Homer, Plato, the dramatists. Greek architecture and sculpture. 5 cred.; no prereq.; 5 lect. hrs. per week.

12—THE ROMAN AND MEDIEVAL HERITAGE. Roman jurisprudence and organization; epicureanism and stoicism. Selections from Lucretius, Epictetus, Marcus Aurelius. Medieval faith, theocracy, chivalry, monasticism. Selections from St. Augustine, St. Thomas Aquinas, the rule of St. Benedict. Longer readings from Dante, Chaucer. Early religious painting, ecclesiastical and feudal architecture. 5 cred.; no prereq.; 5 lect. hrs. per week.

13—THE RENAISSANCE HERITAGE. Humanism; magnificence and individualism; secularism, skepticism, political realism; the protestant strain; modern science and scientific method. Selected reading in Machiavelli, Castiglione, Valla, Petrarch, More, Luther, Calvin; longer readings in Montaigne, Cervantes, Shakespeare, Milton, Bunyan, Molière. Renaissance architecture, sculpture, and painting; Dürer, Raphael, Michelangelo, Leonardo da Vinci, Velasquez, Rubens, Rembrandt. 5 cred.; no prereq.; 5 lect. hrs. per week.

21—AMERICAN LIFE I. The growth and the interrelation of nationalism, regionalism, and internationalism in American social thought, literature, and the fine arts, against a background of history. 3 cred.; no prereq.; 3 lect. hrs. per week.

22—AMERICAN LIFE II. The growth and interrelation of individualism and democracy, with particular attention to the status of minorities. 3 cred.; no prereq.; 3 lect. hrs. per week.

23—AMERICAN LIFE III. The place in American civilization of work, the pursuit of happiness, the good life: their implications and interrelations. 3 cred.; no prereq.; 3 lect. hrs. per week.

51-52-53—HUMANITIES IN THE MODERN WORLD. This course is similar to Humanities 1-2-3 except that it is confined to juniors and seniors. A student may not receive credit for any quarter of this course if he has completed the corresponding quarter of Humanities 1-2-3. 5 cred. per qtr.; no prereq. Students may enter any quarter.

61-62-63—THE EUROPEAN HERITAGE: FROM HOMER TO MOLIERE. This course is similar to Humanities 11-12-13 except that it is confined to juniors and seniors. A student may not receive credit for any quarter of this course if he has completed the corresponding quarter of Humanities 11-12-13. 5 cred. per qtr.; no prereq. Students may enter any quarter.

71-72-73—HUMANITIES IN THE UNITED STATES. This course is similar to Humanities 21-22-23 except that it is confined to juniors and seniors. A student may not receive credit for any quarter of this course if he has completed the corresponding quarter of Humanities 21-22-23. 3 cred. per qtr.; no prereq. Students may enter any quarter.

Industrial Engineering

150—ELEMENTS OF INDUSTRIAL ENGINEERING AND MANAGEMENT. Background of modern industry; management and administrative functions; industrial organization. Production engineering; industrial plants; planning and control of manufacturing operations. Manufacturing costs and their relationships; economic considerations in product design and selection of materials, methods, and production facilities. 3 cred.; prereq. M.E. 15 and 17 or consent of instr. 3 rec. hrs. per week. Whitson and others.

153—METHODS ANALYSIS AND DEVELOPMENT. Process and operation analysis, methods engineering, and work simplification. Effective work procedures, motion economy principles, workplace layout, design of special tools and equipment. Process and flow charts, motion study, micromotion analysis, methods standardization, and elementary time study. Emphasis on economic considerations and cost reduction. 3 cred.; prereq. I.E. 150; 2 rec., 3 lab. hrs. per week. Whitson and others.

154—WORK MEASUREMENT AND PRODUCTION STANDARDS. Measures of plant, departmental, and individual productivity. Work measurement principles, job standardization, time study, motion-time analysis, and establishment and maintenance of production standards. Applications of standards for planning and control purposes; wage incentives; labor relations aspects of productivity. Emphasis on management and policy considerations. 3 cred.; prereq. I.E. 153; 2 rec., 3 lab. hrs. per week. Whitson and others.

155—PRODUCTION METHODS AND STANDARDS. Analysis and development of production processes and methods; work simplification. Motion economy principles applied to factory operations and product design; equipment and workplace layouts; design of special tools and equipment. Work measurement and establishment of production standards; applications of standards for planning and control purposes; wage incentives. (Primarily for students in mechanical engineering, but open to others.) 2 cred.; prereq. I.E. 150; 1 rec., 3 lab. hrs. per week. Whitson and others.

156—METHODS ANALYSIS AND WORK MEASUREMENT. Process and operation analysis, work simplification, motion study and micromotion study principles and applications. Work measurement principles, job standardization, time study, and motion-time analysis. Production standards and their application for planning and control purposes. (Primarily for students in School of Business Administration, but open to others. Also listed as B.A. 170.) 3 cred.; prereq. B.A. 184 or I.E. 150; 2 rec., 3 lab. hrs. per week. Whitson and others.

157—ADVANCED METHODS ENGINEERING AND WORK MEASUREMENT. Advanced techniques for the development of effective production methods and processes. Studies of group operations, multiple machine operations, and line production. Advanced problems in work measurement and the development and use of standard time data. Problems from local industrial plants. 3 cred.; prereq. I.E. 154 and 165 or reg. in 165, or consent of instructor; 2 rec., 3 lab. hrs. week. Whitson and others.

165—INDUSTRIAL PLANTS. Over-all planning of manufacturing processes, determination of equipment and space requirements, and analysis of materials flow. General arrangement of manufacturing plants, layout of production and service departments, and analysis and improvement of existing plant layouts. Design and specification of plant buildings, service facilities, and materials handling equipment. Economic analysis of plant layouts, plant locations, decentralization, and related problems. 3 cred.; prereq. I.E. 154, 155, or 156; 2 rec., 3 lab. hrs. per week. Whitson and others.

166—INDUSTRIAL PLANTS SURVEY. Over-all planning of manufacturing processes, analysis of materials flow, and layout of production and service departments. Analysis and improvement of existing plant layouts. Plant buildings, service facilities, and materials handling equipment. Problems of plant location and decentralization. (Primarily for students in mechanical engineering, but open to others.) 2 cred.; prereq. I.E. 155 or equiv.; 1 rec., 3 lab. hrs. per week. Whitson and others.

170—PRODUCTION PLANNING AND CONTROL. Long range and immediate planning for efficient manufacture. Determination of plant, equipment, personnel, and materials requirements from sales projections. Coordination of production and sales; routing, scheduling, and follow-up of current production. Standardization, economic lot sizes, inventory policies and control. 3 cred.; prereq. I.E. 154, 155, or 156; 3 rec. hrs. per week. Whitson and others.

171—QUALITY CONTROL. Control of quality of raw materials, work in process, finished parts, and completed product. Quality requirements and their effect on production and costs. Quality standards, inspection, interpretation of results, corrective action. Application of statistical methods and sampling theory. 3 cred.; prereq. I.E. 150, M.&M. 133; M.E. 115 recommended but not required; 3 lect. hrs. per week. Whitson and others.

172—ELEMENTS OF QUALITY CONTROL. Similar in content to Course 171, except no previous courses in statistics are required. 3 cred.; prereq. I.E. 150; M.E. 115 recommended but not required; 3 rec. hrs. per week. Whitson and others.

173—ENGINEERING ECONOMIC ANALYSIS AND COST CONTROL. Economic studies and reports as the basis for management decisions on major equipment installations, plant expansions, plant locations, decentralization, and similar problems. Determination of capital expenditures and annual operating costs associated with alternate courses of action. Control of current plant operating costs, productivity, equipment utilization, and materials waste; budgetary control; supervisory incentives. 3 cred.; prereq. I.E. 165, B.A. 130, and M.&M. 133 or B.A. 112; 3 rec. hrs. per week. Whitson.

180—ELEMENTS OF SUPERVISION. Principles of administration and supervisory control; organization structure. Supervisory functions; relations with employees, other supervisors, staff functions, and management. Selection, training, and placement of employees; stimulation of interest; handling of grievances; discipline. Interpretation and application of company policies. 3 cred.; prereq. I.E. 150; 3 rec. hrs. per week. Whitson and others.

181—INDUSTRIAL RELATIONS. Labor-management relations and their effect on plant operations and industrial engineering functions. Relations with individual employees; collective bargaining; labor laws. Employee selection and training, job evaluation, wage and salary administration, employee attitudes. Industrial safety and hygiene. 3 cred.; prereq. I.E. 150; 3 rec. hrs. per week. Whitson and others.

182—INDUSTRIAL SAFETY AND HYGIENE. Management, technical, and legal aspects; major industrial hazards; preventive and remedial measures; follow-up procedures. Safety considerations in the development of production processes and methods and the design of equipment and plants. Organization and administration of industrial safety and hygiene programs. 3 cred.; prereq. I.E. 150; 3 rec. hrs. per week. Whitson and others.

190-191-192—INDUSTRIAL ENGINEERING SEMINAR. Current developments in industrial engineering and management. Reading of assigned articles, classroom presentation, and discussion. 1 cred. per qtr.; sr.; 1 rec. hr. per week. Staff.

193—INSPECTION TRIP. Visits to selected industrial plants during spring vacation period. Studies of production methods and processes, equipment, layouts, and plant structures. Required of sr. I.E.; 1 cred. Staff.

194-195-196—APPLIED PRODUCTION ENGINEERING AND MANAGEMENT. Integration of previous course material and application to current manufacturing problems. Cost reduction surveys and reports; analysis and correction of manufacturing difficulties; major revisions of existing operations and plants. Establishment of new manufacturing plants or departments; getting new products into production. Problems from local industrial plants. 3 cred. per qtr.; prereq. 18 cred. in I.E. or consent of instr.; 2 rec., 3 lab. hrs. per week. Whitson.

251-252-253—ADVANCED INDUSTRIAL ENGINEERING AND MANAGEMENT. Advanced studies in selected fields of industrial engineering and management. Problems in manufacturing policy, production engineering, and plant operation. Management engineering surveys and reports; advanced engineering economic studies; long-range industrial planning and development. engineering organization and administration. Emphasis on management and policy considerations. 3 cred. per qtr.; prereq. 18 cred. in I.E. or consent of instr.; grad. only. Whitson.

261-262-263—PRODUCTION ENGINEERING PROBLEMS. Application of industrial engineering principles to the solution of practical production problems. Development of manufacturing processes and methods, special production equipment, and plant layouts. Establishment of suitable controls over production, costs, quality, and other factors. 3-5 cred. per qtr.; prereq. 18 cred. in I.E. or consent of instr.; grad. only. Whitson.

271-272-273—INDUSTRIAL ENGINEERING RESEARCH. Special investigations and research studies in selected areas of industrial engineering, production, and management. Work of thesis quality but lesser scope. 3-5 cred. per qtr.; prereq. 18 cred. in I.E. or consent of instr.; grad. only. Whitson.

Mathematics

(College of Science, Literature, and the Arts)

62—INTRODUCTION TO THE THEORY OF EQUATIONS. A study of complex numbers, solution of algebraic equations, tangents of polynomials; isolation of the real zeros of a real polynomial; determinants and linear equations. 3 cred.; jr., sr.; prereq. M.&M. 24 or Math. 50 or registration in 50 and consent of instructor. 3 rec. hrs. per week.

Mathematics and Mechanics

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. M.&M. 11; 5 rec. hrs. per week.

13—ANALYTIC GEOMETRY. Rectangular coordinate systems, locus and equation, straight line, circle, parabola, ellipse, hyperbola. Transformation of coordinates and simplification of equations. Polar coordinates, higher plane curves, tangents, normals. Empirical equations, solid analytic geometry. 5 cred.; prereq. M.&M. 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, and integration of standard elementary forms. 5 cred.; prereq. M.&M. 13; 5 rec. hrs. per week.

25—CALCULUS II: INTEGRAL. Integration of 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, series, and expansion of functions. 5 cred.; prereq. M.&M. 24; 5 rec. hrs. per week.

80—ELEMENTARY DIFFERENTIAL EQUATIONS. Equations of the first order and first degree, higher degree, singular solutions; total, linear, and systems of simultaneous differential equations, integration in series. 3 cred.; prereq. M.&M. 25; 3 rec. hrs. per week.

90—ELEMENTARY ENGINEERING STATISTICS. Probability, permutations and combinations. Frequency distributions—binomial, Poisson, and normal. Introduction to sampling, significance tests, regression charts. 3 cred.; prereq. M.&M. 13; 3 rec. hrs. per week. McElrath.

91*—CALCULUS. (Arch., Prebus.) Short course, derivatives, maxima and minima, integration of simple forms, definite integrals, areas. 4 cred.; prereq. M.&M. 13; 4 rec. hrs. per week.

132-133-134—INDUSTRIAL STATISTICS. Statistics as applied to engineering problems and quality control. 3 cred. per qtr.; prereq. M.&M. 25; 3 rec. hrs. per week. McElrath.

