

DEPARTMENTS OF PHYSICAL SCIENCES

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(Earth/Space Science)

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<http://www.emporia.edu/physci/physci.htm>

The Departments of Physical Sciences offers programs leading to the following degrees:

- Bachelor of Arts
- Bachelor of Science
- Bachelor of Science in Education

For the degree Bachelor of Arts, there are majors in chemistry, earth science, physical science, and physics. For the degree Bachelor of Science, there are majors in chemistry, earth science, physical science, and physics. For the degree Bachelor of Science in Education, there are programs for licensure in chemistry, earth-space science, physics, and science 5-8 (middle-level science). In addition, the departments offer dual-degree engineering programs in conjunction with other universities, a pre-engineering, a pre-medical, a pre-chiropractic, and a pre-dental program, and minor programs. The specific requirements for each of these programs are given on the following pages. While certain basic background courses in the discipline are required, the student is permitted flexibility in selecting course work, independent study, and field experiences to meet his or her specific career goals.

Majors in the physical sciences programs may prepare for a variety of career possibilities: research in government and industrial laboratories; sales or technical positions in scientific companies; product development responsibilities in industry; further education at the graduate level; teaching in middle/secondary schools; numerous occupations in health-related fields; pre-professional preparation for law, engineering, or medicine; employment in environmental fields; and finally graduate work in such related areas as library science and business.

While the Bachelor of Science is the traditional degree for the physical sciences, the degree Bachelor of Arts is available and intended for students who want a broad liberal arts education while majoring in a selected discipline. Students seeking teaching licensure normally work toward the Bachelor of Science in Education, although licensure is possible within the BS or BA in the discipline.

Chemistry

Chemistry is the science of understanding the structure of matter and the transformations which this matter undergoes. Persons involved in chemistry-related professions are interested in discovering how they can help society fulfill its traditional material needs for improved clothing, shelter, and food; and further, how they can conquer physical ailments and afflictions

associated with our technical age. The BA program is designed to provide a more general type of educational background through broad exposure to various disciplines. Students seeking this degree are normally preparing for an interdisciplinary professional career which requires training in the sciences as well as in other fields, such as scientific sales, scientific writing, or social or environmental programs. The Bachelor of Arts degree is frequently used by many students in pre-professional programs, such as pre-medicine, pre-pharmacy, pre-optometry, and in some cases pre-law. Emporia State chemistry students have the opportunity to take part in a student affiliate chapter of the American Chemical Society. This chapter has been consistently recognized as one of the most active in the nation. The chemistry department has its undergraduate BS program approved by the Committee for Professional Training of the American Chemical Society. This committee endorses programs by careful evaluation of the major course requirements, faculty credentials, and facilities.

BACHELOR OF ARTS CHEMISTRY MAJOR

See introductory comments under "chemistry" section heading above concerning BA degree.

Required Courses (30 hours):

The student is cautioned that some chemistry courses require a background in physics and mathematics; for example, 15 hours of required associated courses for the BA with a chemistry major include MA 165, Basic Calculus, 5 hours, and PH 140-144, College Physics I and II and laboratories, 10 hours. Early consultation with a chemistry faculty advisor is strongly recommended.

See the general education requirements for the Bachelor of Arts degree in the General Education section of this catalog. (Note: The BA general education program requires 10 hours of a foreign language, and a minor or second program of study.)

In addition to the courses listed below, the student must select electives with course numbers of 300 and above to ensure that the 45-hour requirement is met.

Required Courses (25+ hours):

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours
CH 479	Undergraduate Research	1 hour
CH 730	Seminar in Chemistry	1 hour
CH 370-371	General Organic Chemistry & Lab	5 hours
	OR	
CH 572-575	Organic Chemistry I & II (lecture and lab)	10 hours
	AND	
CH 620	Elements of Physical Chemistry	3 hours
	OR	
CH 720-722	Physical Chemistry I & II (lecture and lab)	8 hours

Required and/or Free Electives (a possible 5+ hours):

A minimum of 30 hours in chemistry is required for the degree. A maximum of three hours of Undergraduate Research may be used to meet these requirements. Students may also select additional hours as desired to meet specific educational goals.

Required Associated Courses (15 hours):

A student must take at least MA 165, Basic Calculus, 5 hours, and at least PH 140/141 and PH 143/144, College Physics I

& II and Lab, 10 hours.

Earth Science/Geology electives 3 hours

Required Second Program of Study:

The student is required to complete a second program of study of 15 to 30 hours in another discipline.

BIOCHEMISTRY CONCENTRATION

This is a course of study leading to the BA degree in chemistry in which biochemistry and the relevance of chemistry in biological functions is emphasized. The required second field of study for the BA degree will be completed in biology.

Required Chemistry Courses (33+hours):

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours
CH 370-371	General Organic Chemistry & Lab*	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours
CH 479	Undergraduate Research	1-3 hours
CH 560-561	Biochemistry & Lab	5 hours
CH 620	Elements of Physical Chemistry**	3 hours
CH 730	Chemistry Seminar	1 hour
CH 760	Advanced Biochemistry	3 hours

*CH 572-575 may substitute for CH 370-371. Required substitution for premeds.

**CH 720-722 may substitute for CH 620.

Required Biology Courses (19 hours):

GB 140-141	Principles of Biology & Lab	4 hours
MC 316-317	Microbiology & Lab	4 hours
	Biology Electives	11 hours

ENVIRONMENTAL CHEMISTRY CONCENTRATION

The following courses will prepare a student for a career in environmental chemistry. This preparation in chemistry enables a student to perform essential laboratory analyses while broadening the base of knowledge to include course work in a related discipline (biology or earth science).

Required Chemistry Courses (31 hours):

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours
CH 370-371	General Organic Chemistry & Lab*	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours
CH 479	Undergraduate Research	1 hour
CH 506	Environmental Chemistry	3 hours
CH 578	Water Analysis	3 hours
CH 620	Elements of Physical Chem	
CH 730	Seminar in Chemistry	1 hour

*CH 572-575 Organic Chemistry I & II/Lab may be substituted

**CH 720-722 Physical Chemistry I & II/Lab may be substituted

Second field of study (either option may be selected):

Biology Option

GB 140-141	Principles of Biology & Lab	4 hours
BO 212-213	Biology of Plants & Lab	4 hours
ZO 214-215	Biology of Animals & Lab	4 hours
MC 316-317	Microbiology & Lab	4 hours
EB 480	Principles of Ecology	2 hours
EB 481	Field Ecology	2 hours

Earth Science Option

ES 110-111	Intro to Earth Science & Lab	5 hours
ES 333	Environmental Geology	3 hours
ES 351	Intro to Geospatial Analysis	3 hours
GO 240	Hand Specimen Petrology	2 hours
ES 545	Geomorphology	3 hours
GO 571	Geohydrology	3 hours

BACHELOR OF SCIENCE CHEMISTRY MAJOR

This program is designed to provide the necessary background for employment in the chemical industry, for pre-professional education requiring chemistry (e.g., pharmacy, medicine, or law), for continued study at the graduate level, or for a combined career in chemistry and engineering, information science, or patent law.

A minimum of 49 hours is required for a BS in chemistry. This includes 46 hours of required courses, plus electives which vary depending on whether the student seeks the American Chemical Society (ACS)-certified BS degree.

Students desiring to complete an ACS-certified BS degree must choose three advanced courses in chemistry. Advanced courses in biology, mathematics, or physics may be substituted with departmental approval for the "non-certified" degree. Courses in statistics, German, and computer programming are highly recommended.

In addition to the chemistry requirements, students must complete the University-wide general education and graduation requirements. See the General Education section of the catalog.

Major Area Required Courses (46 hours):

CH 123-124	Chemistry I & Lab*	5 hours
CH 126-127	Chemistry II & Lab*	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours
CH 479	Undergraduate Research	1 hour
CH 525	Descriptive Inorganic Chemistry	3 hours
CH 560	Biochemistry	3 hours
CH 572-573	Organic Chemistry I & Lab	5 hours
CH 574-575	Organic Chemistry II & Lab	5 hours
CH 720	Physical Chemistry I	3 hours
CH 721	Physical Chemistry Lab	2 hours
CH 722	Physical Chemistry II	3 hours
CH 730	Seminar in Chemistry	1 hour
CH 777	Instrumental Analysis	5 hours

For a non-certified degree, one advanced elective must be chosen from the following:

CH 724	Topics in Physical Chemistry	3 hours
CH 725	Advanced Inorganic Chemistry	3 hours
CH 760	Advanced Biochemistry	3 hours
CH 772	Topics in Organic Chemistry	3 hours

In order to earn an ACS-certified BS degree, three advanced electives must be chosen as follows:

CH 725	Advanced Inorganic Chemistry	3 hours
CH 726	Advanced Inorganic Chemistry Lab	2 hours
Plus choose one advanced elective from among:		
CH 723	Advanced Physical Chemistry Lab	2 hours
CH 724	Topics in Physical Chemistry	3 hours
CH 760	Advanced Biochemistry	3 hours
CH 772	Topics in Organic Chemistry	3 hours

Required Associated Courses (20 hours):

These courses are pre- or co-requisites to CH 720 and should be taken as early as possible; ideally CH 720 should be taken in the fall of the junior year.

MA 161	Calculus I	5 hours
MA 262	Calculus II	5 hours
PH 190-192	Physics I Lecture, Recitation, & Lab	5 hours

PH 193-195 Physics II Lecture, Recitation, & Lab 5 hours

MEDICAL TECHNOLOGY

Students interested in medical technology may elect a dual-degree program. After four years at ESU, a Bachelor of Science with a major in chemistry can be awarded. Students selecting this plan must complete the above chemistry major with the following changes:

Major Area Required Courses (49 hours):

Same as above.

Associated Courses for Medical Technology:

GB 140-141	Principles of Biology & Lab	4 hours
MC 150-151	Molecular & Cellular Biology & Lab	4 hours
ZO 362-363	Human Anatomy & Physiology & Lab	5 hours
MC 316-317	Microbiology & Lab	4 hours
MC 549-550	Immunology & Lab	4 hours
MC 562-563	Pathogenic Microbiology & Lab	5 hours
GB 425-426	General Genetics & Lab	4 hours

PRE-MEDICAL PROGRAM

General Information:

1. The two programs presented here--one a Bachelor of Science and the other a Bachelor of Arts--are based on the entrance requirements of the University of Kansas School of Medicine (KUMC) because most ESU students apply to that institution. Students applying to other institutions may find that the school of their choice requires a slightly different mix of courses. Although pre-medical students can successfully meet the entrance requirements for medical school with any major, the chemistry programs presented here provide additional useful background and provide expanded medical career options such as the PhD-MD.

2. The programs presented here also meet or exceed the entrance requirements for the Kansas City College of Osteopathic Medicine to which most ESU osteopathy students apply.

3. Pre-medical students are advised by a four-member interdepartmental Pre-Medical Advisory Committee. A pre-medical student who chooses to major in chemistry is advised by a chemistry faculty member who is a member of this committee. Other members of this committee are biology faculty members.

4. Students must complete the University-wide general education and graduation requirements. See the General Education section of the catalog.

5. Most successful ESU pre-med students have GPAs of 3.5 or higher.

6. Successful pre-med students must score well (e.g., 9's or higher) on sections of the nationally administered Medical College Admission Test (MCAT).

7. We strongly suggest that pre-meds take an active role in the Student Affiliate of the American Chemical Society (Chemistry Club) and the Caduceus Society (Pre-Med Club). Most medical schools also consider community volunteer work and/or experiences with the medical profession to be essential..

BACHELOR OF SCIENCE

CHEMISTRY MAJOR

PRE-MEDICAL PROGRAM

Major Area Required Courses (46 hours minimum):

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours
CH 479	Undergraduate Research	1 hour
CH 525	Descriptive Inorganic Chemistry	3 hours
CH 560	Biochemistry	3 hours
CH 572-573	Organic Chemistry I & Lab	5 hours
CH 574-575	Organic Chemistry II & Lab	5 hours
CH 720	Physical Chemistry I	3 hours
CH 721	Physical Chemistry Lab	2 hours
CH 722	Physical Chemistry II	3 hours
CH 730	Seminar in Chemistry	1 hour
CH 777	Instrumental Analysis	5 hours

Choose one advanced chemistry elective from the following:

CH 724	Topics in Physical Chemistry	3 hours
CH 725	Advanced Inorganic Chemistry	3 hours
CH 760	Advanced Biochemistry	3 hours
CH 772	Topics in Organic Chemistry	3 hours

Required Biology Courses:

The minimum to satisfy entrance requirements at the University of Kansas School of Medicine include:

GB 140-141	Principles of Biology	4 hours
ZO 362-363	Anatomy and Physiology & Lab	5 hours

In addition, the following courses are strongly recommended:

CH 561	Biochemistry Lab	2 hours
MC 316-317	Microbiology & Lab	4 hours
GB 425	General Genetics	3 hours
ZO 515-516	Vertebrate Structure & Development & Lab	5 hours

Required Associated Courses (20 hours):

These courses are pre- or co-requisites to CH 720 and should be taken as early as possible; ideally CH 720 should be taken in the fall of the junior year.

MA 161	Calculus I	5 hours
MA 262	Calculus II	5 hours
PH 190-192	Physics I Lecture, Recitation, & Lab	5 hours
PH 193-195	Physics II Lecture, Recitation, & Lab	5 hours

If a pre-med student also wishes to earn an ACS-certified BS degree, three advanced chemistry electives, rather than one, must be chosen as follows:

CH 725	Advanced Inorganic Chemistry	3 hours
CH 726	Advanced Inorganic Chemistry Lab	2 hours

Plus choose one advanced elective from among:

CH 723	Advanced Physical Chemistry Lab	2 hours
CH 724	Topics in Physical Chemistry	3 hours
CH 760	Advanced Biochemistry	3 hours
CH 772	Topics in Organic Chemistry	3 hours

BACHELOR OF ARTS

CHEMISTRY MAJOR

PRE-MEDICAL PROGRAM

Major Area Required Courses (38 hours):

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours

CH 479	Undergraduate Research	1 hour
CH 560	Biochemistry	3 hours
CH 561	Biochemistry Lab	2 hours
CH 572-573	Organic Chemistry I & Lab	5 hours
CH 574-575	Organic Chemistry II & Lab	5 hours
CH 620	Elements of Physical Chemistry*	3 hours
CH 730	Seminar in Chemistry	1 hour
CH 760	Advanced Biochemistry	3 hours

*CH 720-722 may substitute for CH 620

Required Biology Courses for BA in Chemistry (19 hours)

GB 140-141	Principles of Biology & Lab	4 hours
MC 316-317	Microbiology & Lab	4 hours
ZO 362-363	Anatomy and Physiology	5 hours
xxx	Biology electives	6 hours

The following courses are strongly recommended for medical school preparation:

GB 425	General Genetics	3 hours
ZO 515-516	Vertebrate Structure and Development & Lab	5 hours

Required Associated Courses (15 hours)

MA 165	Basic Calculus*	5 hours
<i>*MA 161 may substitute for MA 165.</i>		
PH 140-144	College Physics I & Lab	5 hours
PH 143-144	College Physics II & Lab	5 hours

The pre-med student must also satisfy the university requirements for the BA degree. See the Undergraduate Degrees section of the catalog.

