

# CHEMISTRY AND PHYSICS

*Head of the Department:* Professor McCarthy

*Professors:* Munchausen

*Associate Professors:* Blanchard, Doughty, Elbers, Norwood, Parkinson

*Assistant Professors:* Allain, Belter, Dolliver, Howard, Kruse, Malozovsky, Temple, Weaver, Yoshida

*Instructors:* Allen, Ladogana, Moore, Thomson

Corresponding lecture and laboratory courses numbered below 400 must be scheduled concurrently unless prior credit has been received for either the lecture or the laboratory.

Credit toward the degree will not be granted for corresponding lecture and laboratory courses numbered below 400 until both lecture and laboratory courses have been successfully completed unless permission to do otherwise has been obtained from the Department Head. Such permission will be granted only in unusual circumstances.

Students who violate the laboratory safety policy of the Department are subject to dismissal from the laboratory and withdrawal from the course.

Credit toward the degree will be granted for only one of the Chemistry courses in each of the following combinations: 101-106-109-121, 102-122, 103-123, 104-124, 261-265, 263-267, 281-481, 283-485.

Credit toward the degree will be granted for only one of the Physics courses in each of the following combinations: 142-191-221, 192-222, 193-223, 194-224.

## CHEMISTRY (CHEM & CLAB)

**101. General Chemistry.** Credit 3 hours. Prerequisites: An Enhanced ACT standard score in Mathematics of 18 or greater or completion of or registration for Mathematics 160 or 161. A course in the fundamentals of chemistry designed primarily for students in Nursing and applied sciences. This course is not recommended for students whose curricula require Chemistry 251, 253, 254 and courses numbered above 300.

**102. General Chemistry.** Credit 3 hours. Prerequisite: Chemistry 101. A continuation of Chemistry 101. General inorganic chemistry with selected topics in organic chemistry. This course is not recommended for students whose curricula require Chemistry 251, 253, 254 and courses numbered above 300.

**103. General Chemistry Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Chemistry 101. A series of laboratory experiments designed to illustrate the material studied in Chemistry 101 and give the student an introduction to the experimental techniques of chemistry. Two hours of laboratory a week. Laboratory fee: \$18.00.

**104. General Chemistry Laboratory.** Credit 1 hour. Prerequisites: Completion of Chemistry Lab 103 and registration for or prior credit for Chemistry 102. A continuation of Chemistry 103. Two hours of laboratory a week. Laboratory fee: \$18.00.

**105.<sup>1</sup> Forensic Science.** Credit 4 hours. Scientific aspects of law enforcement; role and functions of the crime laboratory. This course may not be used to satisfy the General Education sequence requirement in the Natural Sciences. Course consists of four hours of lecture and demonstrations a week.

**106.<sup>1</sup> Chemistry for the Consumer.** Credit 4 hours. A survey course in the cultural and applied aspects of chemistry designed primarily for students majoring in the Colleges of Business, Education, and the humanities portion of the College of Arts and Sciences. This course may not be used to satisfy the General Education sequence requirement in the Natural Sciences. Course consists of four hours of lecture and demonstrations a week.

**109. Chemistry for Non-Science Majors.** Credit 3 hours. A survey course in the cultural and applied aspects of chemistry designed primarily for students majoring in a non-science degree. This one-semester course may be used to satisfy the General Education requirement in the Natural Sciences but not the General Education sequence requirement. Course consists of three hours of lecture and demonstrations per week.

**121. Inorganic Chemistry.** Credit 3 hours. Prerequisites: Enhanced standard Act Math score of 21 or completion of Math 161 or Math 165. A course in general chemistry required of all chemistry and physics majors and other technical students whose curricula require chemistry above the introductory level.

**122. Inorganic Chemistry.** Credit 3 hours. Prerequisite: Chemistry 121. A continuation of Chemistry 121 required of all chemistry and physics majors and other technical students whose curricula require chemistry above the introductory level.