150—CALCULUS III. Intermediate Calculus. Partial differentiation, multiple integrals, and other advanced topics. 3 cred.; prereq. M.&M. 25; 3 rec. hrs. per week. Loye.

151—ORDINARY DIFFERENTIAL EQUATIONS. Linear equations of second order, successive approximations. Existence theorems, systems of ordinary differential equations, total differential equations. Numerical integration and solution of differential equations, infinite series. 3 cred.; prereq. M.&M. 80; 3 rec. hrs. per week. Polansky.

152—CALCULUS IV. Special Topics in Advanced Calculus. 3 cred.; prereq. M.&M. 150; 3 rec. hrs. per week. Kochler.

153—CALCULUS V. Special Topics in Advanced Calculus. 3 cred.; prereq. M.&M. 152; 3 rec. hrs. per week. Koehler.

154—VECTOR ANALYSIS. 3 cred.; prereq. M.&M. 25; 3 rec. hrs. per week. Wilcox.

155—VECTOR ANALYSIS AND DYADICS WITH APPLICATIONS. 3 cred.; prereq. M.&M. 154; 3 rec. hrs. per week. Wilcox.

156—ELEMENTS OF TENSOR ANALYSIS. 3 cred.; prereq. M.&M. 154; 3 rec. hrs. per week. Munro.

164-165-166—OPERATIONAL METHODS AND THE OPERATIONAL CALCULUS. 3 cred. per qtr.; prereq. M.&M. 80 or by permission; 3 rec. hrs. per week. Turrittin.

* For permissible substitute, see page 93.

167—SELECTED TOPICS IN MATHEMATICS FOR SENIOR AERONAUTICAL ENGINEERS. 3 cred.; prereq. M.&M. 26; 3 rec. hrs. per week. Polansky.

168—ELEMENTARY THEORY OF COMPLEX VARIABLES. Derivative and integral of a function of a Complex Variable. Cauchy's integral theorem and formula, residues. Application of evaluation of integrals, conformal mapping. 3 cred.; prereq. M.&M. 152; 3 rec. hrs. per week. Fulks.

173-174-175—ELEMENTARY PARTIAL DIFFERENTIAL EQUATIONS WITH APPLICATIONS. 3 cred. per qtr.; prereq. M.&M. 80 and 153; 3 rec. hrs. per week. Munro.

184—ELEMENTARY NUMERICAL ANALYSIS IN ENGINEERING. Operation of ordinary computers. Approximate solution of algebraic and transcendental equations, Newton's and Graffe's method. Numerical integration and interpolation. 3 cred.; prereq. M.&M. 80. Munro.

185-186—ADVANCED NUMERICAL ANALYSIS IN ENGINEERING. Approximation of functions and least squares. Approximate solution of ordinary and partial differential equations, Moulton's, Runge's, relaxation and iteration methods. Integral equations. Programming of computers. 3 cred. per qtr.; prereq. M.&M. 151, 153, and 184. Munro.

190-191-192—PROBLEM SEMINAR. 3 cred. per qtr.; prereq. permission of instructor; 3 rec. hrs. per week. Warschawski.

227-228-229—MATHEMATICS OF COMPUTERS AND CONTROL DEVICES. Theory of elementary control and computing devices, open and closed systems, dynamics and transient responses. Synthesis and analysis of systems. Analog and digital computers. 3 cred. per qtr.; prereq. M.&M. 186. Munro.

230—ADVANCED TENSOR ANALYSIS. Selected topics in tensor analysis with applications. 3 cred.; prereq. M.&M. 156; 3 rec. hrs. per week. Munro.

261-262-263—FUNCTIONS OF A COMPLEX VARIABLE. Elliptic functions and integrals with applications. 3 cred. per qtr.; prereq. M.&M. 153; 3 rec. hrs. per week. Warschawski.

264-265-266—CONFORMAL MAPPING. 3 cred. per qtr.; prereq. M.&M. 261 or by permission; 3 rec. hrs. per week. Warschawski.

274-275-276—PARTIAL DIFFERENTIAL AND INTEGRAL EQUATIONS OF APPLIED MATHEMATICS. 3 cred. per qtr.; prereq. M.&M. 151 and 153 or permission of instructor. 3 rec. hrs. per week. Warschawski.

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. M.&M. 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. M.&M. 25 or 91; 5 rec. hrs. per week.

92*—MECHANICS FOR ARCHITECTS. Statics, resolution of forces, conditions of equilibrium, center of gravity, moment of inertia of plane sections, stresses in framed structures. 4 cred.; prereq. M.&M. 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. M.&M. 26; 5 rec. hrs. per week. Wilcox.

* For permissible substitute, see page 93.

161-162-163—ADVANCED TECHNICAL MECHANICS. Moving axes, Eulerian angles, Lagrange's equations, generalized coordinates, 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. M.&M. 127 or permission of instructor; 3 rec. hrs. per week. Koehler.

169—MATHEMATICAL THEORY OF FLOW. Laplace's equation, steady flow of fluids, heat, electricity. Two-dimensional flow, Poisson's integral. Streamlines, circulation, and vortices, application to airfoils. 3 cred.; prereq. M.&M. 130; 3 rec. hrs. per week. Doeringsfeld.

193-194-195—THEORY OF VIBRATIONS. Mathematical treatment of one, two, and many degrees of freedom, forced and damped vibrations. Critical speeds, torsional vibrations, criterion of stability, nonlinear characteristics, vibrations of plates and shells. 3 cred. per qtr.; prereq. M.&M. 80, 127, and registered in 152. Priester.

232-233-234—MECHANICS OF CONTINUOUS MEDIA. 3 cred. per qtr.; prereq. M.&M. 80, 127, 153, and 154; 3 rec. hrs. per week. Turrittin.

277-278-279—PARTIAL DIFFERENTIAL EQUATIONS OF THE FIRST ORDER WITH APPLICATIONS TO MECHANICS. 3 cred. per qtr.; prereq. M.&M. 127, 151, and 153; 3 rec. hrs. per week. Munro.

281-282-283—POTENTIAL THEORY. 3 cred. per qtr.; prereq. M.&M. 80 and 153. 3 rec. hrs. per week. Warschawski.

284-285-286—NONLINEAR MECHANICS. 3 cred. per qtr.; prereq. M.&M. 127, 151 and 153; 3 rec. hrs. per week. Koehler.

297-298—VIBRATION PROBLEMS. 3 cred. per qtr.; prereq. M.&M. 127; 3 rec. hrs. per week. Turrittin.

MATERIALS

85*—STRENGTH OF MATERIALS. (E.E., Chem.E., and Prebus.) Mechanical and elastic properties of materials of construction, beams, shafts, columns, combined stresses, dynamic stresses. 3 cred.; prereq. M.&M. 26 or 84; 3 rec. hrs. per week.

87—MATERIALS TESTING LABORATORY. (E.E., 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. M.&M. 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. M.&M. 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. M.&M. 26; 5 rec. hrs. per week. Miller.

141—MATERIALS TESTING LABORATORY. Investigation of the physical properties of various metals and engineering materials (steel, cast iron, wood, brick, etc.). Standard methods of testing. 1 cred.; prereq. M.&M. 128 or reg. in 128; 2 lab. hrs. per week. Miller.

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. Miller.

181-182-183—APPLIED ELASTICITY. Special problems in stress analysis. 3 cred. per qtr.; prereq. M.&M. 128; 3 lect. hrs. per week. Priester.

290-291-292—THEORY OF PLATES AND SHELLS. 3 cred. per qtr.; prereq. M.&M. 153 and 294; 3 rec. hrs. per week. Priester.

* For permissible substitute, see page 93.

294-295-296—MATHEMATICAL THEORY OF ELASTICITY. 3 cred. per qtr.; prereq. M.&M. 128, 153; 3 rec. hrs. per week. Priester.

HYDRAULICS

86—FLUID MECHANICS. (Aero.E., E.E., and Chem. E.) Hydrostatics, Bernoulli's theorem, compressible and incompressible flow through orifices and pipes, dynamic action of jets. 3 cred.; prereq. M.&M. 26 or 84; 3 rec. hrs. per week.

129—FLUID MECHANICS. 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. M.&M. 26; 4 rec. hrs. per week. Loye.

130—FLUID MECHANICS. (M.E.) Hydrostatics, Bernoulli's theorem, compressible and incompressible flow through orifices and pipes, dynamic action of jets and streams, elementary principles of turbines and pumps. 5 cred.; prereq. M.&M. 26; 5 rec. hrs. per week. Doeringsfeld.

143—HYDRAULICS LABORATORY. Experimental and demonstrational work. Pressure head, Peizometer tubes, gauges, stability of flotation, Bernoulli's theorem. Venturi meter, flow through orifices, over weirs, and through pipes. Open channels, gauging, impact on vanes, pumps, and hydraulic machines. 1 cred.; prereq. cred. or registration in M.&M. 86, 129, 130 or Chem.E. 101. Doeringsfeld.

Mechanical Engineering

GENERAL: M.E. 70, 190, 191, 192, 194, 195, 290, 291, 292, 293.

HEATING, VENTILATING, AND AIR CONDITIONING: M.E. 160, 161, 162, 165, 169, 265, 266, 267.

INDUSTRIAL LABORATORIES: M.E. 1, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 60, 61, 110, 111, 112, 113, 114, 115, 117, 118, 119, 170.

INTERNAL COMBUSTION ENGINES: M.E. 50, 55, 150, 150A, 151, 151A, 152, 153, 154, 154A, 155, 156, 157, 158, 159, 250. 251, 252, 253, 254, 255, 256, 257.

KINEMATICS AND AUTOMATIC CONTROL: M.E. 21, 22, 23, 26, 198, 199.

MACHINE DESIGN: M.E. 20, 24, 27, 120, 121, 122, 123, 124, 125, 127, 128, 129, 221, 222, 223, 228, 229.

MECHANICAL ENGINEERING LABORATORIES: M.E. 33, 34, 35.

MILLING ENGINEERING: M.E. 100, 101, 102, 103, 104, 105, 106, 107.

REFRIGERATION: M.E. 180, 181, 182, 189, 280, 281, 282.

STEAM POWER: M.E. 38, 39, 40, 41, 42, 138, 141, 142, 144, 146, 147, 148, 149, 242, 243, 244.

THERMODYNAMICS: M.E. 131, 132, 133, 134, 231, 232, 233.

1—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. Hughes.

4—MACHINE WOODWORKING. (Prebus., For.) Safe operation, maintenance, and adjustment of woodworking machinery. Procurement, inspection, and storage of woodworking materials and products. Planning and execution of a wood manufacturing project based on interchangeable parts. 2 cred.; no prereq.; 2 lect. and 3 lab. hrs. per week. Staff.

5—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 to 4 cred.; no prereq.; 6 lab. hrs. per week. Hughes.

6—MACHINE SHOP PRACTICE. (Aero.E. and Met.E.) Care and operations of machine tools for job shop work and manufacture of interchangeable parts. 2 to 4 cred.; no prereq.; 2 lect. and 3 hrs. lab. per week. Crowder and others.

7—MACHINE SHOP PRACTICE. (Ind.Ed.) Care and operation of the lathe, drill press, shaper, milling machine, cylindrical and surface grinders. 2 cred.; no prereq.; 6 lab. hrs. per week. Crowder and others.

8—MACHINE SHOP PRACTICE. (E.E., Prebus.) Fundamental operations on the lathe, drill press, milling machine, grinder, punch press, and bench work. 2 cred.; prereq. Draw. 2 and Inorg. Chem. 2, 5, 7, or 10; 2 lect. and 3 lab. hrs. per week. Crowder and others.

11—MATERIALS AND PROCESSING I. A study of fundamental properties of ferrous and nonferrous metals and alloys. Their processes of production and some of their industrial applications and uses. Principles of pattern design as related to casting of metals. 2 cred.; prereq. Inorg.Chem. 2, 5, 7, or 10. Draw. 2; 2 lect. per week. Hughes and others.

12—MATERIALS AND PROCESSING II. 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. (M.E.) Inorg.Chem. 1 or 4, M.E. 11 or reg. in 11; (Mines, Met.) Inorg.Chem. 1 or 4 and jr.; (Prebus.) Inorg. Chem. 1 or 4 and M.E. 1 and 4; 2 lect. and 3 lab. hrs. per week. Holtby and others.

13—MATERIALS AND PROCESSING III. Theory and practice of forging, welding, and heat treating, production and working of metals; operation of furnaces; thermit, electric arc, oxyacetylene, and spot welding. 2 cred.; prereq. (M.E.) Inorg.Chem. 2 or 5, Draw. 2, M.E. 11 or reg. in 11; (Mines, Met.) Inorg.Chem. 2 or 5 and jr.; 2 lect. and 3 lab. hrs. per week. Hughes and others.