BACHELOR OF SCIENCE IN EDUCATION

SECONDARY C

CHEMISTRY TEACHING FIELD

See Physical Science section.

DUAL-DEGREE IN ENGINEERING

CHEMISTRY MAJOR

See Engineering section.

CHEMISTRY MINOR

The minor in chemistry consists of a minimum of 23 hours of credit in chemistry courses.

Required Courses (20 hours):

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours
CH 370-371	General Organic Chemistry & Lab*	5 hours

Elective Courses (3+ hours):

The student in conjunction with a chemistry faculty advisor must select and complete at least one of the following courses in addition to those required above (unless CH 572-575 were elected):

CH 506	Environmental Chemistry	3 hours
CH 525	Descriptive Inorganic Chemistry	3 hours
CH 560	Biochemistry	3 hours
CH 578	Water Analysis	3 hours
CH 620	Elements of Physical Chemistry	3 hours

*Organic Chemistry I (CH 572-573) is not considered to be an appropriate substitute for CH 370-371. However, CH 572-573 and Organic Chemistry II (CH 574-575) may be used to fulfill the organic requirement and the elective requirement.

Earth Science

BACHELOR OF ARTS

EARTH SCIENCE MAJOR

The earth science program includes geology, meteorology, environmental and space science. The Bachelor of Arts degree allows the student some specialization in the earth sciences while gaining breadth in other disciplines. See the general education requirements in the General Education section of this catalog.

Required Courses (17 hours):

GO 240	Hand Specimen Petrology	2 hours
GO 325	Earth History	3 hours
<i>(The prerequisite for GO 325 is ES 110/111 or consent of the instructor. ES 110/111 counts for General Education credit.)</i>		
GO 326	Plate Tectonics	3 hours
GO 336	Mineralogy	4 hours
GO 547	Field Geology	5 hours

Required Associated Courses (12 hours):

CH 123-124	Chemistry I & Lab	5 hours
CS 130	Microcomputer Problem Solving	3 hours
OR		
MA 112	Trigonometry	2 hours
PH 140-141	College Physics I & Lab	5 hours

Required Second Program of Study:

The student is required to complete a minor or second major or program of study in another discipline.

BACHELOR OF SCIENCE

EARTH SCIENCE MAJOR

The earth science program includes geology, meteorology, environmental and space science courses. The Bachelor of Science degree is designed for focused professional preparation for employment or graduate study in one of the earth sciences. See the general education requirements in the General Education section of this catalog.

Required Courses (33 hours):

GO 240	Hand Specimen Petrology	2 hours
GO 325	Earth History	3 hours
ES 319	Meteorology	
OR		
ES 365	World Regional Climatology	3 hours
GO 326	Plate Tectonics	3 hours
GO 336	Mineralogy	4 hours
ES 351	Introduction to Geospatial Analysis	3 hours
GO 547	Field Geology	5 hours
CH 123-124	Chemistry I and Lab	5 hours
CH 126-127	Chemistry II and Lab	5 hours

Elective Courses (20 hours):

ES 254	Physical Geography	3 hours
ES 319	Meteorology	3 hours
ES 331	Ice Age Environments	3 hours
ES 333	Environmental Geology	3-5 hours
ES 365	World Regional Climatology	3 hours
ES 439	Independent Study in Earth Science	1-4 hours
ES 475	Senior Thesis	1-5 hours
ES 518	Space Science	3 hours
GO 536	Optical Mineralogy	3 hours
ES 545	Geomorphology	3 hours
ES 546	Field Geomorphology	2 hours

GO	548	Field Stratigraphy	2 hours
ES	551	Computer Mapping Systems	3 hours
ES	555	Small-Format Aerial Photography	3 hours
ES	567	Topics in Earth Science	1-4 hours
GO	568	Structural Geology	3 hours
GO	569	Invertebrate Paleontology	3 hours
GO	570	Sedimentation & Stratigraphy	3 hours
GO	571	Geohydrology	3 hours
ES	703	Seminar in Physical Geography	1-3 hours
GO	766	Petrology & Petrography	4 hours
ES	767	Topics in Earth Science	1-4 hours
GO	769	Vertebrate Paleontology	3 hours
ES	771	Remote Sensing	4 hours
ES	775	Advanced Image Processing	3 hours

Required Associated Courses (10 hours):

Elective courses in allied sciences of biology, chemistry, computer science, geography, mathematics, physics, or physical sciences (10 hours). Specific courses must be approved upon consultation with a student's advisor. This requirement may be satisfied by completing either a minor approved by a student's advisor or a second major in any other field. For employment by the Kansas Department of Health and Environment as an Environmental Geologist I, 10 hours of physics are required.

BACHELOR OF SCIENCE IN EDUCATION SECONDARY -- EARTH-SPACE SCIENCE TEACHING FIELD

See Physical Science section.

DUAL-DEGREE IN ENGINEERING EARTH SCIENCE MAJOR

See Engineering section.

EARTH SCIENCE MINOR

The minor in earth science consists of 20 hours of required or approved elective courses in earth science. The minor is a useful way for students majoring in other fields to expand their understanding of science and the Earth. The minor in earth science consists of a minimum of 20 hours of credit.

Required Courses (11 hours):

ES	110	Intro to Earth Science	4 hours
ES	111	Intro to Earth Science Lab	1 hour
GO	325	Earth History	3 hours
GO	326	Plate Tectonics	3 hours

Elective ES, GO, or PS Courses numbered 200 or above (9 hours):

Electives should be selected in consultation with an earth science advisor (official or unofficial).

GEOSPATIAL ANALYSIS MINOR

Geospatial analysis refers to geographic information systems (GIS) and remote sensing applied to documenting, mapping, interpreting, and managing natural and cultural resources. An interdisciplinary minor in geospatial analysis could be used in combination with any undergraduate Bachelor of Arts or Bachelor of Science major. This minor is especially recommended to enhance majors in biological, physical, and social sciences, as well as mathematics and computer science. GIS techniques have become the preferred method for documenting and monitoring a range of environmental conditions. Additional

information can be obtained from the Departments of Physical Sciences, Cram Science Hall, room 133.

Requirements for the minor are:

General education courses in biological and physical sciences: GB 100/101; CH, ES, or PH 110/111; or advanced courses.

Required Courses (9 hours):

EB/ES351	Introduction to Geospatial Analysis	3 hours
GE 371	Cartography	3 hours
ES 551	Computer Mapping Systems	3 hours

Elective Courses (9 hours):

Electives to be selected *upon approval of student's advisor*. Elective courses must be 200-level or higher and should be chosen to complement courses in the student's major. (Note: courses used to satisfy requirements for the student's major cannot be used as electives for this minor.)

Refer to the list available from the Departments of Physical Sciences office, Cram Science Hall room 133, for recommended elective courses for geospatial analysis, some of which require prerequisites. Consult an advisor for assistance. Other appropriate courses, including topics, seminars, and independent study, may also be used for electives, *but must be* approved by the student's advisor.

PALEONTOLOGY MINOR

This program is designed to provide some specialization and experience in paleontology to complement a major in another field of study (especially biology) for either a B.S. or B.A. degree.

The basic requirements are listed below. The total credit hours necessary are 19. The courses ES 110/111 (Introduction to Earth Science and Lab) are a prerequisite for the GO courses listed.

Required Courses (19 hours):

GO	325	Earth History	3 hours
GO	326	Plate Tectonics	3 hours
GO	569	Invertebrate Paleontology	3 hours
GO	570	Sedimentation & Stratigraphy	3 hours
GO	769	Vertebrate Paleontology	3 hours
GB	325	Bioscientific Terminology	1 hour
GB	725	Evolution	3 hours

Engineering

Two options are available to those wishing to become engineers: the two-year pre-engineering program, and the three-year dual-degree program, which leads to the Bachelor of Science with a major in either chemistry, earth science, physics, or mathematics as well as a second B.S. in engineering.

The two-year pre-engineering program offers excellent preparation in chemistry, computer science, mathematics, and physics. In addition, several specific engineering courses are available as are courses in basic skills and general education. The two-year program has been designed in consultation with and parallels the preparation offered by the engineering degree-granting schools in Kansas.

Students in the dual-degree programs will transfer to the engineering school at either Kansas State University or the University of Kansas after completing three years at Emporia

State University. After one year in attendance at the engineering school, students are eligible for the bachelor's degree from Emporia State. After the second year of engineering school, students will normally be eligible for the bachelor's degree in engineering from KSU or KU.

All engineering curricula assume that Calculus I will be taken during the first semester of the first year. Students needing to take preparatory work in algebra and trigonometry should do so. Such students should expect additional time in completing their programs.

PRE-ENGINEERING

Specific programs have been developed for students planning to transfer to KSU, KU or WSU after spending two years at Emporia State. Students planning to transfer to an out-of-state engineering school should develop programs of study with an advisor.

Recommended program for those planning to transfer to Kansas State University:

This program has been designed for students planning to spend two years at Emporia State, and then transferring to Kansas State University (KSU) or an out-of-state school to complete the requirements leading to the Bachelor of Science in Engineering. The following

Required Courses (67-70 hours):

FIRST YEAR

Fall -- 17-18 hours

EG 101	English Composition I	3 hours
MA 161	Calculus I	5 hours
CH 123	Chemistry I	3 hours
CH 124	Chemistry I Lab	2 hours
PE 100	Lifetime Fitness	1 hour
PS 100	Intro to Engineering	2 hours
PS 200	Intro to Engineering Graphics	1-2 hours

Spring -- 18 hours

MA 262	Calculus II	5 hours
PH 190	Physics I	3 hours
PH 191	Physics I Lab	1 hour
PH 192	Physics I Recitation	1 hour
CH 126	Chemistry II	3 hours
CH 127	Chemistry II Lab	2 hours
EG 102	English Composition II	3 hours

SECOND YEAR (All but Chemical, see below)

Fall -- 17 hours

PH 193	Physics II	3 hours
PH 194	Physics II Lab	1 hour
PH 195	Physics II Recitation	1 hour
PH 315	Statics	3 hours
MA 263	Calculus III	3 hours
CS 260	Programming & Problem Solving (C++)	3 hours
	Technical Elective	3 hours

Spring -- 17 hours

MA 335	Differential Equations I	3 hours
BC 103	Principles of Economics I	3 hours
SP 101	Public Speaking	3 hours
PH 316	Dynamics	3 hours
	Technical Elective(s)	5 hours

SECOND YEAR (Chemical Engineering)

Fall -- 16 hours

MA 263	Calculus III	3 hours
PH 193	Physics II	3 hours

PH 194	Physics II Lab	1 hour
PH 195	Physics II Recitation	1 hour
CH 572	Organic Chemistry I	3 hours
CH 573	Organic Chemistry I Lab	2 hours
PH 315	Statics	3 hours

Spring -- 16 hours

BC 103	Principles of Economics I	3 hours
MA 335	Differential Equations I	3 hours
CH 574	Organic Chemistry II	3 hours
CH 575	Organic Chemistry II Lab	2 hours
CH 376	Quantitative Analysis	3 hours
CH 377	Quantitative Analysis Lab	2 hours

Technical Courses:

PS 100	Introduction to Engineering	*2 hours
PS 200	Introduction to Engineering Graphics	1-2 hours
PH 316	Dynamics	3 hours
PH 410-411	Electrical Circuit Analysis & Lab	4 hours
PH 540	Modern Physics	3 hours
MA 322	Introduction to Linear Algebra	3 hours
MA 380	Probability & Statistics	3 hours
GO 231	Physical Geology	3 hours
GB 140-141	Principles of Biology & Lab	4 hours
CS 315	JAVA Programming	3 hours
CH 310	Engineering Materials	2 hours
CH 370-371	General Organic Chemistry & Lab	5 hours
CH 560	Biochemistry	5 hours
CH 720	Physical Chemistry I	3 hours
CH 721	Physical Chemistry Lab	2 hours
CH 722	Physical Chemistry II	3 hours
AC 223	Financial Accounting	3 hours

Key to courses as electives (Elec) or required (Req):

	Ag	Ch	CE	EE	IM	ME	Ar
PS 100	Elec	Elec	Elec	Elec	Elec	Elec	Elec
PS 200	Req	Elec	Req	Elec	Req	Req	Req
PH 316	Req	---	Req	Req	Req	Req	Req
PH 410	Req	---	Elec	Req	Req	Req	Req
PH 411	Req	---	Elec	Req	Req	Req	Req
PH 540	---	---	---	Elec	---	Elec	---
MA 322	Elec	Elec	Elec	Elec	Elec	Elec	Elec
MA 380	Elec	Elec	Req	Req	Req	Elec	Elec
GO 231	Elec	---	Req	Elec	---	---	---
GB 140	Req	Elec	Elec	Elec	---	---	---
GB 141	Req	Elec	Elec	Elec	---	---	---
CS 315	---	---	---	Elec	---	---	---
CH 310	Elec	Elec	Elec	Req	Req	Req	---
CH 370	Req	---	Elec	---	---	---	---
CH 371	Req	---	Elec	---	---	---	---
CH 560	Elec	Elec	---	---	---	---	---
CH 720	---	Req	---	---	---	---	---
CH 721	---	Req	---	---	---	---	---
CH 722	---	Req	---	---	---	---	---

The total number of elective course transfer credits is limited in some engineering fields.

*PS 100 is recommended for all pre-engineering students.

Humanities and Social Sciences:

Each engineering student at Kansas State University is required to complete 13-15 hours of course work in the areas of the humanities and social sciences, excluding the required

economics course. The following list indicates which courses may be taken at Emporia State University to satisfy this requirement. At least 2 courses must be taken at the 300-level or above. Not more than 3 credit hours may be taken in applied music and/or applied arts.

Art	Only AR 225, 235
Economics	Any course above BC 103
English	Any above those required
Geography	Any course
History	Any course
Modern Languages	At least 8 hours to receive any credit
Philosophy	Any course except PI 256
Political Science	Any course
Psychology	Any course
Sociology and Anthropology	Any course
Theater Arts	Only TA 125 accepted

Recommended program for those planning to transfer to the University of Kansas:

This program has been designed for students planning to spend two years at Emporia State and then transfer to the University of Kansas (KU) to complete the requirements leading to the Bachelor of Science in Engineering.

The following engineering fields are available at KU: aerospace engineering (AE), chemical engineering (Ch), civil engineering (CE), electrical engineering (EE), engineering physics (EP), mechanical engineering (ME), and petroleum engineering (PE).