**123. Inorganic Chemistry Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Chemistry 121. A series of laboratory experiments designed to illustrate the material studied in Chemistry 121 and to introduce the student to the experimental techniques of chemistry. Three hours of laboratory a week. Laboratory fee: \$18.00.

**124. Inorganic Chemistry Laboratory.** Credit 1 hour. Prerequisites: Completion of Chemistry Lab 123 and registration for or prior credit for Chemistry 122. A continuation of Chemistry Lab 123. Three hours of laboratory a week. Laboratory fee: \$18.00.

**150. Chemical Information Sources.** Credit 2 hours. Prerequisite: Must be taken concurrently with either CHEM 121, 122, 251, or 265. Designed to enable chemistry majors to efficiently retrieve, organize, evaluate, and utilize information from traditional and emerging information sources. Includes instruction in the use of on-line databases. Two hours of lecture per week.

**251. Analytical Chemistry.** Credit 3 hours. Prerequisites: Chemistry 122-124. The study of chemical equilibria and stoichiometry as applied to qualitative and quantitative analysis.

**253. Inorganic Solution Chemistry.** Credit 2 hours. Prerequisite: Chemistry 122-124. A laboratory course emphasizing the solution chemistry of inorganic cations and anions. Studies of buffers and Beer's law are done as well as standard analysis of solution and solid unknowns. Separations based on precipitation, oxidation, reduction and complexation are emphasized using the chemistry of inorganic compounds. Six hours of laboratory per week. Laboratory fee: \$18.00.

<sup>1</sup>May not be used as credit toward a major or minor in Chemistry and may not be used to fulfill prerequisites for any other chemistry course.

**254. Quantitative Analysis Laboratory.** Credit 2 hours. Prerequisites: Chemistry 122-124 and registration for or prior credit for Chemistry 251. A laboratory course emphasizing the quantitative analysis of common minerals and ores using volumetric, gravimetric, and elementary instrumental procedures. Six hours of laboratory a week. Laboratory fee: \$18.00.

**261. Survey of Organic Chemistry.** Credit 3 hours. Prerequisites: Chemistry 102 or 122. An introduction to the nomenclature, preparation, properties, and reactions of organic compounds, with attention to biological significance. This course is designed for students in Biological and Applied Sciences who are required to take only one semester of organic chemistry.

**263. Survey of Organic Chemistry Laboratory.** Credit 1 hour. Prerequisites: Chemistry 102-104 or Chemistry 122-124 and registration for or prior credit for Chemistry 261. Designed to acquaint the student with some of the important laboratory operations and techniques in organic chemistry. Two hours of laboratory a week. Laboratory fee: \$18.00.

**265. General Organic Chemistry.** Credit 3 hours. Prerequisites: Chemistry 122. A study of the compounds of carbon, including representative groups and topics in stereochemistry. A course designed for students in biological sciences, chemistry, and pre-professional curricula.

**266. General Organic Chemistry.** Credit 3 hours. Prerequisite: Chemistry 265. A continuation of Chemistry 265 including the study of carbon compounds containing carbonyl, carboxylic acid, amine, and pheno functional groups. A course designed for students in biological sciences, chemistry and pre-professional curricula.

**267. General Organic Chemistry Laboratory.** Credit 1 hour. Prerequisites: Chemistry 124 and registration for or prior credit for Chemistry 265. A course designed to acquaint the student with some of the more important laboratory operations and techniques in organic chemistry including an introduction to spectroscopy. A course designed for students in biological sciences, chemistry, and pre-professional curricula. Three hours of laboratory a week. Laboratory fee: \$18.00.

**268. General Organic Chemistry Laboratory.** Credit 1 hour. Prerequisites: Chemistry 267 and registration for or prior credit for Chemistry 266. A continuation of Chemistry 267. Designed to acquaint the student with important laboratory operations in organic chemistry with special emphasis on reactions and synthesis. A course for students in biological sciences, chemistry, and pre-professional curricula. Three hours of laboratory a week. Laboratory fee: \$18.00.

**281. