

# NATURAL SCIENCES

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The Department of Natural Sciences includes programs in biology, chemistry, physics and the health professions. Many Asbury science students go on to graduate programs or medical school. Asbury also has a long tradition of preparing students for service in medical missions.

Students receive personal attention in both introductory and upper division classes. The curriculum is challenging. The Department has well equipped labs for studies in anatomy, physiology, microbiology, analytical chemistry, biochemistry, organic chemistry and physical chemistry. All of our students conduct a senior research project, some at Asbury and others at research centers around the world.

## **Health Professions**

Medical, dental and veterinary schools do not require a science major, but a strong preparation in science is required. Most medical schools have a prescribed list of science courses applicants must take, including a year each of general and organic chemistry, biology and physics. Asbury students interested in medicine are assigned to the health professions advisor, who assists them in planning their schedule and meeting other admissions requirements.

## **Health Science (Nursing)**

Asbury College offers a major in Health Science which provides several options to Asbury students interested in pursuing a career in nursing.

1. Asbury College and University of Kentucky College of Nursing (UK-CON) offer dual degrees in Health Science and Nursing that can be completed in 5 years. Participating students will take a prescribed course of study at Asbury for 3 years, with nursing classes at UK-CON (in Lexington) beginning in year 3. Students who successfully complete this program will earn a Bachelor of Arts in Health Science from Asbury and a Bachelors of Science in Nursing from University of Kentucky.
2. Students in the Health Science major may take a prescribed course of study for three years at Asbury College, and then transfer to a school of nursing of their choice. Professional nursing courses taken at the school of nursing during the first

year transfer back to Asbury College to complete the Bachelor of Arts in Health Science from Asbury.

3. Students have the option of transferring to a nursing school offering a Bachelor of Science in nursing, or to a school offering an entry level Master of Science degree in nursing.

4. A student who decides not to pursue nursing at the end of three years may complete a B.A. degree in psychology by taking the appropriate courses during the fourth year at Asbury College.

5. A student may also transfer to any accredited School of Nursing after completing the first two years of the Health Science major. The University of Kentucky College of Nursing, for example, has agreed to accept (according to enrollment limitations) any second year Asbury College pre-nursing student who has completed the required courses and has a grade point average of 3.0 or higher. This option does not provide for a degree from Asbury College.

### **Biology Programs**

A degree in biology prepares students for entry level work in the life sciences, medical school, or graduate programs such as anatomy, physiology, genetics, microbiology or plant sciences.

Students interested in Environmental Science take an introductory environmental science course at Asbury and then choose 7 credits of elective coursework offered during the summer at the AuSable Institute in Michigan. AuSable is a cooperative CCCU program described in the Special Programs portion of the Bulletin. Students can also receive credit for approved field experiences abroad.

### **Chemistry Programs**

The most popular chemistry program at Asbury is Biochemistry. A biochemistry major includes basic and intermediate courses in chemistry and upper level work in the chemistry of DNA, proteins and other molecules important to cellular structure and function. The job market in biochemistry is steadily growing.

A traditional chemistry major prepares students for entry level work or for graduate programs. Most graduate programs in chemistry provide full scholarships.

### **Science Education Programs**

Asbury is well known for the quality of its education programs, and science teachers are in demand. The natural science department offers majors leading to grades 8-12 certification in either Biology or Chemistry.

Students interested in middle school certification choose two emphasis areas (minors), one of which can be Science.

### **BIOCHEMISTRY (72 hour major + general education + electives)**

BIO 161, 162, 163, 164, 232/234, 352, 322 or 379; BIO 341, BIO/CHE 372, 399, 400, 475; CHE 121, 122, 201, 202, 321, 322, 371, 421 or 422; MAT 181, 182; PHY 201, 202.

**BIOLOGICAL SCIENCE GRADES 8-12** (86-90 hour major + general education + electives)

BIO 161, 162, 163, 164, 217/219 or 221/225, 272, 322, 211/213 or 331/333, 341, 399, 400, plus 5 hours from 211/213, 232/234, 242, 262, 302, 331/333, 352, 372, 380; CHE 121, 122; ED 200, 210, 220, 240, 320, 385, 405, 410, 420, 470; ESC 202; one of: Math ACT/SAT > 24/580, MAT 111, 112, 131, or 181; PHY 201

**BIOLOGY** (63-65 hour major + general education + electives)

BIO 161, 162, 163, 164, 217/219 or 221/225, 272 or 242, 341, 352, 399, 400, 475; one of 322, 372, and one of 211/213, 331/333, 379 or 7 hours from courses offered by the AuSable Institute; CHE 121, 122, 201, 202; PSY 315; MAT 181; PHY 201, 202.