Required Courses (64-67 hours):

FIRST YEAR

Fall -- 16-17 hours

EG 101	English Composition I	3 hours
MA 161	Calculus I	5 hours
CH 123	Chemistry I	3 hours
CH 124	Chemistry I Lab	2 hours
PS 100	Intro to Engineering	2 hours
PS 200	Intro to Engineering Graphics	1-2 hours

Spring -- 16 hours

MA 262	Calculus II	5 hours
PH 190	Physics I	3 hours
PH 191	Physics I Lab	1 hour
PH 192	Physics I Recitation	1 hour
BC 103	Principles of Economics I	3 hours
EG 102	English Composition II	3 hours

SECOND YEAR (All but Chemical or Petroleum, see below)

Fall -- 17 hours

PH 193	Physics II	3 hours
PH 194	Physics II Lab	1 hour
PH 195	Physics II Recitation	1 hour
PH 315	Statics	3 hours
	Technical Elective	3 hours
MA 263	Calculus III	3 hours
CS 260	Programming & Problem Solving (C++)	3 hours

Spring -- 17 hours

MA 322	Introduction to Linear Algebra	3 hours
MA 335	Differential Equations I	3 hours
PH 316	Dynamics	3 hours
	Technical Courses	5 hours
	Humanities Elective	3 hours

SECOND YEAR (Chemical and Petroleum)

Fall -- 16 hours

MA 263	Calculus III	3 hours
PH 193	Physics II	3 hours

PH 194	Physics II Lab	1 hour
PH 195	Physics II Recitation	1 hour
CH 572	Organic Chemistry I	3 hours
CH 573	Organic Chemistry I Lab	2 hours
PH 315	Statics	3 hours

Spring -- 16 hours

BC 103	Principles of Economics I	3 hours
MA 335	Differential Equations I	3 hours
CH 574	Organic Chemistry II	3 hours
CH 575	Organic Chemistry II Lab	2 hours
CH 376	Quantitative Analysis	*3 hours
CH 377	Quantitative Analysis Lab	*2 hours

*Not required in petroleum engineering. Substitute humanities or social sciences electives.

Technical Courses:

SP 101	Public Speaking	3 hours
PS 100	Introduction to Engineering	**2 hours
PS 200	Intro to Engineering Graphics	1-2 hours
PH 316	Dynamics	3 hours
PH 410-411	Electrical Circuit Analysis & Lab	4 hours
PH 540	Modern Physics	3 hours
MA 322	Intro to Linear Algebra	3 hours
MA 380	Probability & Statistics	3 hours
GO 231	Physical Geology	3 hours
GB 140-141	Principles of Biology & Lab	4 hours
CS 260	Programming & Problem Solving (C++)	3 hours
CS 315	JAVA Programming	3 hours
CH 126-127	Chemistry II & Lab	5 hours
CH 310	Engineering Materials	2 hours
CH 572-573	Organic Chemistry I & Lab	5 hours
CH 574-575	Organic Chemistry II & Lab	5 hours
CH 720	Physical Chemistry I	3 hours
CH 721	Physical Chemistry Lab	2 hours
CH 722	Physical Chemistry II	3 hours

Key to courses as electives (Elec) or required (Req):

	AE	CH	CE	EE	EP	ME	PE
SP 101	----	----	Req	----	----	Elec	----
PS 100**	----	Elec	----	----	----	----	Elec
PS 200	----	----	Req	----	----	Req	----
PH 316	Req	Elec	Req*	Elec	----	----	Elec
PH 410	Req	Elec	Elec	Req	Elec	Req*	Elec
PH 411	Req	Elec	Elec	Req	Elec	Req*	Elec
PH 540	Elec	----	Elec	Req*	Req*	Elec	----
MA 322	Elec	Elec	Elec	Elec	Elec	Elec	Elec
MA 380	----	----	Req	Req	----	Req*	Elec
GO 231	----	----	Req	----	----	Elec	Req*
GB 140	----	----	Elec	----	----	Elec	----
GB 141	----	----	Elec	----	----	Elec	----
CS 260	Req	Elec	Elec	Req	Req	Req	Elec
CS 315	Elec	----	----	Req	Elec	Elec	----
CH 126	----	Req*	Elec	----	Req	Elec	Req*
CH 127	----	Req*	Elec	----	Req	Elec	Req*
CH 310	----	----	Elec	----	----	Elec	Elec
CH 560	----	----	----	----	----	----	----
CH 572	----	Req*	Elec	----	Elec	Elec	Req*
CH 573	----	Req*	Elec	----	Elec	Elec	Req*
CH 574	----	Req	Elec	----	Elec	Elec	Req
CH 575	----	Req	Elec	----	Elec	Elec	Req
CH 720	----	Req	----	----	----	----	Req
CH 721	----	Req	----	----	----	----	Req

CH 722 ---- Elec ---- ---- ---- Elec

The total number of elective course transfer credits is limited in some engineering fields.

*These courses should be taken before transferring to KU.

**PS 100 is recommended for all pre-engineering students.

Humanities and Social Sciences:

Students will be required to complete 15-18 semester hours in the humanities and social sciences, depending upon the field of engineering.

In selecting courses students should follow these guidelines:

- At least one course designated as a humanities course, and one designated as a social sciences course.
- At least two courses offered by one department.
- A maximum of 4 credits from such areas as band, chorus, orchestra, drawing, painting, and sculpture may be acceptable at the discretion of the respective departments.

Courses that may be taken at Emporia State University to fulfill these requirements include:

Anthropology	Any course except AN 100, 355, 356 (SS)
Art	Only AR 225, AR 235 accepted (HU)
Economics	Any course above BC 103 (SS)
English	Any course except EG 301 (HU)
Foreign Language	Only credits earned in second-year courses may apply (HU)
Geography	Any course except GE 371 (SS)
History	Any course (HU)
Philosophy	Any course (HU)
Political Science	Any course (SS)
Psychology	Any course (SS)
Sociology	Any course except SO 500 (SS)

Recommended program for those planning to transfer to Wichita State University:

This program has been designed for students planning to spend two years at Emporia State and then transfer to Wichita State University (WSU) to complete the requirements leading to the Bachelor of Science in Engineering.

The following engineering fields are available at WSU: aerospace engineering (Ae), electrical and computer engineering (EE), industrial engineering (IE), mechanical engineering (ME), and manufacturing engineering (Mf).

Required Courses (67-70 hours):

FIRST YEAR

Fall -- 17-18 hours

EG 101	English Composition I	3 hours
MA 161	Calculus I	5 hours
CH 123	Chemistry I	3 hours
CH 124	Chemistry I Lab	2 hours
	Humanities or Social Science Elective	3 hours
PS 200	Intro to Engineering Graphics	1-2 hours

Spring -- 16-17 hours

MA 262	Calculus II	5 hours
PH 190	Physics I	3 hours
PH 191	Physics I Lab	1 hour
PH 192	Physics I Recitation	1 hour
EG 102	English Composition II	3 hours
	Science Electives	3-4 hours

SECOND YEAR

Fall -- 17 hours

PH 193	Physics II	3 hours
PH 194	Physics II Lab	1 hour

PH 195	Physics II Recitation	1 hour
MA 263	Calculus III	3 hours
PH 315	Statics	3 hours
CS 260	Programming & Problem Solving (C++)	3 hours
	Humanities or Social Science Electives	3 hours

Spring -- 17-18 hours

MA 335	Differential Equations I	3 hours
SP 101	Public Speaking	3 hours
MA 322	Intro to Linear Algebra	3 hours
PH 316	Dynamics	3 hours
	Technical, Natural Science, and/or Humanities and Social Sciences Electives	*5-6 hours

*Courses accepted as technical (T) and natural science (NS) electives

Technical and Natural Science Electives:

PS 100	Introduction to Engineering	*2 hours
PS 200	Intro to Engineering Graphics	1-2 hours
PH 410-411	Electrical Circuit Analysis & Lab	**4 hours
PH 316	Dynamics	3 hours
PH 540	Modern Physics	3 hours
MA 322	Linear Algebra	3 hours
GO 231	Physical Geology	3 hours
EG 305	Technical Writing	3 hours
BC 103	Principles of Economics I	3 hours
CS 260	Programming & Problem Solving (C++)	3 hours
CH 370-371	General Organic Chemistry & Lab	5 hours
AC 223	Financial Accounting	3 hours

*PS 100 is recommended for all pre-engineering students.

**Accepted only if EE 382 lab is completed at WSU.

Key to the above technical courses (electives or required):

	Ae	EE	IE	ME	Mf
PS 100	----	----	T-Elec	T-Elec	T-Elec
PS 200	Req	Req	Req	Req	Req
PH 316	Req	T-Elec	Req	Req	----
PH 410	Req	Req	Req	Req	Req
PH 540	Elec	Elec	Elec	Elec	----
MA 322	----	----	Elec	----	Elec
GO 231	NS-Elec	NS-Elec	NS-Elec	NS-Elec	NS-Elec
EG 305	----	----	----	Elec	----
BC 103	SS-Elec	SS-Elec	Req	SS-Elec	SS-Elec
CS 260	T-Elec	T-Elec	T-Elec	T-Elec	T-Elec
CH 370	NS-Elec	NS-Elec	NS-Elec	NS-Elec	NS-Elec

Humanities and Social Sciences:

Students may complete 15 hours of humanities (HU) and social sciences (SS) course work, using the following guidelines:

- One course from each of two different social sciences areas.
- One course from each of three different humanities or fine arts areas.
- Further study in a second higher-level course in one of the five course areas listed above (except philosophy).

Note: Skills courses such as band, chorus, orchestra, drawing, painting, and sculpture are not acceptable.

Courses that may be taken at Emporia State to fulfill these requirements include:

Anthropology	Any course except AN 200, 355, 356 (SS)
Art	Only AR 225, 235 accepted (HU)
Economics*	Any course (SS)
English	Any course except EG 100, 101, 102, 103, 104, 301, 305 (HU)
Foreign Language	Only credits earned in second-year courses may apply (HU)

History	Any course (HU)
Music	Only MU 226, 228, accepted (HU)
Philosophy	Any course (HU)
Political Science	Any course (SS)
Psychology	Only PY 100, 230, 231, 333, 401, 432 (SS)
Sociology	Any course except SO 125, 350, 351, 352,
Theatre Arts	Only TA 125 (HU)

**Industrial Engineering majors should complete Economics I and II (which also satisfy the requirement of a second higher-level humanities or social sciences course).*

DUAL-DEGREE ENGINEERING

The dual-degree allows the student in three years and a summer to complete the basic pre-engineering program, complete the departmental requirements for a major in chemistry, earth science, physics, or mathematics, and complete all of the general education requirements for a bachelor's degree from Emporia State. Students normally earn the remaining credit hours required for graduation during the first year at an engineering school, and transfer them back and apply for the ESU degree at the end of the year. A fifth year is then necessary to complete the engineering requirements and obtain the B.S. in engineering. The dual-degree is only available in conjunction with Kansas State University and the University of Kansas. Listed below are the curricula that should be followed by students in the dual-degree programs with majors in chemistry, earth science, or physics. See Mathematics section for that dual-degree program.

DUAL-DEGREE ENGINEERING ESU BACHELOR OF SCIENCE CHEMISTRY MAJOR

This program is offered in conjunction with Kansas State University and the University of Kansas. It is especially appropriate for students planning to complete degrees in agricultural, civil, chemical or petroleum engineering.

To earn the B.S. degree at Emporia State, the student must satisfy all major and general education requirements prior to transfer. A minimum of 90 semester hours must be completed at ESU. The student will normally fulfill the requirements for the B.S. in engineering after an additional two years at either Kansas State University or the University of Kansas.

Recommended Courses:

Fall -- 17-18 hours

EG 101	English Composition I	3 hours
MA 161	Calculus I	5 hours
CH 123	Chemistry I	3 hours
CH 124	Chemistry I Lab	2 hours
PE 100	Lifetime Fitness	1 hour
PS 100	Intro to Engineering	2 hours
PS 200	Intro to Engineering Graphics	1-2 hours

Spring -- 18 hours

MA 262	Calculus II	5 hours
CH 126	Chemistry II	3 hours
CH 127	Chemistry II Lab	2 hours
PH 190	Physics I	3 hours
PH 191	Physics I Lab	1 hour
PH 192	Physics I Recitation	1 hour
EG 102	English Composition II	3 hours

Fall -- 18 hours

	Fine Arts Elective	2 hours
MA 263	Calculus III	3 hours
PH 315	Statics	3 hours

PH 193	Physics II	3 hours
PH 194	Physics II Lab	1 hour
PH 195	Physics II Recitation	1 hour
CH 572	Organic Chemistry I	3 hours
CH 573	Organic Chemistry I Lab	2 hours

Spring -- 17 hours

MA 335	Differential Equations I	3 hours
CH 376	Quantitative Analysis	3 hours
CH 377	Quantitative Analysis Lab	2 hours
CH 574	Organic Chemistry II	3 hours
CH 575	Organic Chemistry II Lab	2 hours
	Technical Elective	3 hours
PE	Activity Course	1 hour

Summer -- 9 hours

BC 103	Economics I	3 hours
SP 101	Public Speaking	3 hours
	Social/Behavioral Science Elective	3 hours

Fall -- 17 hours

CH 720	Physical Chemistry I	3 hours
	Chemistry Elective	3 hours
	Fine Arts Elective	2 hours
CH 730	Seminar in Chemistry	0 hours
CS 260	Programming & Problem Solving (C++)	3 hours
	Social/Behavioral Science Elective	3 hours
	Literature/Ideas Elective	3 hours

Spring -- 19 hours

CH 722	Physical Chemistry II	3 hours
CH 721	Physical Chemistry Lab	2 hours
CH 777	Instrumental Methods of Analysis	5 hours
CH 730	Seminar in Chemistry	0 hours
	History (Multicult Intensive) Elective	3 hours
	Technical Elective	3 hours
	Cultural Diversity Elective	3 hours

DUAL-DEGREE ENGINEERING ESU BACHELOR OF SCIENCE EARTH SCIENCE MAJOR

This program is offered in conjunction with Kansas State University and the University of Kansas. It is especially appropriate for students planning to complete the degree in civil engineering.

To earn the BS degree at Emporia State, the student must satisfy all major and general education requirements prior to transfer. A minimum of 90 semester hours must be completed at ESU. The student will normally fulfill the requirements for the BS in engineering after an additional two years at either Kansas State University or the University of Kansas.

Recommended Courses:

Fall -- 18-19 hours

MA 161	Calculus I	5 hours
ES 110	Introduction to Earth Science*	4 hours
ES 111	Introduction to Earth Science Lab*	1 hour
	Fine Arts Elective	2 hours
EG 101	English Composition I	3 hours
PS 100	Intro to Engineering	2 hours
PS 200	Intro to Engineering Graphics	1-2 hours

*GO 231 Physical Geology may be substituted.