14—MATERIALS AND PROCESSING IV. Care and use of precision measuring instruments, cutting tools and machine tools. Fundamental operations on the lathe, drill press, shaper and punch press, for the manufacture of interchangeable parts. 2 cred.; prereq. M.E. 11, 12, 13, 16 and cred. or reg. in 22; 2 lect. and 3 lab. hrs. per week. Crowder and others.

15—MATERIALS AND PROCESSING V. Selection, tooling and operation of machine tools for quantity production of interchangeable piece parts. Preparation of operation analysis and estimating machining time for complete manufacture of piece parts. 2 cred.; prereq. M.E. 14; 2 lect. and 3 lab. hrs. per week. Crowder and others.

16—MATERIALS AND PROCESSING VI. Properties of wood, plywood, and laminated assemblies. Processes for the manufacture, seasoning, treatment, gluing, and fabrication of wood products and composite assemblies. Factors affecting the serviceability of wood products during processing, storage, installation, and use. Laboratory practice in the testing of wood and the operation of woodworking machinery. 2 cred.; prereq. Phys. 7 and M.E. 11; 2 lect. and 3 lab. hrs. per week. Tegge.

17—MATERIALS AND PROCESSING VII. A lecture and laboratory course dealing with the different types, properties, use, and fabrication of engineering materials such as plastics, glass, rubber, die cast metals, etc. 2 cred.; prereq. M.E. 11, 12, 13, and 16; 2 lect. and 3 lab. hrs. per week. Holtby and others.

18—MATERIALS AND PROCESSING. (Aero.E.) Principles and practices relating to the properties and processing of ferrous and nonferrous metals. Lectures, demonstrations, and laboratory. 3 cred.; no prereq.; 2 lect. and 6 lab. hrs. per week. Hughes.

20—ELEMENTARY MACHINE DESIGN. Detail, assembly, and layout drawings. Technique and knowledge necessary to convey information from engineering department to shop. Standard practices in design involving material

and heat treatment specifications, tolerances and allowances, manufacturers' standards, records and changes. 2 cred.; prereq. Draw. 2; 6 lab. hrs. per week. Palmer.

21—KINEMATICS. Kinematic drawings of machine elements. Displacement, velocity, and acceleration analysis of basic mechanisms. Graphical solutions involving instant centers, centroids, and velocity diagrams. Analysis and design of cams. 2 cred.; prereq. Draw. 3; 6 lab. hrs. per week. LaJoy and others.

22—MECHANISMS. Analysis of motion transmitted by curves in direct contact. Friction gearing, tooth gearing, analysis of gear-tooth action, study of the usual forms of gear-tooth profile, and design of gear trains. Use of graphical differentiation and integration to determine velocity and acceleration of machine elements. Miscellaneous connectors, intermittent motion devices, and hoisting mechanisms. 3 cred.; prereq. M.E. 21 and M.&M. 24; 2 rec. and 3 lab. hrs. per week. LaJoy and others.

23—DYNAMICS OF MACHINERY. Application of acceleration analysis to determine inertia forces of moving machine parts. Study of combined static and inertia forces in machinery. Analysis of energy cycle diagrams. Application of inertia forces in vibration and balancing problems. 3 cred.; prereq. cred. or registration in M.&M. 127 and M.E. 22; 2 lect. and 3 lab. hrs. per week. LaJoy and others.

24—ELEMENTS OF MACHINE DESIGN. Applications of the fundamentals of stress analysis in the design of machines. Endurance limits, Mohr's diagrams, working stresses, columns, beams and shafting. Properties of materials. Analysis of machine elements, springs, screw fastenings, riveted and welded joints. 3 cred; prereq. M.&M. 128; 2 rec. and 3 lab. hrs. per week. Ryan and others.

26—MECHANISMS AND KINEMATICS. (E.E., Aero.E., and Ag.E.) Displacement, velocity, and acceleration analysis of basic mechanisms and their application to machines. Analytical and graphical methods of solution involving instant centers, centroids, and velocity diagrams. Link work, cams, gear trains, flexible connectors, and miscellaneous mechanisms. 3 cred.; prereq. M.&M. 24; 3 rec. hrs. per week. Larsen and others.

27—MACHINE DESIGN. (Ag.E.) Applications of the fundamentals of stress analysis in the design of machines. Properties of materials. Analysis and design of machine elements; lubrication, shafts, screws, gears, springs, flywheels, machine frames, shrink fits. 3 cred.; prereq. M.&M. 128; 2 lect. and 3 lab. hrs. per week. Ryan and others.

33—MECHANICAL ENGINEERING LABORATORY I. Fundamentals of report writing. Study and calibration of area, pressure, temperature, speed and power measuring devices, and engine indicators. Study of weight, density, and relative density scales. Elementary heat transfer. 2 cred.; prereq. M.E. 131 or reg. in 131; reg. in Phys. 7 for work-study program; 6 lab. hrs. per week. Solberg and others.

34—MECHANICAL ENGINEERING LABORATORY II. Study and tests of lubricating oils, greases, and other petroleum products. Study and tests of instruments for measuring humidity and vapor quality. Tests of positive displacement air compressors. 2 cred.; prereq. M.E. 33 and cred. or reg. in M.E. 132; reg. in Phys. 8 for work-study programs; 6 lab. hrs. per week. Solberg and others.

35—MECHANICAL ENGINEERING LABORATORY III. Study, analysis, and determination of heating values of industrial fuels. Analysis of gaseous products of combustion. Study, analysis, and methods of treating industrial water. Study and tests of fluid flow measuring devices. 2 cred.; prereq. M.E. 34; 6 lab. hrs. per week. Solberg and others.

38—HEAT ENGINES. (Chem.E.) Elementary thermodynamics with emphasis on steam properties and calorimetry. Construction, selection, operation, and performance analysis of steam generators, prime movers, and power plant auxiliaries. 3 cred.; prereq. Phys. 7; 3 rec. hrs. per week. Lee and others.

39—HEAT ENGINE LABORATORY. (Chem.E.) Calibration and use of instruments; tests of engines, boilers, compressors, and power plant auxiliaries. 1 cred.; prereq. M.E. 38 or reg. in 38; 3 lab. hrs. per week. Lee and others.

40-41—HEAT ENGINES. (E.E.) Elementary thermodynamics, fuels and combustion. Construction, selection, operation, and performance analysis of steam power plant equipment. Tests of boilers, turbogenerators, steam engines, and power plant auxiliaries. 3 cred. per qtr.; prereq. Phys. 7; 2 rec. and 3 lab. hrs. per week. Lee and others.

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. Lee and others.

50—AUTO AND AIRPLANE ENGINES. Principles and types. Electrical systems. Lubrication and cooling. Carburetors. Accessories. 3 cred.; soph.; 3 rec. hrs. per week. Melby and others.

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, compression-ignition, and gas turbine engines. 3 cred.; prereq. M.E. 41; 2 rec. and 3 lab. hrs. per week. Lindquist and others.

60—WOODWORKING MACHINERY. Design and cutting action of knives, saws, bits, etc. Design, power, and speed requirements for typical woodworking machines. Design features of conventional and special machines. 2 cred.; prereq. Draw. 1, 2, and M.E. 4; 1 lect. or rec. and 3 lab. hrs. per week. Staff.

61—GLUES AND GLUING. Types and characteristics of glues and adhesives important to the woodworking industries. Detailed study of fundamental gluing requirements, equipment, and processes. Strength and durability of glue joints under test and service conditions. 3 cred.; prereq. Phys. 7 or Ag.Eng. 24 and reg. in M.E. 16 or For. 53; 2 lect. or rec. and 3 lab. hrs. per week.

70—MECHANICAL TECHNOLOGY. Survey of basic functions in an industrial organization. Product engineering, production engineering, plant engineering, production, purchasing, sales, industrial relations, controlling, quality control, legal, administrative, and management functions. Lectures by various specialists. Open only to soph., jr., and sr.; 1 cred.; 2 hrs. per week. Staff.

100-101-102—MILLING I, II, III. A lecture course on the mechanical technology of the milling of wheat and related operations. 3 cred. per qtr.; prereq. M.&M. 130 or equiv., M.E. 23, 132; 3 lect. hrs. per week. MacKenzie.

103-104—MILLING LABORATORY I, II. Observations and experience in flour milling operations. 2 cred. per qtr.; prereq. M.E. 35, 100 or reg. in 100; 6 lab. hrs. per week. MacKenzie.

105-106—MILLING DESIGN I, II. Fundamentals of design of flour milling equipment and mill layout. 2 cred. per qtr.; prereq. M.E. 100, 121, 160 for Milling Design I, M.E. 104 and 105 for Milling Design II; 6 lab. hrs. per week. MacKenzie.

107—PACKAGING AND HANDLING OF MATERIALS. A lecture course in modern packaging techniques and media combined with materials handling methods in the industry. 3 cred.; prereq. M.E. 101, 104, 105; 3 lect. hrs. per week. MacKenzie.

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. M.E. 12, Inorg.Chem. 16; ar. Holtby.

111—ADVANCED FOUNDRY PRACTICE. Continuation of Course 110. 3 cred.; prereq. M.E. 110, Phys. 9, and Inorg.Chem. 16; ar. Holtby.

112—PLASTIC PROCESSING. A lecture and laboratory course dealing with the materials, equipment, and manufacturing processes used in fabricating plastics, plastic product, and mold design. 3 cred.; no prereq.; 2 lect. and 3 lab. hrs. per week. (Not offered to mechanical engineering students.) Holtby.

113—ADVANCED MACHINE SHOP PRACTICE. Selection, tooling, and set-up of machine tools. Estimating machinery time and preparation of operating instructions for complete units. 3 cred.; prereq. M.E. 15; 1 lect. and 6 lab. hrs. per week. Crowder.

114—ADVANCED WELDING. Theory and applications of welding processes. Fundamental considerations in the design of weldments; factors affecting weldability of metals and alloys; welding in relation to other commercial fabricating processes. 3 cred.; prereq. M.E. 13; hrs. ar. Hughes.

115—CONTROL OF MANUFACTURING STANDARDS. Set-up and operation of the standards laboratory for the checking, calibrating and adjusting gauges, measuring instruments required for the control of dimensions. Inspection of special tools, jigs, and fixtures required for the manufacture of interchangeable parts. Design of special measuring gauges and fixtures for the rapid measurement of interchangeable parts. 3 cred.; prereq. M.E. 15; 1 lect. and 6 lab. hrs. per week. Crowder.

117—ADVANCED PLASTICS. A lecture and laboratory course dealing with theory and application of plastics fabricating methods, material testing, equipment, proper mold and press design, and production set-ups. 3 cred.; prereq. M.E. 17; 1 lect. and 3 lab. hrs. per week. (For mechanical engineering students only.) Holtby.

118—PLYWOOD AND LAMINATED ASSEMBLIES. Detailed study of veneer and plywood manufacturing equipment and production methods. Properties and uses of plywood and laminated assemblies. 3 cred.; prereq. M.E. 61 and reg. in M.&M. 128 or For. 115; 2 lect. or rec. and 3 lab. hrs. per week. Staff.

119—DERIVED AND SPECIAL WOOD PRODUCTS. Manufacture, properties, and uses of fiber board products, modified and treated wood, composite laminates, wood flour, bark and waste products. 2 cred.; prereq. M.E. 61; 2 cred. or rec. hrs. per week. Staff.

120—ADVANCED ENGINEERING DESIGN DRAFTING. Studies in design and layout of a complete machine; punch press, engine, lathe, automatic machine or special machinery, individually or by groups. Complete assembly and detail drafting with emphasis on design modifications and improvements. 2 cred.; prereq. M.E. 20 and 24. 6 lab. hrs. per week. Palmer.

121—MACHINE DESIGN. Advanced machine elements. Force and shrink fits, brakes and clutches, lubrication theory and practice, gear design, flywheel. Design practice and machine layout. 2 cred.; prereq. M.E. 24; 1 rec. or lect. and 3 lab. hrs. per week. Ryan and others.

122—MECHANICAL ENGINEERING DESIGN I. Advanced statics, dynamics and stress analysis applied to machines. Mathematics of elevator design, statically indeterminate structures, theory and application of vibration in machines, study of gyroscopes. Special design problems. 2 cred.; prereq. M.E. 121, 1 rec. or lect. and 3 lab. hrs. per week. Ryan and others.

123—MECHANICAL ENGINEERING DESIGN II. Application of fundamentals of engineering design to individually selected machines. Conception, functional analysis, design calculations, layout drawings and specifications. 2 cred.; prereq. M.E. 121; 1 rec. or lect. and 3 lab. hrs. per week. Ryan and others.

124—EXPERIMENTAL STRESS ANALYSIS. Experimental application and theoretical evaluation of the methods of stress analysis. Strain gauges, surface coatings, photoelasticity, dynamic stress measurements, penetration methods, and fracture methods. Equipment, operation, and tests. 3 cred.; prereq. M.&M. 128; 2 lect. or rec. and 3 lab. hrs. per week. Ryan and staff.