**CHEMISTRY** (57-65 hour major + general education + electives)

BIO 341; CHE 121, 122, 201, 202, 321, 322, 421, 422, 475; CHE 371 or 372; MAT 181, 182; PHY 201, 202 or 211, 212.

Standard track: CHE 399, 400

American Chemical Society certification track: CHE 382, 435, MAT 252

**CHEMISTRY GRADES 8-12** (94 hour major + general education + electives)

BIO 161, 163, 341; CHE 121, 122, 201, 202, 321, 371 or 372, 399, 400, 421 or 422; ED 200, 210, 220, 240, 320, 385, 405, 410, 420, 470; ESC 202; MAT 181, 182; PHY 201, 202.

**HEALTH SCIENCE** (65-66 hour major + general education + electives)

Program Restrictions

In order to receive an Asbury College degree under “transfer-out” nursing major:

1. Students must complete three (3) years at Asbury College.
2. Students may transfer into Asbury College no more than 16 semester hours (on the front end). No more than four of these 16 hours may be credits required for the health science major.
3. Students must transfer 30 semester hours of nursing back to Asbury College from an accredited four-year school of nursing.

BIO 211/213, 252, 262, 331; CHE 115; MAT 111 or 181; PSY 100, 300, 302; PSY 315 or MAT 232; SOC 100; 30 credits transferred from an accredited four-year school of nursing.

**BIOLOGY** (24 hour minor)

BIO 161/163, 162/164, 217/219 or 221/225, plus 8 hours of BIO 200 or above and 4 hours of BIO 300 or above.

**CHEMISTRY** (23-24 hour minor)

CHE 121, 122, 201, 202, 321; one of CHE 322, 371, 372, or 421.

**PHYSICS** (30-32 hour minor)

MAT 181, 182, 252; PHY 211, 212, 311, 314, 382, one of CHE 421 or MAT 351 or PHY 400.

## **BIOLOGY COURSES**

**BIO 100 (3) Biological Science**—Specifically designed, in conjunction with BIO 101, to satisfy the biological lab science general education requirement for non-science majors. Emphasis is placed on the nature, methodology, and limitations of biological scientific investigation, as well as on selected topics relevant to humans, including cell biology, genetics, evolution, and ecology. Corequisite: BIO 101.

**BIO 101 (1) Biological Science Lab**—In conjunction with BIO 100, satisfies the biological lab science general education requirement for non-science majors. Emphasis is placed on using the methodologies of science for problem solving, and on distinguishing among pure, applied, and technological aspects of biological science. Specific labs highlight concepts presented in BIO 100 and cover cell biology, genetics, evolution, and ecology. Three-hour lab per week. Corequisite: BIO 100. Fee.

**BIO 161 (3) General Biology I**—First course in a one-year sequence designed to be taken by students majoring or minoring in biology or biochemistry. Included is coverage of cell biology, ecology, genetics, and evolution. Philosophy and methodology of science will also be treated from a Christian point of view. High school biology and chemistry are assumed. BIO 161/163 satisfies the general education requirement for a biological laboratory science. Three hours lecture per week. Corequisite: BIO 163.

**BIO 163 (1) General Biology Lab I**—In conjunction with BIO 161, satisfies the general education requirement for a biological laboratory science. Emphasis is placed on using the methodologies and tools of science. Developing computer and research report writing skills are integral to the course. Subject matter parallels BIO 161 and includes labs on ecology, cell biology, genetics, and evolution. Three-hour lab per week. Corequisite: BIO 161. Fee.

**BIO 162 (3) General Biology II**—Second course in a one-year sequence designed for students majoring or minoring in biology or biochemistry. Emphasizes biological classification and organismal biology, including a survey of plant and animal organ systems. Three hours lecture per week. Corequisite: BIO 164.

**BIO 164 (1) General Biology Lab II**—Includes laboratory exercises that correspond to the content of BIO 162. A variety of laboratory techniques, including microscopic observation, dissection, and computer data analysis will be used to investigate the biological systems of organisms within the five kingdoms of classification. Three-hour lab per week. Corequisite: BIO 162. Fee.