Spring -- 17 hours

MA 262	Calculus II	5 hours
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PE	100	Lifetime Fitness	1 hour
GO	240	Hand Specimen Petrology	2 hours
PH	190	Physics I	3 hours
PH	191	Physics I Lab	1 hour
PH	192	Physics I Recitation	1 hour
EG	102	English Composition II	3 hours
PE		Activity Course	1 hour

Summer -- 10 hours

CH	123	Chemistry I	3 hours
CH	124	Chemistry I Lab	2 hours
CH	126	Chemistry II	3 hours
CH	127	Chemistry II Lab	2 hours

Fall -- 18 hours

MA	263	Calculus III	3 hours
PH	193	Physics II	3 hours
PH	194	Physics II Lab	1 hour
PH	195	Physics II Recitation	1 hour
GO	325	Earth History	3 hours
GO	336	Mineralogy	4 hours
PH	315	Statics	3 hours

Spring -- 17 hours

ES	351	Intro to Geospatial Analysis	3 hours
MA	335	Differential Equations I	3 hours
GO	326	Plate Tectonics	3 hours
BC	103	Principles of Economics I	3 hours
PH	316	Dynamics	3 hours
		Fine Arts Elective	2 hours

Fall -- 18 hours

CS	260	Programming & Problem Solving (C++)	3 hours
SP	101	Public Speaking	3 hours
		Earth Science Electives	6 hours
		Cultural Diversity Elective	3 hours
		Literature/Ideas Elective	3 hours

Spring -- 18 hours

		Technical Electives	6 hours
		Earth Science Advanced Elective	3 hours
		Social/Behavioral Science Electives	6 hours
		History (Multicult Inten) Elective	3 hours

Summer -- 5 hours

GO	547	Field Geology	5 hours
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CH	124	Chemistry I Lab	2 hours
MA	161	Calculus I	5 hours
PE	100	Lifetime Fitness	1 hour
PH	100	Orientation to Physics	2 hours
PS	200	Intro to Engineering Graphics	1-2 hours

Spring -- 17 hours

MA	262	Calculus II	5 hours
CH	126	Chemistry II	3 hours
CH	127	Chemistry II Lab	2 hours
PH	190	Physics I	3 hours
PH	191	Physics I Lab	1 hour
PH	192	Physics I Recitation	1 hour
		Fine Arts Elective	2 hours

Fall -- 17 hours

EG	102	English Composition II	3 hours
MA	263	Calculus III	3 hours
PH	193	Physics II	3 hours
PH	194	Physics II Lab	1 hour
PH	195	Physics II Recitation	1 hour
CS	260	Programming & Problem Solving (C++)	3 hours
PH	315	Statics	3 hours

Spring -- 17 hours

MA	335	Differential Equations I	3 hours
PH	540	Modern Physics	3 hours
		Fine Arts Elective	2 hours
PH	316	Dynamics	3 hours
		Technical Electives	6 hours

Summer -- 7 hours

SP	101	Public Speaking	3 hours
PE		Activity Course	1 hour
		Social/Behavioral Science Elective	3 hours

Fall -- 18 hours

PH	741	Advanced Physics I Lab	3 hours
PH	760	Mechanics I	3 hours
PH	762	Electricity & Magnetism I	3 hours
MA	322	Linear Algebra	3 hours
BC	103	Principles of Economics I	3 hours
		Literature/Ideas Elective	3 hours

Spring -- 18 hours

PH	763	Electricity & Magnetism II	3 hours
		Physics Elective	3 hours
		History (Multicult Inten) Elective	3 hours
		Technical Elective	3 hours
		Social/Behavioral Science Elective	3 hours
		Cultural Diversity Elective	3 hours

TECHNICAL COURSES B DUAL-DEGREES

Several courses may be used as "technical courses" in the various dual-degree programs. Refer to the charts following the two-year pre-engineering programs to determine which courses are appropriate for each program.

COMPUTER COURSES

All engineering fields require a considerable level of computer expertise.

GENERAL EDUCATION INFORMATION

Emporia State University

Dual-degree students follow the general education program published in the schedule of classes and this catalog, with the following exceptions:

1. Substitute MA 161 (Calculus I) for the basic skills mathematics requirement.
2. SP 101 (Public Speaking) must be used to fulfill the speech requirement.

**DUAL-DEGREE ENGINEERING
ESU BACHELOR OF SCIENCE
PHYSICS MAJOR**

This program is offered in conjunction with Kansas State University and the University of Kansas. It is especially appropriate for students planning to complete degrees in electrical, computer, or mechanical engineering. To earn the BS degree at Emporia State, the student must satisfy all major and general education requirements prior to transfer. A minimum of 90 semester hours must be completed at ESU. The student will normally fulfill the requirements for the BS in engineering after an additional two years at either Kansas State University or the University of Kansas.

Recommended Courses:

Fall -- 17-18 hours

EG	101	English Composition I	3 hours
CH	123	Chemistry I	3 hours

3. Substitute CH 123/124 (Chemistry I/Lab) for the physical sciences requirement.
4. Students in the programs are exempted from the general education requirement in the biological sciences and the applied science graduation requirement.

ES, GO, or PS Elective 2 hours

Career-Supportive Electives:

Fifteen additional hours specifically selected to support the career goal of the student and approved by the student's advisor.

Kansas State University Requirements:

KSU requires that all engineering students complete English Composition I, English Composition II (unless an "A" or "B" is earned in English Composition I), speech, one course in physical education, and technical writing (at the junior level). In addition to the required courses, each KSU student is to complete 15 hours in the humanities and social sciences, which includes such areas as anthropology, art, economics, English, geography, history, journalism, modern language (advanced work only), music, philosophy, political science, psychology, sociology, and speech. At least 2 courses must be taken at the 300-level or above, and not more than three credits may be taken in applied music or applied art.

The University of Kansas Requirements:

Students will be required to complete 15-18 semester hours in the areas of humanities and social sciences, depending upon the field of engineering. When selecting courses, students should follow these guidelines:

1. At least one course designated as a humanities course, and one designated as a social science course.
2. At least two courses offered by one department.
3. A maximum of 4 credits from such areas as band, chorus, orchestra, drawing, painting, and sculpture may be acceptable at the discretion of the respective departments.

Science 5-8

BACHELOR OF SCIENCE IN EDUCATION

SECONDARY C

SCIENCE 5-8 TEACHING FIELD

See Physical Science section, below, Science 5-8 Teaching Field. This program is also referred to as the middle-level science licensure program. (This was formerly the General Science teaching field program.)

Physical Science

BACHELOR OF ARTS

PHYSICAL SCIENCE MAJOR

This program is designed for a wide range of career objectives for which a broad background in the physical sciences may be desirable. It may serve as a preparation for graduate or professional study in such career fields as business, library science, law, environmental science, city planning, and certain interdisciplinary science fields. For the basic structure of this degree, see the degree Bachelor of Arts in this catalog.

Major Area Required Courses:

Physics -- 10 hours

PH 140-141	College Physics I & Lab	5 hours
PH 143-144	College Physics II & Lab	5 hours

Chemistry -- 10 hours

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours

Earth Science -- 10 hours

ES 110-111	Intro to Earth Science & Lab	5 hours
GO 325	Earth History	3 hours

BACHELOR OF SCIENCE

PHYSICAL SCIENCE MAJOR

This program is designed for a wide range of career objectives for which a broad background in the physical sciences is desirable. It can serve as a preparation for graduate and professional study in such career fields as business, library science, law, environmental science, city planning, and certain interdisciplinary science fields. In addition to 39 hours of study in the physical sciences and 11 hours of mathematics, students choose at least 15 hours of study in courses specifically selected to support their career goals.

See the general education requirements in the General Education section of this catalog.

Required Courses in Major Area:

Mathematics -- 11 hours

MA 161	Calculus I	5 hours
MA 240	Discrete Mathematics	3 hours
	Mathematics/Computer Science Elective	3 hours

Physics -- 13 hours

PH 140-141	College Physics I & Lab	5 hours
PH 143-144	College Physics II & Lab	5 hours
	Physics Elective	3 hours

Chemistry -- 13 hours

CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours
	Chemistry Elective	3 hours

Earth Science -- 13 hours

ES 110-111	Intro to Earth Science & Lab	5 hours
GO 325	Earth History	3 hours
	Earth-Space Science Electives	5 hours

Career-Supportive Electives:

A minimum of 15 additional hours specifically selected to support the career goal of the student and approved by the student's advisor.

Additional Electives:

The student must select additional courses to total 124 credits.

PHYSICAL SCIENCE MINOR

A minor in physical science will consist of a minimum of 20 hours. PS 214, *Physical Science*, may serve on the minor if this is the student's first course in the physical sciences. It is suggested that the student select courses from each of the areas of chemistry, physics, and earth science. Additional information is available from the Departments of Physical Sciences Office, Cram Science Hall, room 133.

BACHELOR OF SCIENCE IN EDUCATION

SECONDARY TEACHING FIELDS --

CHEMISTRY (71321)

EARTH-SPACE SCIENCE (71381)

SCIENCE 5-8 (71341)*

PHYSICS (71331)

*Science 5-8 as a field of licensure may also be known as middle-level science; it was formerly the General Science teaching field.

The program variations are designed to satisfy **requirements to teach in the secondary schools of Kansas in the fields of chemistry, earth-space science, physics, and science 5-8**. Students are required to complete licensure in two of these fields or one of these fields plus an additional field (mathematics or biology, for example).

While there are two university options available for students preparing to teach at the secondary level (Option A, two teaching fields, and Option B, one teaching field), the Physical Sciences offer only Option A. Beginning science teachers are nearly always required to teach in more than a single field. In Physical Sciences (CH, ES, GO, PH or PS) teaching field courses, students must have a GPA of 2.5 or higher, and no more than one course with a "D" grade. The departments must also approve admission to Phase I and Phase II.

See the general education requirements in the General Education section of this catalog.

See also, the professional education requirements in the Secondary Education Programs section of this catalog.

The following requirements exist for the various teaching fields; the core is common to all fields (licensures):

Physical Science Core Requirements (20 hours):

CH 123-124	Chemistry I & Lab	5 hours
PH 140-141	College Physics I & Lab	5 hours
ES 110-111	Intro to Earth Science & Lab	5 hours
PS 516	Teaching Physical Sciences in Middle/High Schools	3 hours
PS 430	Nature of Science	2 hours

Additional Requirements:

Complete the set or sets of courses listed below for each teaching field selected.

Chemistry -- 15 hours*

CH 126-127	Chemistry II & Lab	5 hours
CH 370-371	General Organic Chemistry & Lab	5 hours
CH 376-377	Quantitative Analysis & Lab	5 hours

Earth-Space Science -- 13 hours*

GO 325	Earth History	3 hours
GO 547	Field Geology	5 hours
ES/GO/PS/PH	Earth-Space Science or Geology	
	Approved Electives	5 hours

*Proficiency in trigonometry must be demonstrated. This pertains to chemistry and earth-space science as teaching fields.

Physics -- 18 hours

PH 143-144	College Physics II & Lab	5 hours
PH 540	Modern Physics	3 hours
PH	Elective(s) (including a lab beyond general physics level)	5 hours
MA 161	Calculus I	
	OR	
MA 165	Basic Calculus	5 hours

Science 5-8/Middle-Level Science --

See also Biology section.

NOTE: Persons seeking general science as a teaching field in addition to other teaching fields administered by the Departments of Physical Sciences must take PS 430. If a science 5-8/ middle-level science endorsement is desired, a portion of student teaching must be at that level.

Physics

BACHELOR OF ARTS

PHYSICS MAJOR

This program is designed to allow some specialization in physics while gaining breadth in other disciplines. Required courses in the major total 25 hours.

Required Courses (14 hours):

PH 190	Physics I	3 hours
PH 191	Physics I Lab	1 hour
PH 192	Physics I Recitation	1 hour
PH 193	Physics II	3 hours
PH 194	Physics II Lab	1 hour
PH 195	Physics II Recitation	1 hour
PH 490	Independent Study	1-3 hours
PH 540	Modern Physics	3 hours

NOTE: College Physics I (PH 140/141) and College Physics II (PH 143/144) may be substituted for Physics I (PH 190/191/192) and Physics II (PH 193/194/195), respectively.

Elective Courses (12 hours):

A student must complete an additional 12 hours of approved electives in physics. All physics courses at the 300-level or above may be used to fulfill this requirement. An upper division laboratory course is highly recommended. The degree program may include a maximum of 6 hours of credit for any combination of PH 315, PH 316, PH 760, and PH 761.

Required Associated Courses (15 hours):

CH 123	Chemistry I	3 hours
CH 124	Chemistry I Lab	2 hours
MA 161	Calculus I	5 hours
MA 262	Calculus II	5 hours

Required Second Program of Study:

The student is required to complete a second program of study from 15 to 30 hours in another discipline of choice, or an ESU approved minor.

BACHELOR OF SCIENCE

PHYSICS MAJOR

This degree is designed primarily for students planning a graduate degree in one of the many areas of experimental or theoretical physics or a career in a closely allied field. The program of study is flexible, permitting students to achieve a certain degree of specialization, but also requiring significant experience in both theory and experimentation. PH 490, Independent Study, is a capstone course to be taken in the final year. In addition to the physics courses, students develop a solid background in mathematics, computer science, and chemistry, which provides many career options. For some, physics provides an excellent foundation for the professions of law or medicine, or

applied opportunities for careers such as health physics or computer science, for example. Recommended programs of study are available for students who wish to obtain a BS in physics and simultaneously prepare for employment or further education in an allied field, e.g., engineering, geophysics, medicine, computer science, etc. Additional information about recommended programs and opportunities in physics may be obtained in the Departments of Physical Sciences Office, Cram Science Hall, room 133. See the general education requirements in the General Education section of this catalog.

Required Courses (23-25 hours):

PH 190/191/192	Physics Lecture/Lab/Recitation	5 hours
PH 193/194/195	Physics II Lecture/Lab/Recitation	5 hours
PH 490	Independent Study	1-3 hours
PH 540	Modern Physics	3 hours
PH 741	Advanced Physics I Lab	3 hours
PH 760	Mechanics I	3 hours
PH 762	Electricity & Magnetism I	3 hours

Elective Courses (8 hours):

At least 6 hours of electives must be at the 300-level or above. PH 100 may be used as an elective. The degree program may include a maximum of 6 hours of credit for any combination of PH 315, PH 316, PH 760, and PH 761, and a maximum of 3 hours of credit in PH 490.

Required Associated Courses (19 hours):

CH 126-127	Chemistry II & Lab	5 hours
MA 262	Calculus II	5 hours
MA 263	Calculus III	3 hours
MA 335	Differential Equations	3 hours
CS 260	Programming & Problem Solving (C++)	3 hours

PHYSICS MINOR

This program is designed to allow a degree of specialization in physics while majoring in another field such as chemistry, mathematics, earth science, or computer science. The total credit hours necessary is 19.

Required Courses:

PH 190/191/192	Physics I Lecture/Lab/Recitation	5 hours
PH 193/194/195	Physics II Lecture/Lab/Recitation	5 hours

Elective Courses:

The student may select from these and other physics courses for a minimum of 9 hours. PH 540 Modern Physics and an advanced laboratory course are highly recommended.

PH 100	Orientation to Physics	2 hours
PH 520	Light	3 hours
PH 530	Heat & Thermodynamics	3 hours
PH 540	Modern Physics	3 hours
PH 547	Analog Electronics	3 hours
PH 548	Analog Electronics Lab	2 hours
PH 550	Digital Electronics	3 hours
PH 551	Digital Electronics Lab	2 hours
PH 730	Seminar in Physics	0-2 hours
PH 741	Advanced Physics Lab I	3 hours
PH 742	Advanced Physics Lab II	3 hours
PH 760	Mechanics I	3 hours
PH 761	Mechanics II	3 hours
PH 762	Electricity & Magnetism I	3 hours
PH 763	Electricity & Magnetism II	3 hours
PH 790	Theoretical Physics	3 hours

PH 795 Introduction to Quantum Mechanics 3 hours

**BACHELOR OF SCIENCE IN EDUCATION
PHYSICS TEACHING FIELD**

See Physical Science section.