125—MACHINE DESIGN LABORATORY. Experimental studies of fundamental vibration models, lateral and torsional vibrations of shafting, balancing machines, noise measurements on machinery. Use of vibration instruments, stroboscopes, sound meters and analyzers, photoelastic polariscope, 8-inch journal-bearing testing machine, electronic measuring devices. 2 cred.; prereq. M.E. 24; 1 lect. and 3 lab. hrs. per week. Ryan and others.

127—LUBRICATION. Fluid friction and viscosity, properties of lubricants, hydrodynamic theory of lubrication, dimensional analysis, full, partial, and fitted bearings, oil thickness, pressure and velocity distributions, end leakage, thermal equilibrium, roller and ball bearings. Bearing design and construction, laboratory tests on 8-inch journal-bearings. 3 cred.; prereq. M.E. 121. 3 lect. or rec. hrs. per week. Ryan and others.

128—PHOTOELASTIC STRESS ANALYSIS. Fundamentals of advanced stress analysis; equations of equilibrium, optics of polarized light, design and construction of polariscopes and models. Use of polariscope in solution of special design problems, photography and equipment. 3 cred.; prereq. M.&M. 128; 2 lect. and 3 lab. hrs. per week. Ryan and others.

129—VIBRATION ENGINEERING. Fundamental analysis of vibrations, free harmonic vibrations, critical speeds, lateral and torsional vibration of shafting, effects of damping, dynamic equations of equilibrium, balancing and balancing machines, vibration absorption and isolation, measuring instruments. Application of vibration analysis in the design of machines. 3 cred.; prereq. M.&M. 127; 3 lect. or rec. hrs. per week. Ryan and others.

131-132—THERMODYNAMICS. A study of the thermodynamic properties of gases and vapors and the fundamental laws correlating energy with heat and work in systems such as air compressors, internal combustion engines, gas turbines, steam engines and steam turbines, refrigerators, heat pumps, etc. 3 cred. per qtr.; prereq. M.&M. 25, Phys. 8; 3 rec. hrs. per week. Hall and others.

133—HEAT TRANSMISSION. The introduction, theory, and principal empirical rules for problems in conduction, forced and free convection, and radiation. Emphasis will be given to obtaining facility in the use of established empirical correlations. 3 cred.; prereq. M.E. 132; 3 rec. hrs. per week. Ritchey.

134—THERMODYNAMICS OF FLUID FLOW. The fundamental thermodynamic procedures for the energy analysis of the flow of viscous and compressible fluids. Applications to flow systems such as ducts, diffusors, nozzles, ejectors, orifice plates, combustion chambers, heat exchangers, etc. Compressible flow phenomena occurring in mechanical engineering equipment. Flow of gases with suspended particles. 3 cred.; prereq. M.E. 132 or Phys. 73; 3 rec. hrs. per week. Hall.

138—GENERAL LABORATORY. (Min.E. only.) (a) Calibration of pressure gauges. Steam calorimetry. Steam indicator practice, card calculation. Test of oils, engines, turbines, air compressors, and pumps. (b) The use of weirs, differential gauges, etc., in the tests of centrifugal pumps, hydraulic turbines, etc. 2 cred.; prereq. Min.E. 122; 4 lab. hrs. per week. Lee and others.

141—HEAT POWER ENGINEERING. Study of fuels and combustion. Heat transfer in engineering equipment. Thermodynamics and equipment of simple power plants. Industrial water treatment. Units of rating and efficiency in steam generators and prime movers. Problems from fundamental steam engineering. 3 cred.; prereq. M.E. 132; 3 rec. hrs. per week. Ritchey and others.

142—ADVANCED HEAT POWER ENGINEERING. Practice and economics relating to steam generators, prime movers, and plant auxiliaries. Specialized power plant cycles. Plant controls. Trends in power development. 3 cred.; prereq. M.E. 141; 3 rec. hrs. per week. Andeen.

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. M.E. 132; 3 rec. hrs. per week. Lee.

146—FUELS AND COMBUSTION. Fuels classification and analysis, stoichiometry, rates, combustion processes, combustion equipment and controls. 3 cred.; prereq. M.E. 141; 3 rec. hrs. per week. Ritchey.

147—DESIGN OF STEAM MACHINERY. Steam generating station layout. General design of all component parts. 2 cred.; prereq. M.E. 141; 6 lab. hrs. per week. Andeen.

148—DESIGN OF POWER PLANT UNITS. Steam generating station heat balance. Detail design of some component part—boiler, economizer, superheater, condenser, etc. 2 cred.; prereq. M.E. 147; 6 lab. hrs. per week. Andeen.

149—ADVANCED STEAM LABORATORY. Tests of steam engines, steam turbines, evaporators, air compressors, and multiple turbo-generator units simulating actual power plant conditions. 2 cred.; prereq. M.E. 141, 35; 4 lab. hrs. per week. Andeen.

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. 4 cred.; prereq. M.E. 131; 3 rec. and 3 lab. hrs. per week. Lindquist and others.

150A—INTERNAL COMBUSTION ENGINES. (Aero.E.) Thermodynamics and combustion processes of real gases and vapors in Otto, Diesel, and Brayton cycle engines; volatile fuels; mixtures of real gases and vapors; explosion pressures, flow temperatures, and combustion phenomena; heat losses, real cycle efficiencies. 4 cred.; prereq. M.E. 131 or Phys. 73; 4 rec. hrs. per week. Lindquist and others.

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. M.E. 150; 3 rec. hrs. per week. Melby and other.

151A—ADVANCED INTERNAL COMBUSTION ENGINES. (Aero.E.) Special reference to aircraft engines. Theoretical consideration of fuels, combustion, detonation, lubrication, superchargers, and induction systems. Recent developments in airplane engines. 2 cred.; prereq. M.E. 150A or 150; 2 rec. hrs. per week. Melby and others.

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. M.E. 55 or 150; 3 rec. hrs. per week. Lindquist and others.

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. M.E. 150; 3 rec. hrs. per week. Murphy and others.

154-155—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. per qtr.; prereq. M.E. 121 and 150; 6 lab. hrs. per week. Murphy and others.

154A—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. M.E. 150 or 150A; 6 lab. hrs. per week. Murphy and others.

156—HIGH SPEED ENGINE TESTING. Advanced laboratory procedure and instrumentation. Effects of fuel mixture, distribution, etc., upon general engine performance. 2 cred.; prereq. M.E. 158 or 159 and minimum honor-point average of 1.5; 6 lab. hrs. per week. Murphy and others.

157—GAS TURBINE AND JET PROPULSION POWER PLANTS. Gas turbine cycles and principles; calculations on reheaters, regenerators, intercoolers, and closed and open systems; characteristics of compressors and turbines; power and efficiency calculations; combustion performance characteristics with propeller and jets. Combined effects of altitude, speed, compression ratio, turbine temperature, etc., upon performance. 3 cred.; prereq. M.E. 150 or 150A; 3 lect. hrs. per week. Murphy.

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. M.E. 150 or 150A or reg. in 150A; 6 lab. hrs. per week. Murphy and others.

159—INTERNAL COMBUSTION ENGINE LABORATORY. Tests of gasoline, aircraft, and Diesel engines. Power plant units, automotive engines, aircraft engines. 2 cred.; prereq. M.E. 150 or reg. in 150; 4 lab. hrs. per week. Murphy and others.

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. M.E. 132, M.&M. 127, and 129 or 130; 1 lect. and 2 rec. hrs. per week. Algren and others.

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 building. 2 cred. per qtr.; prereq. M.E. 160; 6 lab. hrs. per week. Algren and others.

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. M.E. 160; 3 rec. hrs. per week. Algren and others.

169—HEATING AND VENTILATION LABORATORY. Tests of heating, ventilation, and air conditioning equipment. The determination of air quantities as required for comfort and for specific industries. Tests and studies of complete installation. 2 cred.; prereq. M.E. 35, and 160, or reg. in 160; 4 lab. hrs. per week. Algren and others.

170—TOOL DESIGN. Study of the principles of design for jigs, fixtures, and punch press dies required to produce low cost interchangeable piece parts. Preparation of a manufacturing analysis of a piece part and the design of a jig, fixture, or die for the particular piece part. 2 cred.; prereq. M.E. 15, 171; 6 lab. hrs. per week. Crowder.

180—REFRIGERATION. Refrigeration cycles; thermodynamics of refrigeration; refrigerants; load calculations; compression, steam jet, and absorption refrigeration; refrigeration equipment. 3 cred.; prereq. M.E. 132 and 160 or reg. in 160; 2 lect. and 1 rec. hr. per week. Jordan and others.

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. M.E. 180; 2 lect. and 1 rec. hr. per week. Jordan and others.

182—REFRIGERATION DESIGN. Calculation of refrigeration loads; selection of compressors, evaporators, condensers, piping sizes and control; design of refrigeration systems for various types of buildings. 2 cred.; prereq. M.E. 180; 6 lab. hrs. per weeks. Jordan and others.

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. M.E. 180 or reg. in 180; 4 lab. hrs. per week. Jordan and others.

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. Staff.

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. Staff.

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. M.E.; 1 cred. Staff.

198—INDUSTRIAL INSTRUMENTATION AND AUTOMATIC CONTROL. Theory and operation of instruments and automatic controls. Domestic and industrial control mechanisms. Techniques used for obtaining control responses. Electric, pneumatic, and hydraulic methods. On-off, proportional, floating, and rate response in control instruments. 3 cred.; prereq. sr.; 2 lect. and 3 lab. hrs. per week. LaJoy and others.

199—SERVOMECHANISMS. Discussion of elementary control systems and basic servomechanisms. Mechanical and electrical error indicators. Theory and analysis of servomechanisms with various types of damping. Methods of obtaining desired system characteristics. 3 cred.; prereq. M.&M. 80, E.E. 37, or registration in E.E. 37; 3 rec. hrs. per week. LaJoy and others.

221—ADVANCED MECHANICAL ENGINEERING DES'GN. Applications of elasticity in the solution of design problems. Tension and compression; torsion; stresses and deflections in beams and shafts; statically indeterminate problems in bending of beams, shafts, frames. 3 cred.; prereq. M.E. 121; grad. only; ar. Ryan and others.

222—APPLICATIONS OF ELASTICITY IN MECHANICAL DESIGN. Applications of strain-energy methods in the analysis of design problems. Bending of bars on elastic foundations; reinforced tubes and cylinders. Stress concentration. Study of mechanical properties of materials, theories of failure, and material testing. 3 cred.; prereq. M.E. 121; grad. only; ar. Ryan and others.

223—ADVANCED MATHEMATICAL THEORY IN MECHANICAL DESIGN. Two-dimensional problems in Theory of Elasticity. Bending stresses and deflections in curved bars, thick cylinders, and rotating discs. Concentrated and

distributed forces on beams, thin plates, and shells. Combined bending and twist. Stresses produced by dynamical causes. 3 cred.; prereq. M.E. 121; grad. only; ar. Ryan and others.

228—PHOTOELASTICITY. Advanced studies in stress analysis by photoelasticity. Methods of determining principal stresses from measurements. Studies of stress patterns. Investigation of material constants and behavior. Frozen stresses. Solution of individual problems. 3 cred.; prereq. M.E. 128; 2 lect. and 3 lab. hrs. per week; grad. only. Ryan and others.

229—ADVANCED VIBRATION ENGINEERING. Advanced dynamics of vibration, Lagrange's equations, vibration in mechanical, electrical, and equivalent systems. Model analysis, vibration of bars, rings, plates, etc. Vibration tests and analysis with instruments. Design problems. 3 cred.; prereq. M.E. 129; 3 lect. or rec. hrs. per week; grad. only. Ryan and others.

231—ADVANCED THERMODYNAMICS. Review of basic concepts and laws. Equations of state and thermodynamic properties of gas, vapors, and mixtures. Thermodynamic functions and their differential relations. Analysis of thermodynamic cycles with critical examination of concepts of efficiency, availability, and other loss measurements. Thermodynamic equilibrium, supersaturation and supercooling, combustion. 3 cred.; prereq. M.E. 132; grad. only; 3 rec. hrs. per week. Hall.

232—ADVANCED FLUID THERMODYNAMICS. A critical examination of the principles of energy transformation and dynamics of flow of viscous and compressible fluids. Applications to laminar and turbulent flow of viscous fluids including boundary layer phenomena affecting friction and heat transfer. Energy transfer in heat exchangers and in rotating machinery. 3 cred.; prereq. M.E. 134, M.&M. 153 or permission of instructor; grad. only; 3 rec. hrs. per week. Hall.

233—ADVANCED HEAT TRANSMISSION. The mathematical theory of heat conduction with application to steady and nonsteady heat flow for various boundary conditions and configurations. Development of radiation theory of heat with application to heat transfer from solids and high temperature gases. 3 cred.; prereq. M.E. 133, M.&M. 153 or permission of instructor; grad. only; 3 rec. hrs. per week. Hall.

242—POWER PLANT SPECIFICATION. Estimating of initial installation, maintenance and depreciation costs of power plant components, and their effect on selection of units. Specification of units and components. 2 cred.; prereq. M.E. 148; grad. only. Andeen.

243—POWER PLANT LAYOUT. Power plant layout and selection of most economical fuel components for location and type of service. 2 cred.; prereq. M.E. 242, grad. only. Andeen.

244—POWER PLANT MANAGEMENT. Maintenance and operating schedules. Records on performance. Operating problems. Load curves and efficient operation of plants. 3 cred.; prereq. M.E. 142, grad. only. Andeen.

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. M.E. 121 and 150. Murphy.

251—AUTOMOTIVE VEHICLES. Study of transmission systems, running gears, chassis, bodies, riding qualities of vehicles, and current developments. Cred. ar.; lect. and problems; grad. only. Murphy.

252—ADVANCED RECIPROCATING ENGINES. Study of reciprocating engines for aircraft and other power applications with regard to problems of performance at sea level and at altitude as affected by airflow, fuel-air ratio, mixture temperature, manifold pressure, and spark timing; problems with regard to detonation limits of fuels and use of antidetonants; problems with re

gard to cooling characteristics under limiting conditions of power and altitude. 3 cred.; prereq. M.E. 151 or 151A, grad. only. Murphy.

253—ADVANCED GAS TURBINES. Study of gas turbines for aircraft and other power applications with regard to problems of performance, control, basic design analysis of diffusors; nozzles, axial and centrifugal compressors, and turbines; cooling, lubrication, and construction. 3 cred.; prereq. M.E. 157, grad. only. Hall, Murphy.

254—FLEET MAINTENANCE. Study of available types of motor coaches, automobiles, 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.; prereq. M.E. 153, grad. only. Murphy.

255—THERMAL JETS AND ROCKETS. Study of thermal jets and rockets with particular regard to the problems of design and calculations of the performance of ram jets, pulse jets as affected by altitude, flight velocity, and combustion phenomena; problems of design and calculation of the performance of solid fuel and liquid fuel rockets as affected by the energy of combustion, required weights of fuel delivery, cooling of combustion chamber, etc. 3 cred.; prereq. M.E. 134, 157, grad. only. Hall, Murphy.

256—ENGINE TESTING AND RESEARCH. Problems involving volumetric efficiency, manifolding, friction losses, oil deterioration, cylinder corrosion, and other engine performance factors of current interest. Cred. ar.; prereq. M.E. 158 or 159, grad. only. Murphy.

257—COMBUSTION AND FUELS FOR GAS TURBINES, JET PROPULSION, AND RECIPROCATING POWER PLANTS. Characteristics of petroleum fuels and manufacturing processes. Combustion reactions—ideal and real. Heating value, heat of formation, energy of reaction, flame temperatures, equilibrium in combustion. Fuels for reciprocating engines—octane and performance numbers, volatility, specifications; fuel for gas turbines, turbo jets, and ram-jet motors; liquid and solid fuels for rockets. 3 cred.; prereq. M.E. 150, 157, grad only. Hall.

265—ADVANCED AIR CONDITIONING. Advanced study of the thermodynamics of air and water vapor mixtures, objective of heating or cooling and the physiological principles involved, solar transmission, solar radiation, cooling loads, humidification, and dehumidification. 3 cred.; prereq. M.E. 160, grad. only. Algren.

266—ADVANCED VENTILATION AND AIR DISTRIBUTION. Physiological principles as applied to ventilation, ventilation systems, exhausting and conveying systems, mechanics of air distribution, air duct design; a study of fans, their classification, performance, and characteristic curves; sound control, air pollution and air cleaning devices. 3 cred.; prereq. M.E. 160, 265 or permission of instructor, grad. only. Algren.

267—APPLIED HEATING, VENTILATION, AND AIR CONDITIONING. Practical problems of radiant heating from a physiological standpoint, fundamental computation and application methods, district heating, heating equipment, automatic fuel-burning equipment, and assigned field studies. 3 cred.; prereq. M.E. 160 or permission of instructor, grad. only. Algren.

280—THEORETICAL REFRIGERATION. Advanced study dealing with problems involving the theory and design of refrigeration systems. Lectures, assigned reading, and reports. 3 cred.; prereq. M.E. 180, grad. only. Jordan.

281—APPLIED REFRIGERATION. Advanced study involving the applications of refrigeration systems to commercial and industrial equipment and processing. Lectures, assigned reading, and reports. 3 cred.; prereq. M.E. 180, grad. only. Jordan.

282—REVERSE APPLICATIONS OF REFRIGERATION—THE HEAT PUMP. Industrial, commercial, and residential applications of refrigeration systems as heat pumps. Lectures, assigned readings, and reports. 3 cred.; prereq. M.E. 180, grad. only. Jordan.

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. Staff.

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. Staff.

Metallography

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. MacKay.

153-154-155—METALLOGRAPHY. (Long course for metallurgical engineers.) Theory of metallic alloys. Metallographic technique. Properties of metals and alloys. Metallography of steel and nonferrous alloys. Laboratory work. 4 cred. per qtr.; prereq. Met. 12 or equiv.; 3 lect. and 4 lab. hrs. per week. Jerabek.

156—METALLOGRAPHY FOR MECHANICAL, MINING, AND PETROLEUM ENGINEERS. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, miscroscopic technique; metallography and heat treatment of iron and steel. 3 cred.; prereq. jr., sr.; 2 lect. and 2 lab. hrs. per week. MacKay.

157—ADVANCED METALLOGRAPHY FOR MECHANICAL, MINING, AND PETROLEUM ENGINEERS. Metallography of alloy steels, tool steels, and important nonferrous alloys; metallography applied to engineering practice and specifications. Outside reading and special reports. 3 cred.; prereq. Met. 152, 156 or 160; 3 lect. per week. MacKay.

159—DENTAL METALLOGRAPHY. Metallography of dental alloys. Basic course for dental students involving phase diagrams, metallography, heat treatment, and application of dental metals and alloys. MacKay, Jerabek.

160—METALLOGRAPHY. (Chem.E.) Principles of metallography, including constitution, diagrams, preparation and standardization of thermocouples, preparation and thermal analysis of alloys, their microscopic examination; typical alloy systems such as iron carbon (steel, cast iron), and some nonferrous alloys. Institute of Technology elective. Lab. work; 3 cred.; prereq. Anal.Chem. 1, 2; 2 lect. and 2 lab. hrs. per week. De Money.

161—ADVANCED METALLOGRAPHY. Metallography and heat treatment of iron and steel, including alloy steels, commercial uses of various steels, and engineering specifications. 2 or 3 cred. depending on lab.; prereq. Met. 152, 156, or 160; 2 lect. and 3 lab. hrs. per week. Institute of Technology elective. MacKay.

162—ADVANCED METALLOGRAPHY. 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. Met. 152, 156, or 160; 2 lect. and 3 lab. hrs. per week. Institute of Technology elective. MacKay.

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. Dowdell.

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. Dowdell.

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. Dowdell.

166-167-168—LABORATORY. Laboratory work on special problems in ferrous, nonferrous, and X-ray metallography. 1, 2, or 3 cred. per qtr.; prereq. Met. 155; 1 lect. and 4 lab. hrs. per week for 166 and 168; 9 lab. hrs. per week for 167. Dowdell, Jerabek.

170-171-172—SPECIAL PROBLEMS IN METALLOGRAPHY. 1, 2, or 3 cred. per qtr.; hrs. ar.; prereq. sr. Met.E. or grad. Dowdell, Jerabek.

201-202-203—ADVANCED METALLOGRAPHY FOR GRADUATE STUDENTS. Intended primarily for research work. Cred. and hrs. ar. Dowdell, Jerabek.

204-205-206—METALLOGRAPHIC RESEARCH. Special research and seminar in physical metallurgy. Cred. and hrs. ar. Dowdell, Jerabek.

210-211-212—THESIS COURSES FOR GRADUATE STUDENTS. Intended primarily for research work. Cred. and hrs. ar. Dowdell, Jerabek.

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. 3 cred.; prereq. Chem. 5 or equiv.; 3 lect. and 4 lab. hrs. per week. Bitsianes.

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.; 3 lect. hrs. per week. Joseph.

12—METALLURGY OF STEEL. The chemistry and technology of the principal steelmaking processes. 3 cred.; prereq. Met. 11; 3 lect. hrs. per week. Martin.

106—NONFERROUS METALLURGY. Metallurgical principles involved in nonferrous metallurgy including leaching, roasting, smelting, and refining. Metallurgy of copper. 3 cred.; prereq. Inorg.Chem.; 3 lect. hrs. per week. Bitsianes.

107—NONFERROUS METALLURGY. Pyrometallurgy and hydrometallurgy of the recovery and refining of lead, zinc, and cadmium. 3 cred.; prereq. Met. 106; 3 lect. hrs. per week. Bitsianes.

108—NONFERROUS METALLURGY. The metallurgy of aluminum, magnesium, nickel, gold, silver, and other metals. 3 cred.; prereq. Met. 107; 3 lect. hrs. per week. Bitsianes.

110—MINERAL DRESSING. Study of jaw and gyratory crushers, ball mills, rod mills, tube mills, volumetric sizing, gravimetric sizing. 3 cred.; prereq. Geol. 24; 2 lect. and 3 lab. hrs. per week. Cooke.

111—MINERAL DRESSING. Principles of ore beneficiation by gravity concentration. Concentration by jigs, tables, classifiers, log washers, and miscellaneous devices. 3 cred.; prereq. Met. 110; 2 lect. and 3 lab. hrs. per week. Cooke.

112—MINERAL DRESSING. Principles of flotation in ore beneficiation. Special attention to chemical and physical action of the different reagents used, such as frothing, collecting, depressing, activating, conditioning, etc. 3 cred.; prereq. Met. 111; 2 lect. and 3 lab. hrs. per week. Cooke.

121—ORE TESTING (IRON ORES). Methods of beneficiation, principles, methods and machines, concentration, formulas, metallurgical and economic considerations. 2 cred.; prereq. Met. 110; 1 lect. and 3 lab. hrs. per week. Davis.

122—ADVANCED MINERAL DRESSING. Determination of methods for metallurgical and economic extraction of nonferrous minerals from ores. 3 cred.; prereq. Met. 112; 2 lect. and 1 rec. hr. per week. Cooke.

123—ADVANCED MINERAL DRESSING. Continuation of Course 122. Consideration of factors affecting extraction. Study of distribution of values in mill and metallurgical products. 3 cred.; prereq. Met. 122; 2 lect. and 1 rec. hr. per week. Cooke.

124-125-126—SPECIAL PROBLEMS IN MINERAL DRESSING. Detailed study of mineral dressing problems. Cred. and hrs. ar.; prereq. Met. 112. Cooke.

130-131-132—SPECIAL PROBLEMS IN NONFERROUS METALLURGY. Seminar work on metallurgical problems, primarily for graduate students. Cred. and hrs. ar.; prereq. Met. 123. Bitsianes, Martin.

133—ELECTROMETALLURGY. A study of arc, induction, and resistance furnaces used in the metallurgical industry. 3 cred.; prereq. Met. 12. 3 lect. hrs. per week. Martin.

134—ADVANCED METALLURGY. Raw materials, manufacture, properties, and uses of refractories. Temperature stresses and spalling. Heat transmission. 4 cred.; prereq. Met. 12; 3 lect. and 4 lab. hrs. per week. Joseph, Martin.

135—ADVANCED METALLURGY. 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. Met. 134; 3 lect. and 4 lab. hrs. per week. Joseph, Martin.

136—ADVANCED METALLURGY. A detailed study of the basic open hearth process of making steel with emphasis on the physical chemistry involved in the process. 4 cred.; prereq. Met. 135. 3 lect. and 4 lab. hrs. per week. Martin.

140—ADVANCED ORE TESTING (IRON ORES). Continuation of Course 121. Metallurgical calculations and report writing. 2 cred.; prereq. Met. 121. Davis.

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. Joseph, Martin, Bitsianes.

175—STUDY OF METALLURGICAL OPERATIONS IN IMPORTANT IRON AND STEEL CENTERS. 3 cred.; prereq. jr. year; time ar., duration 2 weeks. Martin, Jerabek.

213-214-215—THESIS COURSE FOR GRADUATE STUDENTS. Intended primarily for research work. Cred. and hrs. ar. Joseph, Martin, Bitsianes, Cooke.

216-217-218—SEMINAR IN PROCESS METALLURGY. 1 cred. per qtr.; prereq. grad.; 1 hr. ar. Martin.

219-220-221—SPECIAL PROBLEMS IN ADVANCED METALLURGY. Intended primarily for research work. Cred. and hrs ar. Joseph, Martin, Bitsianes, Cooke.

Military Science and Tactics (ROTC)

The department offers a four-year program consisting of Military Science I, II, III, and IV, leading to a commission in the Army Officers Reserve Corps. The program is offered as a university elective, enabling students to qualify for a reserve officer's commission concurrently with enrolment in any of the undergraduate courses offered by the University. Students accepted for the program must be enrolled in a four-year or longer college course, and meet physical and age requirements established by the Army.

Military Science I consists of 3 hours per week for 3 consecutive quarters of separate basic subjects pertaining to all branches of the Army. Military Science II consists of 3 hours per week of specialized subjects pertaining to the Army branch in which the student elects to receive his reserve commission, such as Artillery, Signal Corps, Corps of Engineers, Ordnance Department, and others.

Military Science III and IV (third and fourth years) consist of 5 hours per week of continuing specialized branch subjects, and one six-week summer camp between the two years. During these last two years students are paid approximately $27 per month. A separate pay scale for the six-week summer camp provides travel pay and $75 per month for the camp period.

Military Science courses carry college credits of 1 credit per quarter for M.S. I and II, and 3 credits per quarter for M.S. III and IV.

Students enrolling in the program may be deferred from service under the Selective Service Act of 1948 until completion of their undergraduate college program within quotas established by the Army. Subsequent service, if required, would be performed in a commissioned officer grade.

Further information may be obtained from the Professor of Military Science and Tactics, Room 102, Armory.

Mining Engineering

11-12-13—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 Course 11 and 12; 2 cred. for Course 13; prereq. Draw. 3, M.&M. 12; 3 lect. and 1 quiz. hr. per week for Courses 11 and 12; 2 lect. and 1 quiz hr. per week for Course 13. Heilig.

14—SURVEYING FIELD WORK. General work in plane surveying and adjustment of instruments. 5 cred.; prereq. Min. 11, 12; 20 hrs. per week. Heilig, Yardley.

15—FIELD WORK IN SURVEYING 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. 6 cred.; prereq. Min. 13, 14; 4 weeks beginning about June 15. Heilig, Pfleider, Yardley.

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. Min. 15; 8 lab. hrs. per week. Heilig or alternate.

107—MINE MAPPING. Mapping mine surveyed during the field trip. 1 cred.; prereq. Min. 15; 3 lab. hrs. per week. Heilig or alternate.

111-112-113—ELEMENTS OF MINING. Fundamentals of mining, embracing the exploration, development, and exploitation of mineral deposits. The principles and technology of prospecting, drilling, blasting, hoisting, and transporting of ores, mine drainage. Support of excavations, tunneling, and underground mining methods. 3 cred. per qtr.; prereq. Min. 14; 4 lect. hrs. per week. Pfleider, Yardley.

121-122-123—MINE PLANT. Application of basic mathematics and physics to mining and petroleum plant. Principles and design of equipment. Calculation of problems involving hoisting, compressed air, transmission of gases and fluids, ventilation, excavating and transporting of materials. 2 cred. per qtr.; prereq. M.&M. 129 and M.E. 131; 6 lab. hrs. per week. Staff.

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. Yardley.

127—ENGINEERING CONSTRUCTION. Design of structures for mining and petroleum plant. 3 cred.; prereq. Min. 126; 8 lab. hrs. per week. Yardley.

138—THE STONE INDUSTRIES. Monumental and building stones, crushed stone, sand and gravel plants and operations. 2 cred.; prereq. Min. 113. Staff.

139—STUDY OF MINING OPERATIONS, MINE PLANT, AND METALLURGICAL PLANTS IN ONE OR MORE WESTERN MINING CAMPS. 6 cred.; prereq. jr. year. Three weeks beginning about September 1. Pfleider, Yardley.

141—EXAMINATION AND VALUATION. Mine examinations and reports; mining economics, taxation, capitalization, and amortization. Organization and administration. 3 cred.; prereq. Min. 113 or Pet. 112; 4 lect. hrs. per week. Pfleider or alternate.

142—OPEN PITS, QUARRIES, PLACERS, AND MINING LAW. Surface mining techniques. Excavation by shovels and draglines; handling materials by railroad, trucks, and conveyors. Quarries; methods, equipment, field for product. Placers: dredging, hydraulicking. Mineral laws, court interpretations. 3 cred.; prereq. Min. 113; 4 lect. hrs. per week. Pfleider.

143—INDUSTRIAL MINERALS AND COAL. Coal mining methods, mechanization, coal preparation, mine gases; safety work and organization. Mining of nonmetallic mineral products. 3 cred.; prereq. Min. 113; 4 lect. hrs. per week. Yardley.

144-145—ADVANCED MINING. Preparation of a report on a mining property or some phase of the mineral industry. 2 cred.; 6 lab. hrs. per week for Course 144, 4 cred.; 10 lab. hrs. per week for Course 145; prereq. Min 141. Pfleider and staff.

151-152-153—SPECIAL PROBLEMS IN MINING. Seminar work on mining problems. Cred. and hrs. ar.; prereq. Min. 113. Staff.

Natural Science

(College of Science, Literature, and the Arts)

7-8-9†—GENERAL BIOLOGY. The main principles of plant and animal life with particular reference to man and his place in the biological world. 10 cred.; no prereq.; 2 lect. hrs. and 4 lab. hrs. per week.

Naval Science

The courses in naval science are primarily for those students in the Naval ROTC but are available to students in the Institute of Technology as well as to students in the other colleges of the University. These courses are acceptable electives in most of the courses offered by the Institute of Technology.

All courses require three recitation-lecture periods, plus a two-hour laboratory period per week.

11—NAVAL ORIENTATION (111). 3 cred.
12—NAVAL ORIENTATION (112). 3 cred.
13—NAVAL ORIENTATION (113). 3 cred.
21—NAVAL WEAPONS (211). 3 cred.
22—FIRE CONTROL (212). 3 cred.
23—ELECTRONICS (213). 3 cred.
51—PILOTING (311). 3 cred.

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

52—AEROLOGY. (312). 3 cred.
53—NAVIGATION (313). 3 cred.
55—MILITARY POLICY, POWER, AND PRINCIPLES (313M). 3 cred.
64*—NAVAL ENGINEERING (411). 3 cred.
65*—NAVAL ENGINEERING (412). 3 cred.
66—SHIP CONSTRUCTION AND STABILITY (413). 3 cred.
67—NAVY SUPPLY (411S). 4 cred.
68—NAVY SUPPLY (412S). 4 cred.
69—NAVY SUPPLY (413S). 4 cred.

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 Min. 14; 4 lect. hrs. per week. Lacabanne.

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. Pet. 111; 4 lect. hrs. per week. Lacabanne.

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. 12, Phys. 7; 2 lect. hrs. per week. Lacabanne.

134—PETROLEUM PLANT. Gas flow and fundamentals of metering methods and calculations. Natural gasoline extraction. Mechanical features of transmission lines for oil and gas. Flow formulas, soil corrosion and prevention. 2 cred.; prereq. Pet. 152; 2 lect. hrs. per week. Lacabanne.

135—STUDY OF OIL WELL DRILLING AND PRODUCTION METHODS AND REFINING PRACTICE IN ONE OR MORE OIL FIELDS. 3 cred.; prereq. jr. year. Two-week field trip to be arranged. Lacabanne.

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. 107; 6 lab. hrs. per week. Lacabanne.

144-145—ADVANCED PETROLEUM ENGINEERING. Preparation of report on the exploration and development of an oil property or some phase of the industry. 2 cred.; 6 lab. hrs. per week for Course 144; and 4 cred.; 10 lab. hrs. per week for Course 145; prereq. Min. 141. Pfleider.

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, problems. 3 cred. per qtr.; prereq. Pet. 112; 1 lect. and 6 lab. hrs. per week. Lacabanne.

155-156-157—SPECIAL PROBLEMS IN PETROLEUM ENGINEERING. Seminar in petroleum problems. Cred. and hrs. ar.; prereq. reg. in Pet. 144-145. Lacabanne.

* Students may enter any quarter.

Philosophy

(College of Science, Literature, and the Arts)

1—PROBLEMS OF PHILOSOPHY. An introductory course dealing with man's most important attempts to understand the world and himself. Brief survey of great philosophies; methods of obtaining knowledge; chief data of the sciences; doctrines of evolution, especially in their bearing on ethics and religion. 5 cred.; no prereq.; 5 lect. hrs. per week. Swanson, Hospers, Conger, and others.

2—LOGIC. A study of the difference between logical and fallacious reasoning; types of fallacies; rules of a good definition; syllogisms; proof; hypotheses; generalization; probability. 5 cred.; no prereq.; 3 lect. hrs. and 2 quiz sections per week.

3—ETHICS. Problems of life treated in terms of (1) contemporary social, political, and economic forces, and (2) the character of the individual; psychological and philosophical foundations of morality; the reconstruction of morality. 5 cred.; no prereq.; 5 lect. hrs. per week.

2A-1A-3A—SELECTED PROBLEMS OF LOGIC, OF PHILOSOPHY, OF ETHICS. A special sequence of courses in philosophy especially for prelegal freshmen, but open to other students. 3 cred. per qtr.; no prereq.; 3 lect. hrs. per week.

10—SCIENCE AND RELIGION. An inquiry into the nature of science and religion as currently interpreted, with an attempt to find grounds of conflict and/or reconciliation. 3 cred.; soph., jr., sr.; no prereq.

20—SOCIAL PHILOSOPHY. A study of conflicting social philosophies of today; liberalism vs. authoritarianism; evaluation of various social, political, and economic institutions in terms of ethical ideals; other problems of social morality; social reconstruction; social utopias. 3 cred.; soph., jr., sr., no prereq. (Not offered in 1950-51.)

70—PHILOSOPHIES OF SOCIAL REFORM I: FROM THE FRENCH REVOLUTION TO 1848. Social criticism in the period of rising industrialism. A consideration of the philosophical bases of liberalism, utopian socialism, and democracy. 3 cred.; jr., sr.; no prereq.; 3 lect. hrs. per week.

81-82-83—SCIENCE AND CIVILIZATION. (Formerly 80-81-82.) The course attempts to provide an adequate understanding of the evolution of the sciences and of the scientific point of view within the frame of the history of civilization; the meaning of the fundamental problems, methods, concepts, and assumptions of modern science; and the human and social implications of science in the contemporary world. 3 cred. per qtr.; designed primarily as a senior integrative course, but open to juniors on consent of instructor; no prereq. Brodbeck.

135—PHILOSOPHY IN MODERN LITERATURE. A survey of basic philosophical ideas in modern civilization as they are expressed in major works of literature. 3 cred.; jr., sr., grad.; no prereq.; 3 lect. hrs. per week.

153—PHILOSOPHY OF SCIENCE. An attempt to provide a clear understanding of the meaning, methods, and implications of modern science through the examination of basic concepts, presuppositions, and procedures. The topics include description, explanation, prediction, experimentation; space, time, number, matter, energy; causality, probability, statistics; organic life, evolution, mind. 4 cred.; jr., sr., grad.; prereq. Course 2 or consent of instructor; 4 lect. hrs. per week.

Physical Education for Men

(College of Science, Literature, and the Arts)

The courses in sports education are offered in 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.

The facilities of the Department of Physical Education including the golf course, tennis courts, gymnasium, swimming pools, handball and squash courts, golf gymnasium, 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 of Cooke Hall.

SPORTS EDUCATION

1A-B-C—SPORTS EDUCATION. 1 cred. per qtr.; no prereq.
2A-B-C—SPORTS EDUCATION. 1 cred. per qtr.; no prereq.
Substitution of athletic team practice may be allowed by the department.

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.; prereq. M.&M. 9 or equiv.; 3 lect. hrs. per week.

7-8-9—GENERAL PHYSICS. Mechanics, heat, electricity, sound, and light. Laboratory work an integral part of course. 5 cred. per qtr.; prereq. reg. in M.&M. 24; 4 lect., 1 quiz, and 2 lab. hrs. per week.

73—INTERMEDIATE THERMODYNAMICS. (Not open to M.E. students.) 3 cred.; prereq. M.&M. 25 and Phys. 7-8-9; 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. hrs. per week.

107-109-111—MODERN PHYSICS. 3 cred. per qtr.; prereq. 15 cred. in phys. and M.&M. 25; 3 lect. hrs. per week.

110-112*—MODERN EXPERIMENTAL PHYSICS. 3 cred. per qtr.; prereq. Phys. 144; 6 lab. hrs. per week.

114-116-118—ELEMENTARY PHYSICAL INVESTIGATION. 3 cred. per qtr.; prereq. 15 cred. in phys. Permission of chairman of department. Staff.

131—GEOMETRICAL OPTICS. 3 cred.; prereq. 15 cred. in phys.; ar.

133—PHYSICAL OPTICS. Theory of interference and interferometers. Theory of diffraction, resolving power, and diffraction gratings. Polarized light, crystal optics, and applications. 3 cred.; prereq. 15 cred. in phys. and M.&M. 25.

134—EXPERIMENTAL OPTICS. 3 cred.; prereq. 15 cred. in phys. and M.&M. 25; 6 lect. and lab. hrs. per week.

135—SPECTROSCOPY. Light sources, instruments, and methods used in spectroscopy of the X ray, ultraviolet, visible, and infrared regions of the spectrum. 3 cred.; prereq. 15 cred. in phys. and M.&M. 25.

* Students may enter any quarter.

136—SPECTRUM ANALYSIS. 3 cred.; prereq. 15 cred. in phys. and M.&M. 25; 6 lect. and lab. hrs. per week.

144—ELECTRICAL MEASUREMENTS. An experimental course covering ballistic and current galvanometers, magnetic flux measurements, potentiometer methods, D.C. bridges, and audiofrequency A.C. bridges. 3 cred.; prereq. 15 cred in phys. and M.&M. 25.

146—PHYSICS OF VACUUM TUBES. Thermionics, vacuum tube circuits. 3 cred.; prereq. Phys. 144 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. Phys. 101-103-105, or reg. in 101-103-105.

191-192-193—MATHEMATICAL PHYSICS. 3 cred. per qtr.; prereq. Phys. 101-103-105 and M.&M. 150-152-153 or reg. in M.&M. 150-152-153.

Physiological Chemistry

(Medical School)

100-101—PHYSIOLOGICAL CHEMISTRY. Components of the animal body; foods, digestion, excretion, and metabolism. Prereq. organic and physical chemistry and physics; 4 lect., 1 quiz, and 6 lab. hrs. per week. Armstrong, Barnum, Glick, Cohen, Carr.

153—PROBLEMS IN PHYSIOLOGICAL CHEMISTRY. Special work arranged with qualified students. May be taken one or more quarters. Cred. and hrs. ar.; prereq. Physiol.Chem. 100-101. Armstrong, Barnum, Glick, Cohen, Frame, Carr.

200—SEMINAR IN PHYSIOLOGICAL CHEMISTRY. 1 cred.; 11 hrs. Staff.

205—RESEARCH IN PHYSIOLOGICAL CHEMISTRY. Cred. and hrs. ar. Armstrong, Barnum, Glick, Cohen, Frame, Carr.

206—ADVANCED ENDOCRINOLOGY AND STEROID CHEMISTRY. 3 cred.; prereq. Physiol.Chem. 101-101. (Offered in sessions which begin with an odd numbered year and only if 8 or more students are registered.)

207—RADIOTRACERS AND MINERAL METABOLISM. 3 cred.; prereq. Physiol.Chem. 100-101. Armstrong. (Offered in sessions which begin with an odd numbered year and only if 8 or more students are registered.)

208—ADVANCED LABORATORY TECHNIQUE. 3 cred.; prereq. Physiol. Chem. 100-101. Staff. Registration limited to 10 students. (Offered in sessions which begin with an odd numbered year.)

209—HISTOCHEMISTRY. 3 cred.; prereq. Physiol.Chem. 100-101 and histology or permission of instructor. Glick. (Offered in sessions which begin with an even numbered year and only if 8 or more students are registered.)

210—ADVANCED NITROGEN METABOLISM. 3 cred.; prereq. Physiol. Chem. 100-101. Frame. (Offered in sessions which begin with an even numbered year and only if 8 or more students are registered.)

211—ADVANCED INTERMEDIARY METABOLISM. 3 cred.; prereq. Physiol. Chem. 100-101. Barnum. (Offered in sessions which begin with an even numbered year and only if 8 or more students are registered.)

Plant Pathology and Botany

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

1—PLANT PATHOLOGY. An introductory course in plant diseases. Lectures, laboratory, and reference. 5 cred.; soph., jr., sr.; not open to those who have completed Course 10; prereq. 9 cred. in plant sciences of which at least 6 shall be in botany.

3—WEEDS. A study of the identification, structures, and habits of weed plants in relation to methods of controlling them. 3 cred.; fr., soph., jr., sr.; prereq. bot. 6 cred.

9—SEED TECHNOLOGY AND TESTING. Testing, including germination, identification, purity, seed storage; processing and preparation of seed for trade, seed legislation. 3 cred.; soph., jr., sr.; prereq. Bot. 9 cred. or equiv.

52—BIOCHEMISTRY AND MICROBIOLOGY OF CEREAL GRAINS. Physical properties and chemical composition of cereal grains and their mill products; microorganisms associated with cereal grains and their products; the biochemistry and microbiology of grain storage, milling, malt production and breadmaking. 3 cred.; jr., sr.; open only to students in Mechanical Engineering (milling option); prereq. elem. org. chem. 5 cred., and gen. biol. 9 cred. or equiv. (Same as Ag.Bio.Chem. 52.)

Political Science

(College of Science, Literature, and the Arts)

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 of 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. Christensen, Warp.

A-B†-C—THE STATE IN THE MODERN WORLD. An examination of principles, structure, and operation of the modern state. Emphasis on nation state; historical development; democratic government: United States, Great Britain; totalitarian government: Nazi Germany, Soviet Russia; conflict between states. This course will replace Elements (15), Fundamentals of Government and Politics (9-10), and Comparative European Government (7). 9 cred.; no prereq. Lippincott.

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. deGrazia.

25—WORLD POLITICS. Introduction to contemporary international relations; the policies of the great powers; nationalism; imperialism; internationalism. 3 cred.; no prereq.; 3 rec. hrs. per week. Mills.

124—RECENT SOCIAL LEGISLATION. With special reference to social security, labor, housing, and health. 3 cred.; prereq. third, fourth, or fifth year student; 3 rec. hrs. per week. Christensen.

153—JAPANESE GOVERNMENT AND POLITICS. Constitutional and political development in Japan; political theory, government, political parties, and problems. 3 cred.; jr., sr., grad.; prereq. 6 cred. or consent of instructor. Quigley.

154—CHINESE GOVERNMENT AND POLITICS. Constitutional and political development in China, political ideas, government, political parties, and problems. 3 cred.; jr., sr., grad.; prereq. 6 cred. or consent of instructor. Quigley.

155-156—GOVERNMENT AND INTERSTATE RELATIONS IN LATIN AMERICA. The constitutional and political development of the principal Latin-American nations; present governmental organization and the role of political parties; development and functioning of inter-American political and administrative organizations. 3 cred. per qtr.

161—PROBLEMS OF DEMOCRACY. An intensive examination of the main criticisms of democracy: intellectualist, scientific, Marxist, Fascist. 3 cred.; prereq. 6 cred. in political science or 12 cred. in social science or consent of the instructor; 3 rec. hrs. per week. Sibley.

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

Psychology

(College of Science, Literature, and the Arts)

1-2†—GENERAL PSYCHOLOGY. A general introduction to the study of human behavior with emphasis on the development of the individual. 3 cred. per qtr.; no prereq.; 3 lect. hrs. per week.

3—PSYCHOLOGY APPLIED TO DAILY LIFE. A course in the use of psychological methods in solving such problems as come up in the treatment of ill health, in the court room, reformatory, and prison, in business offices and factories, in advertising, in education, in social and political life, in artistic creation and esthetic enjoyment, and in everyday life. 3 cred.; prereq. Psy. 1 and 2; 3 lect. hrs. per week.

130—VOCATIONAL AND OCCUPATIONAL PSYCHOLOGY. Psychology of individual differences in intelligence, aptitudes, interests, and training, with special reference to vocational guidance and problems of occupational adjustment. Lectures and laboratory work. 3 cred.; jr., sr., grad.; prereq. 9 cred. in psy.

160—PSYCHOLOGY IN PERSONNEL WORK. 3 cred.; jr., sr., grad.; prereq. Psy. 1-2, 4-5, or 3 cred. in statistics, and Principles of Economics or consent of instructor. Longstaff.

Public Health

(School of Public Health)

3—PERSONAL HEALTH. Elementary principles of normal body functions; predisposing and actual causes of disease; ways in which disease may be avoided. 2 cred.; no prereq. Thomson.

100—ELEMENTS OF PREVENTIVE MEDICINE AND PUBLIC HEALTH. Susceptibility and resistance to disease; occurrence and prevention of communicable, degenerative, and industrial diseases; protection of food, water, and milk; school health work; vital statistics. 5 cred.; prereq. Course 3 or 50, or equiv. and a course in bacteriology. Anderson, Thomson, Taylor.

102—ENVIRONMENTAL SANITATION I. Methods for promoting man's health and comfort by controlling his environment; water supply sanitation, food sanitation; sewage, excreta, and waste disposal; bathing place sanitation; air hygiene; housing; control of insect and animal vectors of disease, industrial hygiene and sanitation. 3 cred.; sr., grad.; prereq. P.H. 50 or 51 or 53 or 100 or by consent of instructor or may be taken concurrently with any of these. Pierce, Olson.

106—PUBLIC HEALTH ADMINISTRATION. Structure, basic functions, and activities of public health agencies; public health laws and regulations; administrative procedures in public health practice; relationship to other governmental and social activities. 3 cred.; physicians, engineers, nurses, social workers, and others by arrangement; prereq. P.H. 53 or 100, or equiv. Anderson.

112—WATER SUPPLY SANITATION. Sanitary problems associated with the location, construction, and operation of water supplies, purification works, and distribution systems and of swimming pools. Seminars, plan examinations, field and laboratory investigations. 4 cred.; prereq. P.H. 102 and either 100 or 104. Whittaker, Pierce, Olson.

113—SEWAGE, EXCRETA, AND WASTE DISPOSAL. Public health supervision of the treatment and disposal of sewage, excreta, garbage, and other wastes; methods for the study and control of stream, lake, and ground water pollution. Seminars, plan examinations, field and laboratory investigation. 4 cred.; prereq. P.H. 102 and either 100 or 104. Whittaker, Pierce, Olson.

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

115—FOOD SANITATION. Sanitary problems associated with the production, processing and distribution of milk, meat, shellfish, and other foods, methods of public health supervision. Lectures, field and laboratory demonstrations. 3 cred.; prereq. P.H. 102, 106, and either 100 or 104. Olson.

116—PUBLIC HEALTH ENGINEERING ADMINISTRATION. Administrative organization of environmental sanitation activities at the various levels of government and in other organizations including methods and procedures for supervision and control. 2 cred.; prereq. P.H. 102, 100 or 104, and 106. Whittaker.

117-118—SANITARY BIOLOGY. Survey of plant and animal forms important in environmental sanitation, with special reference to disease vectors and to those of concern in problems relating to water supply, sewage treatment, water pollution, bathing places, air pollution, and food sanitation. 3 cred. per qtr.; prereq. consent of instructor. Olson.

126—INDUSTRIAL HEALTH PROBLEMS. Organization of industrial health services, state programs in industrial hygiene. Industrial hazards and their control. Procedures in industrial health services. 3 cred.; prereq. P.H. 53 or 100, Chem. 1-2 or equivalent, or permission of department. Foker.

152—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.; prereq. consent of instructor. Pierce.

194—HUMAN FACTORS IN INDUSTRY. Job requirements, physiological cost of work, industrial fatigue, industrial hazards, environment, accidents, absenteeism. 3 cred.; sr., grad.; prereq. 20 cred. in at least two of the following: chemistry, biology, psychology, engineering; primarily for students in the Schools of Business Administration and Public Health, and Institute of Technology. Brozek.

Rhetoric

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

22—PUBLIC SPEAKING. A practical course in the fundamentals of speech making. Particular emphasis upon organizing the speech and projecting it to the audience. 3 cred.; soph., jr., sr.; prereq. Engl. 6 or Rhet. Comm. requirement.

Social Science

(College of Science, Literature, and the Arts)

1-2-3—INTRODUCTION TO SOCIAL SCIENCE. A study of the great issues of our times and analysis of the proposed solutions. Information and insights from every source—sociological, economic, political, geographical, historical—are utilized to assist the student in making judgments necessary for effective citizenship. 4 cred. per qtr.; no prereq.; 3 lect. hrs. and one arranged discussion per week.

Sociology

(College of Science, Literature, and the Arts)

1—INTRODUCTION TO SOCIOLOGY. A study of the characteristics of human group life. An analysis of the factors associated with the development of human group life and man's social environment; the structure of the social environment and its influence upon the individual's behavior. 5 cred.; no prereq.; 3 lect. and 2 rec. hrs. per week.

2—INTERMEDIATE SOCIOLOGY. A sociological analysis of modern American society. Topics emphasized include the distribution of population, urban-rural differences, social factors in the business system, occupational groups, the determination of social status, and minority group adjustment. An attempt is made to familiarize the student with current research methods. 5 cred.; prereq. Soc. 1; 3 lect. and 2 rec. hrs. per week.

14—RURAL SOCIOLOGY. A presentation of factual data necessary to an understanding of the problems of rural life. 3 cred.; prereq. Soc. 1; 3 rec. hrs. per week.

106—CITY PLANNING. General survey of the economic, governmental, social, and technical phases of city planning and group housing. (The same as Arch. 104, Econ. 111, and Pol.Sci. 123.) 3 cred.; jr., sr., grad.; no prereq. 3 rec. hrs. per week.

Soils

(College of Agriculture, Forestry, Home Economics, and Veterinary Medicine)

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. In.Chem. 1-2 or 4-5; 3 lect. hrs. per week. Caldwell.

5—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. Rost.

103—PRINCIPLES OF SOIL EROSION. Causes and forms of erosion; relation of erosion to climate, vegetation, slope, soil type, and soil management. Practices employed in controlling soil erosion. Organizations dealing with soil conservation. 3 cred.; jr., sr., grad.; prereq. Soils 4.

108—PHYSICAL PROPERTIES OF SOILS. Determination of physical constants of soils, including mechanical composition. 3 cred.; jr., sr.; prereq. Soils 4; 1 lect. and 4 lab. hrs. per week. McMiller, Arneman.

Technical Aid

11—ENGINEERING DRAFTING. A beginning course in drafting, including the use of instruments, geometric constructions, lettering, freehand sketching, orthographic projection, isometric and oblique drawing, and dimensioning. 5 cred.; no prereq.; 2 lect. and 13 lab. hrs. per week.

12—ENGINEERING DRAFTING. A continuation of Course 11 including sectional and auxiliary views, detail and assembly drawings, fastenings, piping, wiring diagrams, gears, and cams; tracing and reproduction. 5 cred.; prereq. 11; 2 lect. and 13 lab. hrs. per week.

13—ENGINEERING DRAFTING (APPLIED DESCRIPTIVE GEOMETRY). The solution of space problems, intersections, developments, triangulation, true shapes and true angles. Use of planimeter, construction of scale models. 5 cred.; prereq. 12; 2 lect. and 13 lab. hrs. per week.

14—ENGINEERING DRAFTING (STRUCTURAL DETAILING). Detail, assembly, and construction drawings of riveted and welded steel, reinforced concrete and timber structures. Use of steel handbook and drafting machines. 5 cred.; prereq. 13; 2 lect. and 13 lab. hrs. per week.

15—PRODUCTION ILLUSTRATION. Pictorial drawing as used in industry. Detail and assembly drawing by the use of axonometric and perspective drawing, shaded drawings. 5 cred.; prereq. 14; 2 lect. and 13 lab. hrs. per week.

16—LETTERING. Construction and analysis of gothic, modern roman, and italic styles. Exercises in composition and title construction. Use of mechanical lettering devices. 2 cred.; no prereq.; 1 lect. and 2 lab. hrs. per week.

17—SLIDE RULE. A practical course in computation. Location of the decimal point. Basic theory. 1 cred.; no prereq.; 1 lect. per week.

18—ENGINEERING DRAWING. Orthographic projections, isometric and oblique drawing, sections, conventions, screw threads, fastenings, and standards. Freehand sketching. 2 cred.; no prereq.; 6 lab. hrs. per week.

19—ENGINEERING DRAWING. Drawing reading practice, tabulation of information taken from drawings, bills of materials, calculation and estimates of areas, volumes, and weights. Freehand sketching. 3 cred.; prereq. Course 18; 1 lect. and 7 lab. hrs. per week.

21—APPLIED MATHEMATICS. Principles of mensuration, fractions, slide rule, cancellations, ratio and proportion, powers and roots. Calculations of sizes of screws and threads, belts and pulleys. Fundamental laws of plane and solid geometry. 6 cred.; no prereq.; 5 lect. and 5 rec. hrs. per week.

22—APPLIED MATHEMATICS. Fundamental principles of algebra, equations, fractions, exponents, powers and roots, quadratic equations, variation graphical functions. 6 cred.; prereq. 21; 5 lect. and 5 rec. hrs. per week.

23—APPLIED MATHEMATICS. Logarithms, trigonometric functions, right triangles, angle, arc and radius, railroad curves, spirals and vectors. 6 cred.; prereq. 22; 5 lect. and 5 rec. hrs. per week.

24—APPLIED MATHEMATICS. Relations between trigonometric functions, graphical representation, double and half angles, oblique triangles, area of triangles. 6 cred.; prereq. 23; 5 lect. and 5 rec. hrs. per week.

25—APPLIED MATHEMATICS. Resolution of velocity and forces, resultant and condition of equilibrium, moments, motion, work, power, energy, momentum, friction, machines. Elasticity and strength of materials. 6 cred.; prereq. 24; 5 lect. and 5 rec. hrs. per week.

26—APPLIED MATHEMATICS. Coordinate geometry, straight line, circle, second degree functions, polar coordinates, curve fitting, linear, power, and exponential type, logarithmic graphing; graphing of statistical data. 6 cred.; prereq. 25; 5 lect. and 5 rec. hrs. per week.

27—ENGINEERING PROBLEMS. Use of handbooks. 3 cred.; prereq. 25; 3 lect. hrs. per week.

34—TECHNICAL WRITING. Written descriptions of devices and explanations of processes, integrated with speaking and reading exercises and grammar review. 3 cred.; no prereq.; 3 rec. hrs. per week.

35—TECHNICAL WRITING. Written interpretation of tables and diagrams in long and short form of reports. Related exercises in speaking and reading. 3 cred.; prereq. 34; 3 rec. hrs. per week.

36—TECHNICAL WRITING. Business letters, library research report, talks and reading of a book. 3 cred.; prereq. 35; 3 rec. hrs. per week.

37—ORAL COMPOSITION. Collecting material and delivering prepared talks; training in the spur-of-the-moment comment and conference technique. 3 cred.; prereq. 36; 3 rec. hrs. per week.

41—ENGINEERING DRAFTING (ARCHITECTURAL DRAWING). Objectives and special techniques of architectural drafting. Sketches and presentation drawings, working drawings, conventions and dimensioning, theory of shades and shadows, theory of perspective. 5 cred.; prereq. 14; 2 lect. and 13 lab. hrs. per week.

42—ENGINEERING MATERIALS (BUILDING MATERIALS). Basic types of construction. Characteristics and use of principal building materials; wood, steel, concrete, and masonry. 2 cred.; no prereq.; 2 lect. hrs. per week.

71—D.C. CIRCUITS, MACHINERY, AND EQUIPMENT. Principles of D.C. circuits, wire table, direct methods for solution of electric resistance networks, inductance, capacitance. The direct current dynamo, starting boxes, control methods, and equipment. 3 cred.; prereq. Course 23; 3 lect.-rec. hrs. per week.

72—DIRECT CURRENT LABORATORY. Laboratory study of direct current circuits, machinery and applications. 2 cred.; prereq. registration in Course 71; 4 lab. hrs. per week.

73—A.C. CIRCUITS, MACHINES, AND EQUIPMENT. Study of principles of A.C. circuits, effective current value, power factor. Solution of simple A.C. networks and power systems. Induction, synchronous and universal type motors; single phase and three phase. Starting equipment, protection, relays, measurement of single and three phase power. 3 cred.; prereq. Course 71; 3 lect.-rec. hrs. per week.

74—A.C. LABORATORY. Laboratory study of alternating current circuits, machinery, and applications. 2 cred.; prereq. Course 72, registration in Course 73; 4 lab. hrs. per week.

75—INDUSTRIAL ELECTRONICS. Vacuum tube and thratron tube circuit study with applications. Amplifiers, rectifiers, oscillators, dielectric and induction heating. Electric servo-mechanisms, selsyn transmission systems. Industrial applications of electronics. 3 cred.; prereq. Course 73; 3 lect.-rec. hrs. per week.

76—INDUSTRIAL ELECTRONICS LABORATORY. Laboratory study of industrial electronics equipment and applications. 2 cred.; prereq. Course 74, registration in Course 75; 4 lab. hrs. per week.

80A—SHOP PRACTICE, TOOLS, AND FITTINGS. Safety codes and regulations of industrial shops and laboratories, use of hand and measuring tools, pipe threads and fittings, tube fittings, electrical parts and wire joints. Sheet metal fabrication and fasteners, soldering, brazing, and riveting. Layout techniques. 2 cred.; no prereq.; 6 lab. hrs. per week.

80B—SHOP PRACTICE LABORATORY. Basic principles of laboratory equipment and materials. Development of skill in constructing and using general laboratory items such as glass and metal tubing, balances, scales, verniers, hydrometers, gauges, manometers, etc. 3 cred.; prereq. must be registered in 80A. 2 lect.-rec. periods and one 3-hour lab. period per week.

81—GENERAL SHOP. A demonstration course. Maintenance tools, measuring tools, sheet metal forming and cutting, piping and tubing, valves and pipe fittings, mechanical fastening devices, electrical fittings, soldering, brazing, welding, forming and casting, plastic processing, wood processing, and pattern practice. 2 cred.; no prereq; 2 lect. and 4 lab. hrs. per week.

81A—SHOP PRACTICE, WOOD WORKING. Use and maintenance of hand and power-operated wood tools. Wood fasteners, glues, and protective coatings. Types and classification of patterns, construction of patterns. Use and fabrication of plastic materials. Layout techniques for wood and plastic fabrication. 2 cred.; prereq. Course 80A; 6 lab. hrs. per week.

81B—LABORATORY PRACTICE. Introduction to standard laboratory instruments. Familiarization with, calibration and application of, basic instruments such as for measuring temperature, pressure, humidity, etc. 2 cred.; prereq. 80B, must be registered in 81A; 3 lab. hrs. per week.

82—MACHINE TOOL UTILIZATION. The care and use of machine tools, jigs, and fixtures. Metal cutting tools, machine feeds and speeds for various metals. 2 cred.; prereq. 81; 3 lect. and 3 lab. hrs. per week.

82A—SHOP PRACTICE FOUNDRY. Foundry practice and control techniques, bench and floor molding, core making, and nonferrous metal melting. Use of plaster molds and lost wax casting techniques. Cleaning and hand finishing of castings. Die casting and permanent mold techniques. Plating of cast parts. 2 cred.; prereq. Course 81A; 6 lab. hrs. per week.

82B—LABORATORY PRACTICE, STANDARD PROCEDURES. Application of developed skills and basic instruments to standard laboratory procedures. Determination of heating value of fuels; measurement of fluid flow; gas sampling and analyzing, etc. 3 cred.; prereq. 81B, must be registered in 82A; 1 lect.-rec. and 3 lab. hrs. per week.

83—METAL PROCESSING. Production of ferrous and nonferrous alloys, mechanical properties, hot and cold working welding, casting, and allied processes, surface protective coatings, corrosion, powder metallurgy, heat treatment principles and relations to mechanical properties. 2 cred.; prereq. 82; 2 lect. and 4 lab. hrs. per week.

83A—SHOP PRACTICE, FORGING, AND HEAT TREATING. Forging methods and techniques, forming of simple shapes and tools, heat treatment of metals, cyanide and carbonizing, use of gas, oil and electric furnaces. Gas and arc welding, gas cutting, spot welding. 2 cred.; prereq. Course 82A; 6 lab. hrs. per week.

84—MACHINE SHOP. Selection of proper machine for economical production. Tooling and set-up of turret lathes and milling machines. 2 cred.; prereq. 83; 2 lect. and 4 lab. hrs. per week.

84A—SHOP PRACTICE, MACHINE SHOP. Use of hand and measuring tools, bench and vise work. Use of drill press, engine lathe and shaper, use and care of drills, taps, dies, and other tools. Cutting tools and tool sharpening. Layout techniques. 2 cred.; prereq. Course 83A; 6 lab. hrs. per week.

85—ENGINEERING MATERIALS. Castings, forgings, plastics, rolled shapes, extrusions, etc. 2 cred.; no prereq.; 2 lect. hrs. per week.

85A—SHOP PRACTICE, MACHINE SHOP. Use and calibration of precision measuring tools, inspection practice. Use of universal milling machine, surface and cylindrical grinders, jig bores, duplicator and engraving machines. Gear cutting and cutter grinding, simple jigs and fixtures. Summary and review of all 7 courses. 2 cred.; prereq. Course 85A; 6 lab. hrs. per week.

86—ELEMENTS OF PRODUCTION. Basic manufacturing functions; industrial organization; economic factors. Production methods, work simplification, department layout, and materials handling. Time study, production standards, quality control, production planning and scheduling. Elements of manufacturing cost and their relationship; cost control. 3 cred.; prereq. Course 83A; 3 hrs. per week.

87—INDUSTRIAL AND SUPERVISORY RELATIONS. Departmental organization and procedures; duties of the supervisor; relations with employees, other supervisors, staff departments, and management. Industrial safety; working conditions. Labor-management relations, collective bargaining, labor laws. Employees election and training, job evaluation, merit rating, wage determination, and incentives. 3 cred.; prereq. Course 86; 3 hrs. per week.

Zoology

(College of Science, Literature, and the Arts)

1-2-3†§—GENERAL ZOOLOGY. Structure, physiology, embryology, classification, and evolution of animals. 10 cred.; no prereq.; 2 lect. and 4 lab. hrs. per week. Minnich, Wodsedalek, Olson.

14-15†—GENERAL ZOOLOGY. A shorter version of Zool. 1-2-3 with similar content. Primarily for students in the College of Agriculture, Forestry, Home Economics, and Veterinary Medicine. 6 cred.; no prereq.; 2 lect. and 4 lab. hrs. per week.

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

§ Students should elect sections in which they can continue throughout the three quarters.