**BIO 211 (3) Microbiology**—A comprehensive study of the microbial worlds. Bacterial structure, reproduction, and growth are described. Emphasis is placed on microbial-related disease processes, microbial control and identification of common and medically-important bacteria and parasites. Also includes discussion of microbial genetics and virus replication. In conjunction with BIO 213, satisfies the general education requirement for a biological laboratory science. Three hours lecture per week. Corequisite: BIO 213.

**BIO 213 (1) Microbiology Lab**—Introduces students to the basic microbiological techniques used in the laboratory for the isolation, growth and/or identification of medically important bacteria, fungi and parasites. Special emphasis is placed on identifying "unknown" microbes, utilizing various morphological and biochemical tests. Experimental data is obtained to study the effects of selected physical and chemical factors on bacterial growth. Two 75-minute labs per week. Corequisite: BIO 211. Fee.

**BIO 217 (3) Environmental Science**--Provides a sound foundation in basic principles and unifying concepts of environmental science. Current environmental issues are also covered, with emphasis on the ecological, economic, and human health impacts of air and water pollution, global climate change, ozone depletion, acid rain, hazardous and solid waste, alternative energy resources, soils, deforestation, overfishing, biodiversity, and endangered species. Intended both for biology majors and non-biology majors. Three hours lecture per week. Corequisite: BIO 227.

**BIO 219 (1) Environmental Science Lab**--Applies ecological principles to current environmental problems using experimental and statistical analysis techniques. Exercises are carried out in the lab and in the field. Topics include energy production, consumption, and conservation, soil, air, and water quality testing, and human impacts on plant and animal populations. Three-hour lab per week. Corequisite: BIO 225. Fee.

**BIO 221 (3) Ecology**--Presents the theoretical basis for modern ecology: laws of thermodynamics, population dynamics, evolutionary adaptation, the earth's weather machine, physiological ecology, marine ecology, and nutrient cycling. Three hours lecture per week. Prerequisites: BIO 161/163, BIO 162/164. Corequisite: BIO 223.

**BIO 225 (1) Ecology Lab**--Provides practical learning experiences in major ecological principles. Exercises are conducted both in the field and the laboratory. Topics include population dynamics, community structure and dynamics, biodiversity, soils, and behavior. Collection and evaluation of data are important components of the course. Three hour lab per week. Corequisite: BIO 221. Fee.

**BIO 232 (3) Plant Physiology**—Emphasizes how physiological processes in plants can be explained by the laws of physics and chemistry. Special attention given to processes unique to plants (such as photosynthesis) and how physiological processes lead to increased adaptation. Three hours lecture per week. Prerequisites: BIO 161, 162; chemistry recommended. Corequisite: BIO 234. (alternate years)

**BIO 234 (1) Plant Physiology Lab**—Emphasis is placed on plant biotechnology. Other focuses include water potential, freezing point depression, seed germination, enzyme activity, and effect of light. Three-hour lab per week. Corequisite: BIO 232. Fee.

**BIO 242 (4) Plant Taxonomy**—In a world where there is a growing emphasis on environmental biology, it becomes increasingly necessary to know something about the major groups of plants. Plant phylogeny, major plant families, and modern taxonomic methods are emphasized in lectures. In the laboratory, field identification is stressed, with the greatest emphasis being placed on the use of keys for identifying herbaceous flowering plants. Three hours lecture and three hours lab per week. Prerequisite: One course in BIO. Fee. (alternate years)

**BIO 252 (3) Nutrition**—The basic principles of human nutrition are studied and then applied to the nutritional needs of humans at the various stages of the life cycle. The chemical and physiological approach is emphasized. (alternate years)

**BIO 262 (3) Human Physiology**—The functions of the human body tissues, organs and organ systems are studied. Specifically designed for pre-nursing, pre-physical therapy, and pre-physician assistant students.

**BIO 272 (4) General Botany**—Introduction to plant biology. Topics include plant structure and physiology, development, classification, diversity, and the roles plants play in ecological systems. The different ways humans depend on, and impact, plants in our changing world are also discussed. Three hours of lecture and three hours of lab per week. Prerequisite: BIO 162/164. Fee.

**BIO 302 (2) Modern Science and Religious Thought**—Theories relevant to the origin of the universe, life, species, and humans are studied with reference to the Genesis account of creation. (on occasion)

**BIO 322 (3) Genetics**—A basic knowledge of Mendelian genetics is assumed. Traditional topics such as Mendelian genetics, meiosis, cytogenetics and population genetics are covered. Emphasis is also placed on modern molecular genetics including DNA organization, protein synthesis, gene control and recombinant DNA technology. Prerequisites: BIO 161 and 162. (alternate years)

**BIO 331 (3) Human Anatomy**—A comprehensive study of mammalian anatomy approached through a detailed examination of the organ systems of the human body. Designed for science majors and required for pre-nursing students.