HEALTH-RELATED FIELDS

Students wishing to prepare for careers in the health-related fields (such as dentistry, optometry, medicine, medical technology, optometry, and pharmacy) should consult the appropriate section in this catalog. These programs are under the direction of an interdepartmental committee. Details on preparation for a specific field are available in the office of the Departments of Physical Sciences. The pre-dental and pre-pharmacy programs are outlined below.

PRE-DENTAL PROGRAM

A major in chemistry can provide an excellent background for dental students. All pre-dental students should make use of the Pre-Dental Committee for advice, counseling, and recommendations. Obtain information from the office of the Departments of Physical Sciences, Cram Science Hall, room 133.

Required and Recommended Courses:

A survey of eight dental schools to whom ESU regularly sends applicants indicates the following are the minimum requirements for acceptance. The dental school of UMKC is compared to them because most ESU students apply there. All science courses must have an accompanying laboratory.

	UMKC	Average
General Chemistry	2 semesters	2 semesters
Organic Chemistry	1 semester*	2 semesters
Physics	2 semesters	2 semesters
General Biology	2 semesters	2 semesters

**One semester allowed if "it is a terminal course including a study of both aliphatic and aromatic series.... Biochemistry may not be substituted for Organic Chemistry."*

A poll of ESU students who attended UMKC suggests they consider previous experience in certain courses as an "early introduction" helps them in the courses in dental school. Those courses include biochemistry, anatomy and physiology, microbiology, and histology. There was some feeling that the metalry courses offered by the Department of Art might also help because those courses cover phases of metal working used in dentistry, such as mold-making and casting, metal forming, soldering, and finishing.

PRE-PHARMACY PROGRAM

The Pre-Pharmacy program is a two-year, 60-hour plus curriculum required by schools of pharmacy for admission to their professional programs. An additional three or four years of study at a school of pharmacy is required to become a registered pharmacist. A grade-point average higher than 2.5 is necessary to enter pharmacy school; those accepted typically have much higher grade-point averages.

First-Year Requirements (34 hours):

EG 101	English Composition I	3 hours
EG 102	English Composition II	3 hours
CH 123-124	Chemistry I & Lab	5 hours
CH 126-127	Chemistry II & Lab	5 hours

GB 140-141	Principles of Biology & Lab	4 hours
ZO 362-363	Human Anatomy & Physiology & Lab	5 hours
	Precalculus math or General Studies Elective	3 hours
	Electives - General Studies	6 hours

Second-Year Requirements (33-34 hours):

CH 572-573	Organic Chemistry I & Lab	5 hours
CH 574-575	Organic Chemistry II & Lab	5 hours
MC 316-317	Microbiology & Lab	4 hours
PH 140-141	College Physics I & Lab	5 hours
<i>(Check with advisor)</i>		
Electives	General Studies	6 hours
SP 100	Interpersonal Communication	
	OR	
SP 101	Public Speaking	3 hours
MA 161	Calculus I	
	OR	
MA 165	Basic Calculus	5 hours

Courses offered by the Departments of Physical Sciences:

CHEMISTRY

CH 110. INTRODUCTION TO CHEMISTRY 4 HRS.
(Corequisite, concurrent with CH 111.) A chemical science course for the nonscientist. The necessary scientific background is established in order to consider aspects of the energy crisis, nuclear chemistry, chemical consumer products, and health-related chemical topics. (This course is not a substitute for CH 123.) 4 70 110 0 4005--01

CH 111. INTRODUCTION TO CHEMISTRY LABORATORY 1 HR.
(Required laboratory to accompany CH 110.) The laboratory emphasizes that chemistry is a "real-world" experience. Each laboratory is designed to provide understanding of some aspect of the chemical sciences. 4 70 111 1 4005--01

CH 120. GENERAL CHEMISTRY 3 HRS.
(A one semester course which is designed for health-related professionals, and is not designed to substitute for CH 123.) Introduction to some basic concepts and principles of chemistry and their theoretical, practical, and mathematical interrelationships. Three lecture periods a week. To be taken concurrent with CH 121. 4 70 120 0 4005--01

CH 121. GENERAL CHEMISTRY LAB 2 HRS.
Laboratory to accompany CH 120. 4 70 121 1 4005--01

CH 122. GENERAL CHEMISTRY RECITATION 1 HR.
Recitation class to accompany CH 120 and CH 121. 4 70 122 0 4005--01

CH 123. CHEMISTRY I 3 HRS.
(Prerequisite, H.S. Algebra. Students with outstanding achievement in H.S. Chemistry may be admitted concurrently to CH 126 with consent of department. CH 124 to be taken concurrently.) Fundamental principles and concepts of chemistry, including atomic structure and chemical bonding, exemplary non-metals, chemical equations and their quantitative applications, phases of matter, solutions, and chemical kinetics. Three lecture periods a week. 4 70 123 0 4005--01

CH 124. CHEMISTRY I LAB 1-2 HRS.
Laboratory to accompany CH 123. 4 70 124 1 4005--01

CH 126. CHEMISTRY II 3 HRS.
(Prerequisite, CH 123 or equivalent. CH 127 to be taken concurrently.) A continuation of Chemistry I with emphasis on equilibria and properties of elements and compounds. Three lecture periods a week. 4 70 126 0 4005--01

CH 127. CHEMISTRY II LAB 1-2 HRS.
Laboratory to accompany CH 126. Includes qualitative analysis. 4 70 127 1 4005--01

CH 310. ENGINEERING MATERIALS 2 HRS.
(Prerequisites, CH 123 and PH 190 or concurrent enrollment.) Engineering requirements of materials; arrangements of atoms in materials; metallic and ceramic phases and their properties; polymers; multiphase equilibrium and non-equilibrium relationships; modification of properties through changes in microstructure; thermal behavior in service; corrosion; effect of radiation on materials. Two lectures per week. 4 70 310 0 1401--01

CH 370. GENERAL ORGANIC CHEMISTRY 3 HRS.
(Prerequisite, CH 126. CH 371 to be taken concurrently.) Organic chemistry covering all important functional groups; also sugars and carbohydrates, fats and oils, amino acids and proteins, polymers, drugs. Nomenclature, molecular structures and common chemical reactions are stressed. Three lecture periods per week. 4 70 370 0 4005--04

CH 371. GENERAL ORGANIC CHEMISTRY LAB 2 HRS.
(Laboratory to accompany CH 370.) A specially developed set of classical experiments with some non-classical experiments involving polymers, dyes, chromatography, sugars, amino acids and proteins, enzymes, fats and oils. 4 70 371 1 4005--04

CH 376. QUANTITATIVE ANALYSIS 3 HRS.
(Prerequisites, CH 126 and CH 127. CH 377 to be taken concurrently.) The course is laboratory oriented. Development of good analytical technique is stressed. Includes the determination of quantitative data by volumetric, gravimetric and simple instrumental techniques. Areas discussed are acid-base reaction, oxidation-reduction, complex formation, solubility equilibrium and spectroscopy. 4 70 376 0 4005--02

CH 377. QUANTITATIVE ANALYSIS LAB 2 HRS.
Laboratory to accompany CH 376. 4 70 377 1 4005--02

CH 479. UNDERGRADUATE RESEARCH 1-4 HRS.
(Prerequisite, consent of instructor.) For students wanting to conduct investigative study or do creative work of the type not covered by other courses. The student works independently under the supervision of a faculty member on a project in an area of chemistry in which he/she has an interest. Utilized as capstone course for chemistry majors. 4 70 479 3 4005--99

CH 500. TOPICS IN CHEMISTRY(*) 1-5 HRS.
(Prerequisite, consent of the Chair of the Department.) Selected topics in chemistry for undergraduate and graduate students. The topic(s) to be covered will be announced in the enrollment schedule. Lecture, laboratory, and/or discussion will be utilized depending on the topic(s). Topic(s) will be chosen by the department. *The blank will be filled with the an appropriate short description on the student's transcript to indicate the subject area studied. 4 70 500 1 4005--01

CH 506. ENVIRONMENTAL CHEMISTRY 3-4 HRS.
(Prerequisites, CH 376 and CH 370 or equivalent.) Sources, transport, reactions and effects of chemical species in the hydro-sphere, the lithosphere and the atmosphere. 4 70 506 1 4005--99

CH 508. INDUSTRIAL CHEMISTRY 1-3 HRS.
(Prerequisite, CH 574.) Intended to form a bridge between the academic education of chemists and the chemical industry. Field trips are an integral part of this course. 4 70 508 0 4005--99

CH 525. DESCRIPTIVE INORGANIC CHEMISTRY 3 HRS.
(Prerequisites, CH 126 and CH 127 or equivalent.) The properties and reactions (descriptive chemistry) of inorganic elements and their compounds and the principles, trends, and patterns of inorganic chemistry are studied. These trends are useful for predicting and explaining how and why reactions occur involving inorganic species in areas such as biochemistry, and geochemistry. 4 70 525 0 4005--03

CH 560. BIOCHEMISTRY 3 HRS.
(Prerequisites, CH 126 and CH 370 or equivalents; concurrent enrollment in CH 561 is strongly recommended.) A survey of the common biological molecules, their metabolism, and their roles in life-sustaining processes. Topics include special features of the aqueous environment, structures of basic biological macromolecules, protein and nucleic acid biosynthesis, protein structure and function, enzyme mechanisms and kinetics, energetics, and metabolism of carbohydrates, lipids, and amino acids. Three lecture periods per week. 4 70 560 0 2602--02

CH 561. BIOCHEMISTRY LABORATORY 2 HRS.
(Prerequisite/Corequisite, CH 560.) A laboratory course which introduces the student to several of the major experimental techniques and methodologies used in the study of biochemical systems. Topics may include buffers, protein determinations, chromatography, enzyme kinetics, protein-ligand binding interactions, electrophoresis, DNA analysis, and use of biomolecular databases. One four-hour laboratory and a one-hour recitation per week. 4 70 561 1 2602--02

CH 572. ORGANIC CHEMISTRY I 3 HRS.
(Prerequisite, CH 126. CH 573 to be taken concurrently.) Chemistry of the more important classes of carbon compounds including both aliphatic and aromatic series, stereochemistry, IR and NMR spectroscopy. Three lecture periods per week. 4 70 572 0 4005--04

CH 573. ORGANIC CHEMISTRY I LAB 2 HRS.
Laboratory to accompany CH 572. Two three-hour laboratory periods per week. 4 70 573 1 4005--04

CH 574. ORGANIC CHEMISTRY II 3 HRS.
(Prerequisite, CH 572. Concurrent with CH 575.) A continuation of CH 572, Organic Chemistry I. Three lecture periods a week. 4 70 574 0 4005--04

CH 575. ORGANIC CHEMISTRY II LAB 1-2 HRS.
Laboratory to accompany CH 574. One or two 3-hour laboratory periods a week. 4 70 575 1 4005--04

CH 578. WATER ANALYSIS 3 HRS.
(Prerequisites, CH 376 and CH 377.) Lecture and laboratory

covering analysis of water for inorganic substituents including pH, Oxygen, metal ions, and nutrients. Methods include volumetric, spectrophotometric, and electrochemical analysis. Interpretation of laboratory results is included. 4 70 578 0 4005--02

CH 620. ELEMENTS OF PHYSICAL CHEMISTRY 3 HRS.
(Prerequisites: CH 376, MA 165, PH 140, and PH 143.) A one-semester course covering the areas of physical chemistry. Some of the areas include thermodynamics, chemical and ionic equilibrium, kinetics, solutions and phase equilibrium. 4 70 620 0 4005--06

CH 627. INTERMEDIATE CHEMISTRY 3 HRS.
(Prerequisites, CH 123 and CH 126 or consent of instructor.) Topics include inorganic, organic, analytical and physical chemistry. The course is intended to serve as a review of chemistry for students who require additional study of basic concepts before continuing into advanced courses. Three lecture periods per week. 4 70 627 0 4005--01

CH 645. NUCLEAR TECHNIQUES 3 HRS.
(Prerequisites, PH 192 and CH 126.) Theory and applications of radioactive tracer techniques in chemistry. 4 70 645 1 4005--99

CH 720. PHYSICAL CHEMISTRY I 3 HRS.
(Prerequisites, CH 376, MA 262, and PH 193.) Topics covered include thermodynamics, one component systems, phase equilibria, colligative properties, and chemical statistics. Three lecture periods a week. 4 70 720 0 4005--06

CH 721. PHYSICAL CHEMISTRY LABORATORY 2 HRS.
(Prerequisites, CH 376, CH 720, MA 262, and PH 193; concurrent with CH 722.) Physical Chemistry Laboratory is designed to reinforce an understanding of general physical chemistry principles in the area of error analysis, behavior of gases, thermodynamics, phase behavior, electrochemistry, kinetics, and spectroscopy. 4 70 721 1 4005--06

CH 722. PHYSICAL CHEMISTRY II 3 HRS.
(Prerequisite, CH 720. Concurrent with CH 721.) Topics covered include kinetics, electromotive force, quantum theory, spectra and molecular structure. Three lecture periods a week. 4 70 722 0 4005--06

CH 723. ADVANCED PHYSICAL CHEMISTRY LABORATORY 2 HRS.
(Prerequisites, CH 376, CH 720, CH 721, CH 722, MA 262, and PH 193.) Advanced Physical Chemistry Laboratory is designed to familiarize students with advanced chemistry laboratory techniques through research projects and computational experiments. 4 70 723 1 4005--06

CH 724. TOPICS IN PHYSICAL CHEMISTRY: (*) 3 HRS.
(Prerequisite, CH 722.) A topic in physical chemistry will be chosen from among those topics of interest to students and faculty. Examples include quantum chemistry, statistical mechanics, thermodynamics, surface chemistry, and estimation of physical properties. *Topic to be considered is announced in the enrollment schedule. May be repeated for credit. 4 70 724 0 4005--06

CH 725. ADVANCED INORGANIC CHEMISTRY 3 HRS.
(Prerequisites, CH 525 and CH 720.) A systematic study of the elements and their compounds emphasizing the relationships between the properties of substances and their atomic and molecular structures and the positions of the elements in the periodic table. Three lecture

periods a week. 4 70 725 0 4005--03

CH 726. ADVANCED INORGANIC CHEMISTRY LABORATORY 1-3 HRS.
(Prerequisite or corequisite, CH 725.) Synthesis and characterization of typical inorganic compounds employing methods and techniques which are unique to inorganic chemistry. 4 70 726 1 4005--03

CH 728. CHEMICAL LITERATURE 1 or 2 HRS.
(Prerequisite, consent of instructor.) Use of chemical literature. A study of assorted chemical and related publications, reference books, and other sources of information. One-hour class period and one 2-hour library assignment per week. 4 70 728 0 4005--99

CH 729. RESEARCH PROBLEM IN CHEMISTRY 1-3 HRS.
(Prerequisite, graduate standing and consent of instructor.) Individual studies by advanced students of problems of special interest in chemistry. Training in methods of research. 4 70 729 4 4005--99

CH 730. SEMINAR IN CHEMISTRY 0-2 HRS.
(Prerequisite, consent of instructor.) Seminars are given by students, outstanding chemists from other institutions, and faculty. May be repeated for credit. 4 70 730 2 4005--99

CH 760. ADVANCED BIOCHEMISTRY 3 HRS.
(Prerequisite, CH 560 or equivalent.) The chemistry and biochemistry of nucleic acids are emphasized. Topics include nucleotide biosynthesis, DNA and RNA structure, DNA replication, DNA damage and repair, protein-DNA and drug-DNA interactions, DNA sequencing methods, biochemical aspects of modern molecular biology, and current areas of interest from the literature. Three hours of lecture per week. 4 70 760 0 2602--02

CH 772. TOPICS IN ORGANIC CHEMISTRY: (*) 1-3 HRS.
(Prerequisites, CH 574 and CH 720.) Selected topics in organic chemistry. *The topic to be covered is announced in the enrollment schedule. Some examples of areas are: industrial organic chemistry, reaction mechanisms, organic synthesis and organic polymers. May be repeated for credit. 4 70 772 0 4005--04

CH 773. QUALITATIVE ORGANIC ANALYSIS 3 HRS.
(Prerequisite, CH 574.) Identification of unknown organic compounds using both instrumental and wet chemical methods. The analytical correlation of structure with instrumental and chemical information is stressed. Two lecture periods a week with laboratory by arrangement. 4 70 773 1 4005--02

CH 776. TOPICS IN BIOCHEMISTRY: (*) 1-3 HRS.
(Prerequisite, CH 560.) Advanced studies of selected aspects of biochemistry for the student with previous background in the area. The area of study will be selected prior to the first class meeting. *The topic to be considered will be announced in the class schedule. May be repeated for credit. 4 70 776 0 2602--02

CH 777. INSTRUMENTAL METHODS OF ANALYSIS 5 HRS.
(Prerequisite, CH 720 and pre- or corequisite, CH 722.) The use of instruments to obtain qualitative, quantitative, and structural data is discussed. Basic theory, fundamental principles, and limitations underlying the techniques are included. Laboratory experiments acquaint the student with the operation of the instruments and the interpretation of data. Techniques drawn from the areas of separations, spectroscopy, and electroanalytical methods, include gas and

liquid chromatography; capillary electrophoresis; mass spectrometry; ultraviolet, visible, infrared, Raman, fluorescence, phosphorescence, atomic absorption, atomic emission, nuclear magnetic resonance, and electron paramagnetic resonance spectroscopies; voltammetry; and polarography. 4 70 777 1 4005--02

CH 778. TOPICS IN ANALYTICAL CHEMISTRY: (*) 1-3 HRS.
(Prerequisite, CH 376.) Selected topics in analytical chemistry. *The topic to be covered is announced in the enrollment schedule. Some examples of areas are applied analytical methods, absorption spectroscopy, flame emission and atomic absorption spectroscopy, and electrochemical methods. May be repeated for credit. 4 70 778 1 4005--02

CH 801. TRENDS IN HIGH SCHOOL CHEMISTRY CURRICULA 3 HRS.
(Prerequisites, fifteen hours in chemistry and eight hours in physics and/or earth science.) Designed for in-service physical science teachers. In-depth investigation by class participants of current chemical education curricula to determine trends. Diagnostic study of these trends by the class to determine their relative significance, cost of implementation, and methods of integration into an existent or a new course. Laboratory investigations will be used as advisable. 4 70 801 1 4005--99

CH 802. MODERN DEVELOPMENTS IN CHEMISTRY 3 HRS.
(Prerequisites, fifteen hours in chemistry and eight hours in physics and/or earth science.) Designed for in-service physical science teachers. A study of recent advances in the fields of analytical, inorganic, physical and organic chemistry. 4 70 802 0 4005--99

CH 826. TOPICS IN INORGANIC CHEMISTRY: (*) 1-3 HRS.
(Prerequisite, CH 725.) A treatment of a specific area of inorganic chemistry to be chosen from among the following topics: physical methods, coordination chemistry, stereochemistry and symmetry of inorganic compounds, kinetics and mechanisms of inorganic reactions, aspects of metal chemistry and nonmetal chemistry. *The topic to be covered will be announced in the enrollment schedule. May be repeated for credit. 4 70 826 0 4005--03

CH 829. GRADUATE RESEARCH 1-5 HRS.
(Prerequisites, graduate standing and permission.) Investigative research on a problem in an area of chemistry selected by the student after consultation with and under the supervision of a chemistry faculty member. 4 70 829 4 4005--99

CH 871. TOPICS IN ADVANCED PHYSICAL CHEMISTRY 1-3 HRS.
(Prerequisites, CH 722 and consent of instructor.) Each semester a topic in physical chemistry will be chosen and pursued at an advanced level of study. Some of the topics covered will be the same as those covered in CH 724, but at a different level of presentation. May be repeated for credit. 4 70 871 0 4005--06

CH 875. THESIS M.S. 1-5 HRS.
(Prerequisite, consent of instructor.) Required for the 30-hour degree, Master of Science with a major in chemistry. Research in an approved area of chemistry and the preparation of a thesis. 4 70 875 4 4005--99

EARTH SCIENCE

ES 110. INTRODUCTION TO EARTH SCIENCE 4 HRS.
(Corequisite, concurrent enrollment with ES 111.) This course may be used for general education requirements and also serve as the first course for those majoring in earth science. An introduction to the earth sciences through combined lecture and laboratory experiences in the areas of astronomy, geology, meteorology, and oceanography.
4 71 110 0 4007--03

ES 111. INTRODUCTION TO EARTH SCIENCE LABORATORY 1 HR.
Laboratory to accompany ES 110. 4 71 111 1 4007--03

ES 237. GEOLOGIC ENVIRONMENTS OF THE GREAT PLAINS 2 HRS.
The geological attributes and geologic history of the Great Plains region of North America are intimately involved, directly and indirectly, with its boundaries, scenery, resources, and hazards. Attention will focus on these relationships and on the coexistence of mankind. Aspects of geologic history will be examined for their impact on the present, and the interrelations of the geo-environmental factors of topography, soils, water, mineral resources, and climate will be illustrated and related to human activities.
4 71 237 1 4006--01

ES 254. PHYSICAL GEOGRAPHY 3 HRS.
Primarily for majors and minors in geography, the physical and biological sciences, and others interested in physical geography. Systematic study of the elements of climate, landforms, water resources, vegetation, soil, and minerals. 4 71 254 0 4507--01

ES 314. PROJECT DESIGN SEMINAR 1 HR.
(Prerequisite, earth science major or emphasis (BSE); at least junior standing or consent of instructor.) The course is an introduction to strategies and techniques of research for majors in and/or prospective teachers of earth sciences. Progressive definition of a problem and devising means to solve it will be emphasized. Supporting techniques of library use and conventions of scientific proposal and report writing will also be surveyed. 4 71 314 0 4007--99

ES 319. METEOROLOGY 3 HRS.
(Prerequisite, five hours of earth/physical science.) The physical processes underlying weather phenomena are studied through the construction and analysis of various surface and high-level atmospheric charts, cross-sections and graphs.
4 71 319 0 4004--01

ES 331. ICE AGE ENVIRONMENTS 3 HRS.
(Prerequisite, ES 110 or consent of instructor.) An introduction to geology, landscapes, glaciers, climate, and biology of the Ice Ages. The relationship of Ice Age events to modern environments, the nature of climatic and environmental change, and the role of man. Three hours lecture per week and field trips.
4 71 331 0 4006--01

ES 333. ENVIRONMENTAL GEOLOGY 3-5 HRS.
(Prerequisite, ES 110/111 or equivalent.) Focus on natural operations of systems and cycles involved with geologic hazards and resource distribution/production. Beneficial and disastrous consequences of man's involvement with natural operations will be analyzed and applied to land-use planning. Course appropriate for those interested in environmental studies, but also agriculture, civil engineering, construction, economics, planning, science education.

4 71 333 0 4006--99

ES 351. INTRODUCTION TO GEOSPATIAL ANALYSIS 3 HRS.
(Prerequisite, one general education course in each of biological, physical, and social sciences or consent of instructor.) Introduction to geographic information systems (GIS) and remote sensing techniques as applied to documenting, mapping, interpreting, and managing natural and cultural resources. Types of GIS data, computer hardware and software used for geospatial analysis, basic cartography, and global positioning system. Lectures, laboratory exercises, and field trip. 4 71 351 0 4006--99

ES 365. WORLD REGIONAL CLIMATOLOGY 2-3 HRS.
A study of the world climatic regions based upon a systematic classification system. The investigations of the cause of climatic variations and the effect of climate on man's natural environment.
4 71 365 0 4507--01

ES 439. INDEPENDENT STUDY IN EARTH SCIENCE 1-4 HRS.
(Prerequisite, consent of instructor.) For students wishing to conduct an investigative study or to do creative work in some area of the earth sciences. May be repeated. 4 71 439 3 4007--03

ES 475. SENIOR THESIS IN EARTH SCIENCE 1-5 HRS.
(Prerequisite, Senior status as an earth science major at the time of enrollment. Juniors may begin preliminary work, in connection with other courses, that could lead to a thesis in their senior year.) Advanced undergraduate research conducted on a specific project in climatology, earth-systems science, geology, meteorology, paleontology, planetary science, remote sensing, or related subjects. Students will work with a faculty member to design, carry out, and present the thesis project. 4 71 475 4 4007--03

ES 518. SPACE SCIENCE 3 HRS.
(Prerequisite, PS 214 or equivalent.) Studies include observational evidence for the heliocentric model of the solar system; the solar system with concentration upon the moon and lunar exploration; techniques for studying and physical characteristics of remote stellar bodies; and current concepts regarding the nature and dynamacy of the universe as a system. 4 71 518 0 4002--01

ES 545. GEOMORPHOLOGY 3 HRS.
(Prerequisite, ES 110 or equivalent.) The processes that have shaped the Earth's surface are studied with the aid of topographic maps and aerial photographs. The influence that rock type and geologic structure has in producing land forms is stressed.
4 71 545 1 4006--99

ES 546. FIELD GEOMORPHOLOGY 2-5 HRS.
(Prerequisite, ES 545 or consent of instructor.) Study of landforms and landscape development in the field. Techniques for description, surveying, mapping, and interpretation of landforms in a natural setting. Practical application of geomorphology to terrain analysis.
4 71 546 2 4006--99.

ES 551. COMPUTER MAPPING SYSTEMS 3 HRS.
(Prerequisites, GE 371 or ES 545 or consent of instructor; minimum math background trigonometry.) Theory and use of computer systems for capture, storage, analysis, and plotting of spatial information. Vector and raster geographic information systems, digitizing data, and spatial analysis. Practical applications of computer mapping systems. Two hours lecture and two hours laboratory per week, plus

field trips. 4 71 551 0 1511--02

ES 555. SMALL-FORMAT AERIAL PHOTOGRAPHY

3 HRS.

(Prerequisite, ES 351 Introduction to Geospatial Analysis, or consent of instructor.) Techniques of small-format aerial photography. Acquisition of air photos with conventional cameras as well as compact digital cameras. Low-altitude, large-scale photography from airplanes, kites and balloons. Handling, scanning, processing, interpretation, enhancement, and display of analog and digital aerial images. Practical field and laboratory exercises. Course is designed for students in the geospatial analysis program.

4 71 555 0 4006--99

ES 567. TOPICS IN EARTH SCIENCE (*)

1-4 HRS.

(Prerequisites, 6 credit hours of ES or GO courses and consent of the instructor.) The student may concentrate in an area of the earth sciences for which no regular course is available if there are adequate texts, library holdings, and laboratory resources. Examples of the possible areas of study are: Vertebrate Paleontology, Invertebrate Paleontology, Crystallography, Structural Geology, Economic Geology, Ground Water Geology, Environmental Geology, Optical Mineralogy, and Geophysics. *The blank will be filled with an appropriate short description on the student's transcript to indicate the subject area studied. 4 71 567 3 4006--03

ES 703. SEMINAR IN PHYSICAL GEOGRAPHY

1-3 HRS.

The seminar is designed to provide an opportunity for in-depth examination of selected topics of physical geography. It is a geographical analysis of the spatial characteristics of one or more factors that constitute the physical environment. The seminar specifically treats such subjects as climate, soils, landforms, and biogeography.

4 71 703 0 4507--01

ES 730. GEOLOGIC TOPICS OF THE GREAT PLAINS

1-3 HRS.

(Prerequisite, graduate standing or 5 hours of Earth Science.) The unique combination of natural forces both present and prehistoric have made the Great Plains region unlike any other on the North American continent. The extreme diversity of weather elements, the remote location relative to geologic orogenic upheavals, and the long inundation of prehistoric shallow seas sets this part of the continent apart from the rest. Various aspects of the physical distinctiveness of the Great Plains will be examined in this course. 4 74 730 0 4007-03

ES 739. RESEARCH PROBLEM IN EARTH SCIENCE

1-3 HRS.

(Prerequisite, consent of instructor.) Junior, senior, or graduate students wishing to work on research problems of special interest in the field of earth science. 4 71 739 4 4007--03

ES 747. FIELD STUDIES IN EARTH SCIENCE

1-6 HRS.

(Prerequisite, BSE Degree or consent of instructor.) Designed for teachers K-12, who do not have a strong background in earth science. One credit hour for each week of field/laboratory work. An experience oriented field course for Kansas teachers. The course is designed to help each individual explore his or her geological environment in a field setting. 4 71 747 1 4007--03

ES 767. TOPICS IN EARTH SCIENCE (*)

1-4 HRS.

(Prerequisites, graduate standing, bachelors degree in science or math, 10 hrs. Earth Science and consent of instructor.) The student may concentrate in an area of the earth sciences for which no regular course is available if there are adequate texts, library holdings, and laboratory resources. *The blank will be filled in with an appropriate

short description on the student's transcript to indicate the subject area studied. 4 71 767 3 4007--03

ES 769. WORKSHOP IN EARTH SCIENCE

2-6 HRS.

(Prerequisite, consent of instructor.) Curriculum development in the field of earth science for elementary, junior high, and high school teachers. Lectures, laboratory, and field experience in geology, astronomy, meteorology, and related topics. 4 71 769 1 4007--03

ES 771. REMOTE SENSING

4 HRS.

(Prerequisite, MA 112 and GE 371 or ES 545 or by consent of instructor.) Remote sensing of the Earth's surface utilizing the electromagnetic spectrum. Techniques of photography, multispectral scanning, and microwave imagery from airplane, satellite, and manned-spacecraft platforms. Image interpretations, practical applications in earth science, and use of remotely sensed data in geographic information systems. Two hours lecture and four hours lab per week plus field trips. 4 71 771 0 4007--03

ES 775. ADVANCED IMAGE PROCESSING

3 HRS.

(Prerequisite, ES 771 or consent of instructor.) Advanced techniques of image processing and analysis for remotely sensed digital data. Topics include enhancement, spectral analysis, classification, and change detection. Interdisciplinary applications in Earth resources and environmental conditions; practical exercises based on satellite datasets and other forms of remotely sensed data. Course is designed for advanced students in the geospatial analysis program.

4 71 775 0 4007--03

ES 875. THESIS M.S.

1-5 HRS.

(Prerequisite, consent of instructor.) Required for the 30-hour degree, Master of Science in Physical Sciences, with an emphasis in earth science. Research in an approved area of earth science and the preparation of a thesis. 4 71 875 4 4006--99

GEOLOGY

GO 231. PHYSICAL GEOLOGY

3 HRS.

A descriptive study of the physical and chemical processes occurring on and within the Earth and the associated structures and features produced by these processes. The study and identification of minerals and rocks, topographic maps, and geologic maps. Field trips are required. 4 74 231 1 4006--01

GO 240. HAND SPECIMEN PETROLOGY

2 HRS.

(Prerequisite, ES 110/111 or consent of instructor.) An introduction to recognition, terminology, and classification of minerals, rocks and sediments. Emphasis on sight identification and description using only simple equipment. One lecture hour and two lab hours per week, plus field trips. 4 74 240 1 4006--02

GO 325. EARTH HISTORY

3 HRS.

(Prerequisite, ES 110/111 or consent of instructor.) The history of the Earth from primeval beginning to the emergence of modern man, as deduced from rocks, fossils, and sediments of the Earth's continents and oceans. Analysis of modern geologic and cosmic processes and their relationship to past, present, and possible future events on Earth. Geologic history of central North America. Two lecture hours and two lab hours per week, plus field trips. 4 74 325 1 4006--01

GO 326. PLATE TECTONICS

3 HRS.

(Prerequisite, GO 325 or consent of instructor.) A study of the new global theory of plate tectonics as a unifying geological theory, which explains continental and oceanic geology of the past and present.

Scientific development of plate-tectonic theory over the past decades, as well as unsolved problems and possible future research. Two hours lecture and two hours lab per week. 4 74 326 1 4006--03

GO 336. MINERALOGY 4 HRS.

(Prerequisites, CH 123/124 recommended.) The study of minerals of the Earth's crust with respect to their internal structure, chemistry, physical properties, and identification. The occurrence of these minerals in rocks will be related to the physical and chemical classification of rocks of the earth's crust.

4 74 336 1 4006--99

GO 340. GEMSTONES AND GEMOLOGY 2-3 HRS.

(Prerequisites, ES 110/111 or consent of instructor.) An introductory course that includes gem definitions, identification techniques, synthesis, imitations, enhancements, and precious metals. Gem identification techniques will be emphasized. Two-credit section, lecture only; three-credit section, lecture plus lab.

4 74 340 1 4006--99

GO 521. HISTORY OF GEOLOGY 2-3 HRS.

(Prerequisites, ES 110/111 or equivalent, history of science, or consent of instructor.) The historical development of geology as a scientific discipline from ancient civilizations to the modern space age. Historical context and cultural basis of major geological theories regarding the origin of the Earth and processes that have influenced the Earth's development. The lives and contributions of individuals whose ideas have shaped scientific thought and public opinion. Scientific technology, exploration, and the changing role of earth science through time. History of European, North American, and Kansan geology.

4 74 521 0 4006--01

GO 533. ECONOMIC GEOLOGY 3 HRS.

(Prerequisite, ES 110/111 or equivalent.) The study of economic mineral deposits with respect to genesis, prospecting techniques, and physical characteristics. 4 74 533 0 4006--99

GO 536. OPTICAL MINERALOGY 3 HRS.

(Prerequisite, GO 336.) A three-hour lecture-laboratory course designed to acquaint the student with the use of the polarizing microscope and its applications to the study of rocks and minerals in thin section. 4 74 536 1 4006--99

GO 547. FIELD GEOLOGY 5 HRS.

(Prerequisite, ES 110/111, GO 325 or consent of instructor.) A five-week laboratory and field experience for geologists and earth science teachers designed to acquaint the student with the tools of geology and their application to the solution of geological problems. Offered alternate summers. 4 74 547 2 4006--01

GO 548. FIELD STRATIGRAPHY 2 HRS.

(Prerequisites, ES 110, ES 111, and GO 325.) The identification and interpretation of Upper Paleozoic strata in Eastern Kansas through field experiences. This course requires that the student be free most weekends of early fall. 4 74 548 2 4006--04

GO 568. STRUCTURAL GEOLOGY 3 HRS.

(Prerequisites, MA 112 and GO 325.) Structural Geology deals with description and analysis of deformations produced within the Earth on all scales from the microscopic to the global. Topics investigated include: behavior of rocks and sediments under stress; nature of earthquakes; origin of mountain belts; and significance of ocean ridges, rifts, fracture zones, and trenches.

4 74 568 0 4006--03

GO 569. INVERTEBRATE PALEONTOLOGY 3 HRS.

(Prerequisite, ES 110/111.) Attention in this course is focused on the structure and classification of fossil invertebrate animals. A study of the evolutionary trends and geological distribution of these animals also helps to emphasize their stratigraphic usefulness. This is accomplished through one one-hour lecture and two two-hour labs a week. In the lab the student works with actual fossil specimens of the various invertebrate phyla. 4 74 569 1 4006--04

GO 570. SEDIMENTATION AND STRATIGRAPHY 3 HRS.

(Prerequisites, GO 325 and consent of instructor.) The origin and interpretation of stratified sequences of ancient sedimentary rocks and modern sediments. Methods used to study sedimentary rocks. Comparison of modern and ancient sedimentary environments. Two lecture hours and two lab hours per week, plus field trips.

4 74 570 0 4006--04

GO 571. GEOHYDROLOGY 3 HRS.

(Prerequisite, ES 110/111 or consent of instructor.) Geologic, hydrologic, and chemical factors controlling the distribution, abundance, quality, and development of surface water and groundwater. Surface and groundwater in the central U.S.A. will be emphasized. Two lecture hours per week and two lab hours per week, plus possible field trips. 4 74 571 1 4006--99

GO 766. PETROLOGY AND PETROGRAPHY 4 HRS.

(Prerequisite, GO 336.) A study of rocks and minerals of the Earth's crust as natural chemical systems in which the mineral phases are in dynamic equilibrium with changing temperatures and pressures on and within the Earth's crust. Three hours lecture and three hours laboratory each week. 4 74 766 1 4006--02

GO 769. VERTEBRATE PALEONTOLOGY 3 HRS.

(Prerequisites, GO 325 or equivalent, or consent of instructor.) The course will focus on the fossil record and evolution of vertebrate (backboned) animals through geological time. Origins, adaptive radiations, and extinctions of all major vertebrate groups will be covered, along with the utility of fossil vertebrates in stratigraphic correlations, analysis of depositional environments, paleo-bio-geography, and questions of evolutionary biology. The course is designed for students in Earth Science and Biology who have an interest in vertebrate evolutionary history. 4 74 769 0 4006--04

PHYSICS

PH 100. ORIENTATION TO PHYSICS 2 HRS.

An orientation to physics concepts and research designed for the first semester freshman physics major. Problem solving, graphing, SI units, numerical solutions, and probability are included. A consideration will be given to the various fields of physics and career opportunities in physics. A modest research project will be initiated. 4 73 100 0 4008--01

PH 110. INTRODUCTION TO SPACE SCIENCE 4 HRS.

(Corequisite, PH 111.) A general education course which uses a historical and philosophical perspective when appropriate, and basic principles from the physical sciences to consider the solar system and star-like objects. Emphasis is placed on the nature of science, findings from space exploration, and the evidence for what we know about the universe and Earth's place in the universe. The planetarium and observing sessions with telescopes are integral parts of the course.

4 73 110 0 4008--01

PH 111. INTRODUCTION TO SPACE SCIENCE LAB 1 HR.
(Corequisite, PH 110.) A general education laboratory course which accompanies PH 110. The two-hour weekly laboratory is closely correlated with the PH 110 lecture. The planetarium and observing sessions with telescopes are integral course aids.
4 73 111 1 4008--01

PH 140. COLLEGE PHYSICS I 3 HRS.
(Prerequisite, high school algebra. PH 141 to be taken concurrently.) General principles involved in kinematics, mechanics, sound and heat with emphasis on energy and the relationships among various forms
PH 190. PHYSICS I 3 HRS.
(Prerequisite, concurrent with MA 161, PH 191, and PH 192.) Introductory course for students desiring a calculus approach. Topics include mechanics, hydrodynamics, and thermodynamics. Three lecture periods and six hours of laboratory/recitation work per week.
4 73 190 0 4008--01

PH 191. PHYSICS I LAB 1 HR.
Laboratory to accompany PH 190. 4 73 191 1 4008--01

PH 192. PHYSICS I RECITATION 1 HR.
Recitation class to accompany PH 190. 4 73 192 0 4008--01

PH 193. PHYSICS II 3 HRS.
(Prerequisite, PH 190. Corequisite, concurrent with MA 262, PH 194 and PH 195.) Introductory course for students desiring a calculus approach. Topics include electricity, magnetism, circuit theory, wave motion, and light. Three lecture periods per week, and six hours of laboratory/recitation work per week. 4 73 193 0 4008--01

PH 194. PHYSICS II LAB 1 HR.
Laboratory to accompany PH 193. 4 73 194 1 4008--01

PH 195. PHYSICS II RECITATION 1 HR.
Recitation class to accompany PH 193. 4 73 195 0 4008--01

PH 310. ENGINEERING MATERIALS 2 HRS.
(Prerequisites, CH 123 and PH 193 or concurrent enrollment.) Engineering requirements of materials; arrangements of atoms in materials; metallic and ceramic phases and their properties; polymers; multiphase equilibrium and non-equilibrium relationships; modification of properties through changes in microstructure; thermal behavior in service; corrosion; effect of radiation on materials. Two lectures per week. 4 73 310 0 1401--01

PH 315. STATICS 3 HRS.
(Prerequisite, PH 140 or PH 190.) Primarily for pre-engineers, this course deals with rigid bodies and the forces on them while at rest.
4 73 315 0 4008--01

PH 316. DYNAMICS 3 HRS.
(Prerequisite, PH 190.) Motion, its causes and descriptions, is the subject of Dynamics. Newton's laws and their extensions using energy and impulse are used on systems pertinent to engineering and applied physics careers. 4 73 316 0 4008--01

PH 410. ELECTRICAL CIRCUIT ANALYSIS 3 HRS.
(Prerequisites, PH 193 and MA 335 or concurrent enrollment.) Analysis of linear circuits containing resistors, capacitors, and inductors. Topics include elementary circuits and circuit theorems, sinusoidal excitations, complex numbers and phasor analysis, energy

of energy as related to physics. 4 73 140 0 4008--01

PH 141. COLLEGE PHYSICS I LAB 1-2 HRS.
Laboratory to accompany PH 140. 4 73 141 1 4008--01

PH 143. COLLEGE PHYSICS II 3 HRS.
(Prerequisite, PH 140. PH 144 to be taken concurrently.) General principles involved in electricity, light and modern physics with emphasis on energy and the relationships among various forms of energy as related to physics. 4 73 143 0 4008--01

PH 144. COLLEGE PHYSICS II LAB 1-2 HRS.
Laboratory to accompany PH 143. 4 73 144 1 4008--01
and power, and polyphase circuits. 4 73 410 0 4008--08

PH 411. ELECTRICAL CIRCUIT LABORATORY 1 HR.
(Concurrent with enrollment in PH 410.) A lab course to accompany PH 410. Includes basic V-I measurements, laboratory instruments, power supplies, operational amplifiers, filters, wave-shaping circuits, and oscillators. 4 73 411 1 4008--08

PH 430. COMPUTER INTERFACING IN SCIENCE 3 HRS.
(Prerequisites, CS 130 or equivalent, and ten hours in the natural sciences [biology, chemistry, earth science, geology or physics].) A lecture-laboratory course where students will learn to interface the microcomputer to several common laboratory instruments, both for the purpose of acquiring and analyzing data and for controlling experiments. 4 73 430 0 4008--99

PH 490. INDEPENDENT STUDY 1-3 HRS.
(Prerequisites, consent of instructor and senior college standing.) This course is for students wishing to investigate a problem with the assistance of an instructor but with the primary responsibility themselves. 4 73 490 3 4008--99

PH 500. TOPICS IN PHYSICS (*) 1-5 HRS.
(Prerequisite, physics or physical science teacher certification or consent of instructor.) Study of specialized topics in physics. *The blank will be filled with an appropriate short description on the student's transcript to indicate the topical area studied.
4 73 500 1 4008--99

PH 510. COMPUTER APPLICATIONS IN PHYSICS 3 HRS.
(Prerequisites, PH 143 or PH 193 and CS 130 or equivalent programming experience.) Computer solutions of physics problems using spreadsheets, computer algebra systems and programming languages. Use of the spreadsheet and other appropriate software in the physics laboratory. 4 73 510 0 4008--99

PH 520. LIGHT 3 HRS.
(Prerequisite, PH 193.) An introductory course in geometrical and physical optics. Properties of lenses and simple optical instruments, phenomena of interference, diffraction and polarization, and electromagnetic character of light. 4 73 520 0 4008--07

PH 530. HEAT AND THERMODYNAMICS 3 HRS.
(Prerequisites, PH 190 and MA 262.) Fundamental ideas of temperature, work, internal energy, heat, reversibility, entropy, and other thermodynamic functions. Application of the laws of thermodynamics to physics, chemistry and engineering. An introduction to statistical mechanics. 4 73 530 0 4008--99

PH 540. MODERN PHYSICS 3 HRS.
(Prerequisites, PH 143 or PH 193 and MA 161 or MA 165.) Theories

involved in advances in physics since 1900. Includes: atomic structure, relativity, wave mechanics, radioactivity and nuclear physics.

4 73 540 0 4008--99

PH 541. ATOMIC AND NUCLEAR PHYSICS I 3 HRS.

(Prerequisite, PH 193.) The development of the concept of the atom is presented followed by a study of electrons and electromagnetic radiation which then leads to the atomic models proposed by Rutherford and Bohr. Special relativity is discussed in preparation for the study of X-rays and further topics in nuclear physics.

4 73 541 0 4008--02

PH 550. DIGITAL ELECTRONICS 3 HRS.

(Prerequisite, PH 193, PH 143 or consent of instructor.) After a review of AC and DC circuits, this course covers digital integrated circuits and their use in instrumentation and computer circuits and systems. The TTL and CMOS logic gates are covered in detail. MOS devices such as microprocessors, RAM and ROM memories, FIFO buffers, etc., are introduced. Digital computer circuits, codes, and interfacing are stressed. PH 551 must be taken concurrently.

4 73 550 0 4008--99

PH 551. DIGITAL ELECTRONICS LABORATORY 2 HRS.

Laboratory to accompany PH 550. 4 73 551 1 4008--99

PH 635. INTERMEDIATE PHYSICS 3 HRS.

(Prerequisite, PH 193 or PH 143 or consent of instructor.) Topics include mechanics, wave motion, heat and thermodynamics, electricity and magnetism, and light. The course is intended to serve as a review of physics for students who require additional study of basic concepts before continuing into advanced courses. Three lecture periods per week. 4 73 635 0 4008--99

PH 645. NUCLEAR TECHNIQUES 3 HRS.

(Prerequisite, PH 143 or PH 193.) Nuclear laboratory experiments on detection and measurement of radioactive isotopes using Geiger counters, ionization chambers, and scintillation detectors. Experience with multichannel analyzer instrumentation, shielding, and monitoring equipment. 4 73 645 1 4008--06

PH 700. TOPICS IN PHYSICS (*) 1-5 HRS.

(Prerequisites, Physics degree; physics or physical science teacher certification; or consent of instructor.) Study of specialized topics in physics. *The blank will be filled with an appropriate short description on the student's transcript to indicate the topical area studied.

4 73 700 0 4008--99

PH 730. SEMINAR IN PHYSICS 0-2 HRS.

(Prerequisite, consent of instructor.) Reports by students, staff and visitors are presented on topics of current or historical interest in physics. Graduate students, in particular, have the experience of developing effective presentations. 4 73 730 2 4008--99

PH 741. ADVANCED PHYSICS LABORATORY I 3 HRS.

(Prerequisite, PH 143 or PH 193.) Classical and modern physics experiments on fundamental constants of nature, X-rays, radioactivity, etc. Two 3-hour laboratory periods per week. 4 73 741 1 4008--99

PH 742. ADVANCED PHYSICS LABORATORY II 3 HRS.

(Prerequisites, PH 193, MA 262.) A laboratory course in basic electrical measurement techniques, and short laboratory projects in the areas of light, heat and solid state. Two 3-hour laboratory periods per week. 4 73 742 1 4008--99

PH 547. ANALOG ELECTRONICS 3 HRS.

(Prerequisite, PH 193 or consent of instructor.) The basic physics of the P-N junction and its implementation in diodes and transistors is covered. Design work with diodes, transistors, and analog integrated circuits is stressed, along with the use of analog integrated circuits in instruments, power supplies, and computer interfaces. PH 548 must be taken concurrently. 4 73 547 0 4008--99

PH 548. ANALOG ELECTRONICS LABORATORY 2 HRS.

Laboratory to accompany PH 547. 4 73 548 1 4008--99

PH 752. ATOMIC AND NUCLEAR PHYSICS II 3 HRS.

(Prerequisite, PH 541 or PH 540.) The study of X-rays serves as the starting point for developing the concept of nuclear properties. The masses, sizes and radiations of nuclei are studied and then models of nuclei are considered in light of these properties. Elementary particles are also introduced. 4 73 752 0 4008--02

PH 760. MECHANICS I 3 HRS.

(Prerequisite, PH 193.) The basis of Newton's mechanics is presented and then applied to mass-points, collections of mass points, and finally a rigid body. Gravitation in classical mechanics is also discussed.

4 73 760 0 4008--99

PH 761. MECHANICS II 3 HRS.

(Prerequisites, PH 760 and MA 263.) Newtonian mechanics as formulated by Lagrange is developed, followed by applying elementary tensor theory to the rotation of rigid bodies. The study of small vibrations of systems of particles concludes the course.

4 73 761 0 4008--99

PH 762. ELECTRICITY AND MAGNETISM I 3 HRS.

(Prerequisite, PH 193.) A study of electrostatics, electrical properties of matter, and potential theory. Three lecture periods per week.

4 73 762 0 4008--08

PH 763. ELECTRICITY AND MAGNETISM II 3 HRS.

(Prerequisite, PH 762 and MA 263.) A study of the magnetic field, electromagnetic induction, magnetic properties of matter, alternating current circuits, and Maxwell's equations. Three lecture periods per week. 4 73 763 0 4008--08

PH 770. RESEARCH PROBLEM IN PHYSICS 1-3 HRS.

(Prerequisite, consent of instructor.) Individual studies by advanced students in problems of special interest in physics.

4 73 770 4 4008--99

PH 775. MICROCOMPUTER SYSTEMS 3 HRS.

(Prerequisite, PH 550 or consent of instructor.) This course discusses microcomputers on the systems level. Detailed attention to the electronics which comprise the system will be limited to general familiarization for the student. The criteria for and design of micro-computer systems to accomplish educational, laboratory, or control and monitoring objectives are covered. The emphasis is on the integration of hardware, firmware, and software into a well balanced, easily expandable system which takes advantage of state-of-the-art capabilities of system hardware and software components.

4 73 775 0 4008--99

PH 780. INTRODUCTION TO SOLID STATE 3 HRS.

(Prerequisite, MA 161, PH 540 or PH 541 or consent of instructor.) A

course designed to introduce students to basic concepts in solid state. Topics to be considered include crystalline state, specific heats and lattice vibrations, dielectric and optical properties, conductivity, ferroelectrics, bond theory of solids, semiconductors, transistors, diamagnetism, paramagnetism, ferromagnetism, and resonance phenomena. 4 73 780 0 4008--08

PH 785. NUCLEAR PHYSICS **3 HRS.**
(Prerequisite, PH 541 or PH 540.) Primarily designed for students not planning on physics as a profession, and as a background course for the secondary science teacher, this course deals with modern concepts of the nucleus and the role of nuclear physics today. 4 73 785 0 4008--06

PH 790. THEORETICAL PHYSICS **3 HRS.**
(Prerequisite, PH 760 or consent of instructor.) Various mathematical tools in physics are studied. Infinite series, Fourier series, and many special functions are included. Emphasis is on the application of these ideas in physical theories. 4 73 790 0 4008--99

PH 795. INTRODUCTION TO QUANTUM MECHANICS **3 HRS.**
(Prerequisites, PH 540 or PH 541, and MA 263.) The fundamental concepts of quantum mechanics are developed and applied to problems. Techniques for solving problems in this field are emphasized that involve differential equations, matrix equations and approximation methods. 4 73 795 0 4008--99

PH 801. TRENDS IN HIGH SCHOOL PHYSICS CURRICULA **3 HRS.**
(Prerequisite, fifteen hours in physics and eight hours in chemistry and/or earth science.) Designed for in-service physical science teachers. A laboratory-oriented course stressing an understanding of the philosophies and concepts in new curricula and materials for physics teaching. 4 73 801 1 1313--16

PH 802. MODERN DEVELOPMENTS IN PHYSICS **3 HRS.**
(Prerequisite, fifteen hours in physics and eight hours in chemistry and/or earth science.) Designed for in-service physical science teachers. A study of recent advances in physics. 4 73 802 0 4008--99

PH 810. PLASMA PHYSICS **3 HRS.**
(Prerequisites, PH 763, PH 530 and PH 761, or consent of instructor.) The properties of very hot ionized gases are described as they apply to nuclear fusion energy, gaseous electronics, and space physics. 4 73 810 0 4008--05

PH 820. ASTROPHYSICS **3 HRS.**
(Prerequisites, PH 761, PH 763, and MA 335.) Study of the physics of the sun, planets, stars and galaxies. This includes the study of the motion of planets, the stellar atmosphere and interior, the evolution of stars and cosmology. 4 73 820 0 4008--99

PH 840. MATHEMATICAL PHYSICS **3 HRS.**
(Prerequisite, PH 760.) Advanced applications of mathematical techniques in physics are considered for graduate students. 4 73 840 0 4008--99

PH 845. TOPICS IN PHYSICS (*) **1-3 HRS.**
(Prerequisite, consent of instructor.) Study of specialized topics in physics is done at the graduate level. The topic is chosen by the student and the instructor. *The blank will be filled with an appropri-

ate short description on the student's transcript to indicate the subject area studied. 4 73 845 3 4008--99

PH 860. GRADUATE RESEARCH **1-5 HRS.**
(Prerequisite, consent of instructor.) Investigative research by graduate students with demonstrated ability. 4 73 860 4 4008--99

PH 890. THESIS M.S. **1-5 HRS.**
(Prerequisite, consent of instructor.) Required for the 30-hour degree, Master of Science with a major in physics. Research in an approved area of physics and the preparation of a thesis. 4 73 890 4 4008--99

PHYSICAL SCIENCE

PS 001. BASIC SKILLS FOR ENGINEERING **3 HRS.**
An introduction to basic skills required in engineering, specifically designed for students needing additional preparation in language usage and for those having deficiencies in mathematical or physical science concepts. Topics include algebra, trigonometry, vectors, dimensional analysis, chemical equations, molar concept, forces,

PS 341. PHYSICS FOR THE ELEMENTARY TEACHER **3 HRS.**
Areas of light, photography, energy, electricity, and motion are studied by way of discovery laboratory activities so that the student gains a maximum of confidence using a minimum of mathematics. Designed for elementary education majors desiring more background in science including those desiring an area of concentration in science. (Recommended for the science area of concentration after PS 115.) 4 72 341 1 1313--16

PS 386. INTERNSHIP: PHYSICAL SCIENCES **1-3 HRS.**
(Prerequisites, 12 hours in major field or consent of instructor.) An academic course to provide students with an opportunity to gain field experience in one of the physical sciences (chemistry, earth science, physics, pre-pharmacy or pre-engineering) through paid employment. The academic experience is developed jointly by the student and the faculty advisor. 4 72 386 2 4001--01

PS 430. NATURE OF SCIENCE **2 HRS.**
(Prerequisite, 20 hours of science.) A capstone course required of pre-service physical sciences teachers which considers the major conceptual frameworks of the physical sciences. The characteristics and development of modern scientific inquiry and model building/theory development are central themes of the course. The interactions of science, technology, and society are also considered. 4 72 430 0 4001--01

PS 500. TOPICS IN PHYSICAL SCIENCE (*) **5 HRS.**
(Prerequisite, consent of the chair of the department.) A special course for graduate students who have had a minimal background in physics, chemistry or the earth sciences but who need training in one of these fields. A student may be permitted to enroll in PS 500 more than once but will not be allowed to accumulate more than 6 hours credit. See the chair of the department for details. *The blank will be filled in with an appropriate short description on the student's transcript to indicate the subject area studied. 4 72 500 1 4001--01

PS 516. TEACHING PHYSICAL SCIENCES IN MIDDLE/HIGH SCHOOLS **3 HRS.**
(Prerequisite, at least fifteen credit hours in the Physical Sciences. For pre-service teachers of Physical Sciences.) Introduction to the

modes used to teach contemporary content in chemistry, earth/space science, physics, physical science or general science with emphasis on laboratory instruction and laboratory safety procedures. Teaching strategies, curricula, materials/resources to include instructional technology, evaluation, characteristics of students as they relate to physical science teaching are major topic areas. Students do micro-teaching. 4 72 516 0 1313--16

PS 517. PHYSICAL SCIENCE TECHNIQUES II 3 HRS.
(Prerequisite, at least twenty-one credit hours in the physical sciences. For pre-service or in-service teachers of physical science.) Mutually selected topics not treated in PS 516, determined by the needs of the individual to enhance teaching effectiveness. Individualized instruction, the laboratory, and independent study are utilized. 4 72 517 3 1313--16

PS 520. ENERGY IN TRANSITION 2-4 HRS.
(Prerequisite, consent of instructor.) An examination of personal and societal energy requirements, current sources of energy, and the environmental effects of various methods of energy production and

usage. Consideration of alternatives for present consumption trends, and options for sources of energy other than fossil fuels. Field trips will be utilized as appropriate. 4 72 520 0 4099--99

PS 768. WORKSHOP IN PHYSICAL SCIENCE TEACHING 1-5 HRS.
(Prerequisite, consent of instructor.) Lectures, demonstrations, discussions, and individual projects planned to increase the effectiveness of teaching science at the secondary level. Designed to develop the teacher's ability to better meet the needs of students in the physical sciences. 4 72 768 1 1313--16

PS 801. MODERN DEVELOPMENTS IN THE PHYSICAL SCIENCES 3 HRS.
(Prerequisite, consent of instructor.) Recent curriculum and instructional innovations in physical science education at the secondary level, designed as a refresher course for secondary school science teachers. 4 72 801 0 4001--01

PS 810. SEMINAR IN PHYSICAL SCIENCE 0-4 HRS.
(Prerequisite, consent of instructor.) Reports and discussion by students, staff and visiting lecturers. May include projects and project reports. 4 72 810 2 4001--01

PS 839. GRADUATE RESEARCH 1-5 HRS.
Independent study and research in an approved field in the physical sciences or science education. 4 72 839 4 4001--01

PS 875. THESIS, M.S. 1-5 HRS.
(Prerequisite, Graduate standing and consent of instructor.) Independent study and research in an approved field in the Physical Sciences. 4 72 875 4 4001--01
motion, and numerical computation. 4 72 001 0 1401--01

PS 100. INTRODUCTION TO ENGINEERING 2 HRS.
(Prerequisite, enrollment limited to pre-engineering students only.) An introduction to engineering concepts and design. Graphing, problem solving, metric units, engineering calculations, and computers are included. Problems involving the basic concepts of engineering science are considered. 4 72 100 0 1401--01

PS 110. PHYSICS FOR THE CITIZEN 3 HRS.
A general education course providing a brief foundation in physics

with a stress on everyday applications. The particular subjects considered are largely determined by the interests of the students in the class. Only very elementary mathematical concepts are used in the class. 4 72 110 1 4008--01

PS 115. OUR PHYSICAL WORLD 5 HRS.
A general education course exploring basic physical, chemical and geological concepts by means of student-oriented activities supported by laboratory work. The course is designed for elementary education majors. 4 72 115 1 4001--01

PS 200. INTRODUCTION TO ENGINEERING GRAPHICS 1-3 HRS.
(Prerequisites, MA 112, high school trigonometry or equivalent.) Technical sketching and lettering, the design process, orthographic projection, multiview drawings, pictorials, and reading and interpreting drawings. (6 hours lecture/laboratory time/week.) When the course is offered for 3 credit hours at the discretion of the Department, students would be required to complete an independent design project. 4 72 200 0 1401--01

PS 214. PHYSICAL SCIENCE 3 HRS.
(Prerequisite, concurrent with PS 215.) A general education course exploring the areas of astronomy, motion, energy, chemistry, and geology by way of student-oriented activities closely correlated with the laboratory work. A minimum of mathematics is used as the student examines the physical world. 4 72 214 0 4001--01

PS 215. PHYSICAL SCIENCE LAB 1 HR.
Laboratory to accompany PS 214. Weekly laboratory activities closely correlate with the class work. 4 72 215 1 4001--01

PS 218. DESCRIPTIVE ASTRONOMY 3 HRS.
A general education course with an historical and philosophical approach to various theories of planet Earth's position in the universe as a basis for man's ever-expanding and current concepts of the solar system, stars, and star arrangements. The Planetarium and observation sessions with the telescopes are integral aspects of the course. 4 72 218 1 4002--01

PS 330. EARTH SCIENCE FOR THE ELEMENTARY TEACHER 3 HRS.
(Prerequisite, for elementary education majors only.) A course designed to provide the prospective elementary teacher with the background necessary to teach the earth sciences in the elementary curriculum. Includes a study, with laboratory activity and field experiences, of the classical areas of the earth sciences: astronomy, geology, and meteorology. (Recommended as an elective for the science area of concentration after completion of another physical science course, such as PS 115 or PS 214.) 4 72 330 1 1313--16