**BIO 333 (1) Human Anatomy Lab**—A laboratory approach to the study of mammalian anatomy, including a detailed dissection of *Felis domesticus*. This lab is a corequisite for BIO 331, except for some pre-nursing students. Three-hour lab per week. Fee.

**BIO 341 (2) Ethical Issues**—Designed to help the students explore, from a biblical perspective, ethical issues involved in the practice and application of science. Prerequisite: Sophomore status.

**BIO 352 (4) Physiology**—First half focuses upon the cellular and ionic basis of nerve and muscle function followed by a detailed examination of the physiology of the heart and circulation. The remaining organ systems are each examined briefly in the second half with the major emphasis being the study of higher nervous function. Seeks to develop the student's conceptual and quantitative skills and to prepare the student to understand the nature and potential consequences of common diseases. Prerequisites: One year chemistry and physics; one semester calculus recommended, but not required. Three hours of lecture and three hours lab per week. Fee.

**BIO 361 (3) Histology**—The microscopic study of basic animal tissue, including structural and functional relationships on the organ level. Two hours of lecture, 3 hours lab per week. Prerequisite: BIO 161. Fee. (on occasion)

**BIO 372 (4) Cell and Molecular Biology**—An introduction to the regulation of cellular structure and function at the molecular level with an emphasis on the study of enzymes and nucleic acids. Three hours of lecture and three hours lab per week. Prerequisites: BIO 161, 162, CHE 121, 122, 201, and 202. (CHE 202 may be taken as a corequisite). Fee.

**BIO 379 (3) Immunology**—An introduction to the biology and chemistry of the immune system. Includes discussion of antigen/antibody reactions, antibody synthesis, humoral and cell-mediated immunity, tolerance, the role of the immune system in disease related processes, and immuno-assay procedures. Includes several laboratory exercises. (alternate years)

**BIO 380 (3) Scientific and Medical Terminology**—Designed to provide science and preprofessional health majors with a basic knowledge of the linguistic principles inherent in the specialized vocabulary of medical science.

**BIO 391 (1-3) Independent Study**—Offered by consent by supervising instructor in the biology department. A topic is established by negotiations with the instructor. A student may not take more than 6 hours. Contract.

**BIO 393 (1-4) Seminar**—Discussion of selected topics. May be offered in conjunction with other departments or as a separate course primarily for biology students. (on occasion)

**BIO 399 (1) Introduction to Biological Research**—A practical experience which introduces the student to the methods of biological research and writing. The topic for an independent research project (for BIO 400) is chosen; a literature search is initiated; and essential laboratory techniques pertinent to the project are mastered. Prerequisite: Junior standing and a minimum of 12 hours each of biology and chemistry.

**BIO 400 (1-2) Senior Research in Biology**—Required of all biology majors. Students will, under faculty supervision, independently design and carry to completion an independent, scientific research project of a biological nature. A senior research paper must be written at the completion of the project. Students must earn a total of at least 2 credits but may take 1 credit per semester in their senior year. Prerequisite: Senior standing and completion of BIO 399. Contract

**BIO 475 (1) Senior Seminar**—Designed to provide practical experience in the oral presentation of a scientific paper. Students will prepare and present a seminar on their research projects (BIO 400). Prerequisites: Senior standing and BIO 400.

## **CHEMISTRY COURSES**

**CHE 111 (4) Introductory Chemistry**—Introduction to chemistry for non-science majors and pre-nursing majors. Basic theory, principles, and problems of inorganic chemistry are covered, including scientific measurement, atomic structure, bonding and molecular structure, chemical reactions and stoichiometry, equilibrium, acid-base theory, and nuclear chemistry. Satisfies the general education requirement for a physical laboratory science. Prerequisite: completion of MAT 100 is required by the end of the first semester. Three hours of lecture and one 3-hour lab per week. Fee.

**CHE 115 (4) Chemistry For The Health Sciences**--Basic concepts of general, organic, and biological chemistry. Topics include electronic structure of atoms and molecules, periodicity of the elements, stoichiometry, states of matter, kinetics, equilibria, acids and bases, organic functional groups, stereochemistry, carbohydrates, lipids, proteins, and enzymes. Topics are presented with an emphasis on application to the allied health professions. Prerequisite: high school algebra or MAT 111. Three hours lecture and one 3-hour lab per week. Fee.

**CHE 121, 122 (4 each) General College Chemistry**—For Chemistry majors and minors, pre-medical, and medical technology students. Basic theory, principles and problems of inorganic chemistry, covering stoichiometry, atomic and molecular structure, reactions in solution, properties of gases, liquids and solids, thermodynamics, chemical equilibria, kinetics, electrochemistry, and the descriptive chemistry of main group elements. Includes introduction to organic and nuclear chemistry. This course satisfies the general education requirement for a physical laboratory science. Prerequisite: MAT 100. Three hours of lecture and one 3-hour lab per/week. Fee.

**CHE 201, 202 (4 each) Organic Chemistry**—An introduction to the study of organic compounds. The structure, nomenclature, synthesis and reactions of the major classes of organic compounds are studied, along with the major themes of reaction mechanisms and spectroscopic methods of identification. This course satisfies the general education requirement for a physical laboratory science. Prerequisite: CHE 122 or permission. Three hours lecture and 3-hour lab/week. Fee.

**CHE 321 (4) Analytical Chemistry**—Basic principles, theory, and practice of quantitative analysis, including standard, traditional methods of analysis and instrumental methods of analysis. Three hours of lecture and one 4-hour lab/week. Prerequisite: CHE 122. Fee.

**CHE 322 (3) Chemical Instrumentation**—Modern theory and techniques of instrumental analysis, covering potentiometry, spectroscopy and chromatography. Two hours of lecture and one 3-hour lab/week. Prerequisite: CHE 321 or permission. Fee. (alternate years)

**CHE 371 (4) Biochemistry**—An introduction to cellular chemistry. Includes protein structure and enzyme function, carbohydrate, lipid and amino acid metabolism, nucleic acid synthesis and function and genetic engineering. Three hours of lecture and three hours of lab per week. Prerequisite: CHE 202 or permission. Fee. (alternate years)

**CHE 372 (4) Cell and Molecular Biology**-An introduction to the regulation of cellular structure and function at the molecular level with an emphasis on the study of enzymes and nucleic acids. Three hours of lecture and three hours lab per week. Prerequisites: BIO 161, 162, CHE 121, 122, 201, and 202. (CHE 202 may be taken as a corequisite). Fee.

**CHE 382 (3) Inorganic Chemistry**—Covers the following areas: 1. Theories of chemical bonding, including molecular orbital theory. 2. Symmetry and group theory, and its application to bonding. 3. Advanced topics in acid-base chemistry. 4. Survey of main group chemistry. 5. Coordination chemistry of the transition metals, including structures, bonding, spectra, and reaction mechanisms. 6.

Organometallic chemistry. 7. Bioinorganic chemistry. Prerequisites: CHE 121, 122, 201, 202. (alternate years)

**CHE 391 (1-3) Independent Study**—Offered by consent by supervising instructor in the Chemistry Department. A topic is established by negotiations with the instructor. A student may not take more than 6 hours. Contract.

**CHE 393 (1) Seminar**—Discussion of selected topics. May be offered in conduction with other departments or as a separate course primarily for Chemistry students.

**CHE 399 (1) Introduction to Chemical Research**—A practical experience which introduces the student to the methods of chemical research and writing. The topic for an independent research project (CHE 400) is chosen and the literature search is initiated. Prerequisite: Junior standing and a minimum of 12 hours of chemistry.

**CHE 400 (1-2) Senior Research in Chemistry**—Required of all chemistry majors. Biochemistry majors take BIO 400 or CHE 400. Students will, under faculty supervision, design and carry to completion an independent scientific research project of a chemical nature. A senior research paper must be written at the completion of the project. Students must earn a total of 2 credits but may take 1 credit per semester in their senior year. Prerequisite: Senior standing and completion of CHE 399. Contract.

**CHE 421, 422 (4 each) Physical Chemistry**—The first course (421) focuses on chemical thermodynamics and includes the study of gas behavior, the laws of thermodynamics, enthalpy, entropy, free energy, phase and chemical equilibria. The second course (422) covers quantum mechanics, spectroscopy, and chemical kinetics. Two hours of lecture, one hour of problem solving, and one 3-hour lab/week. Prerequisite or corequisite: PHY 201, 202 or 211, 212; MAT 181 (also MAT 182 for CHE 422). Fee. (alternate years for CHE 422)

**CHE 435 (3) Internship**—A summer undergraduate research experience of at least 6 weeks culminating in a paper on the research. The research may take place at Asbury or at another institution. Contract.

**CHE 475 (1) Senior Seminar**—Designed to provide practical experience in the oral presentation of a scientific paper. Students will prepare and present a seminar on their research projects (CHE 400). Prerequisites: CHE 400 and senior standing.

## **EARTH SCIENCE COURSES**

**ESC 202 (4) Earth Science**—An examination of planet Earth, including its interior and exterior structure (geology and oceanography), its atmosphere and weather (meteorology), and its place in the heavens (astronomy). This course satisfies the

general education requirement for a physical laboratory science. Three hours lecture and one 3-hour lab/week. Fee.

**ESC 391A (2) Directed Study in Geology**—This course extends, and develops in detail, the concepts introduced in ESC 202. Topics include mineral and rock cycles, landforms, glacial and volcanic activity, plate tectonics, earth history, and climatology. Prerequisites: ESC 202 and permission of instructor.

**ESC 391B (2) Directed Study in Astronomy**—This course extends, and develops in detail, the concepts introduced in ESC 202. Topics include constellations and major stars, orbital motion, objects in the solar system, spectroscopy, the structure and classification of stars, galaxies, and cosmology. Prerequisites: ESC 202 and permission of instructor.

## **HEALTH PROFESSIONS COURSES**

**PHP 209 (1) Introduction to the Health Professions**—An introduction to the various health care professions and topics of current interest in health care using a seminar format. Half the course focuses on situational biomedical ethics. Credit/No credit. Prerequisites: sophomore standing or pre-registration with Health Professions Advisor. (on occasion)

**PHP 302 (1) MCAT Preparation**—Devoted to assisting the premedical student prepare for the MCAT exam and to outlining the procedure for applying to medical school. Credit/No Credit.

**PHP 435 (1) Internship**—Spending a minimum of forty hours with one of the health care professions provides an opportunity for the student to observe one of the health-care professions first hand. The student is responsible for the initial contact with the professional with whom he or she wishes to work. Credit/No credit. Contract.

## **PHYSICS COURSES**

**PHY 201, 202 (4 each) Introductory Physics**—An introductory course in physics designed for Chemistry and Biology majors. Concepts from calculus will be used to explain various equations. Topics covered include mechanics of solids and fluids, heat, wave motion, electricity, magnetism and modern physics. This course satisfies the general education requirement for a physical laboratory science. Prerequisite: MAT 181 or MAT 132 or equivalent. Three hours lecture and one 3-hour lab/week. Fee.

**PHY 211, 212 (5 each) General Physics**—A calculus-based introductory course in physics designed for mathematics and engineering majors. Topics covered include mechanics of solids and fluids, heat, wave motion, electricity, magnetism and

modern physics. This course satisfies the general education requirement for a physical laboratory science. Prerequisite: MAT 181, 182. Three hours lecture, one and one-half hours recitation, and one 3-hour lab/week. Fee. (alternate years)

**PHY 311 (3) Modern Physics**—This course covers the quantum mechanics of simple systems, atoms, and molecules; and atomic and molecular spectroscopy, including electronic, vibrational, and rotational spectroscopy. Three hours of lecture and one 3-hour lab per week. The course runs for 2/3 to 3/4 of the semester and is intended to be followed by PHY 314. Prerequisite: PHY 211 and 212; MAT 181 and 182. Fee. Alternate years.

**PHY 314 (1) Relativity**—This course studies the foundations of special relativity. It emphasizes problem solving as a means to give students an understanding and an intuition of space-time. In addition, the course presents a modest introduction to General Relativity. Because of the importance of differential geometry in modern theories of dynamics, it includes the basics of differential forms and their application to electricity and magnetism.

**PHY 382 (3) Analytical Vector Mechanics** —Vector treatment of the statics and dynamics of particles and rigid bodies including Lagrangian mechanics. Prerequisites: MAT 252; PHY 211, 212 (alternate years)

**PHY 393 (1) Seminar**-Discussion of selected topics. May be offered in conjunction with other departments or as a separate course. (on occasion)

**PHY 400 (1-2 hours) Special Problems in Physics**—Independent research in student's preferred area of physics. Prerequisites: 6 hours or more of upper division physics. Not more than 6 hours may apply toward graduation. Fee.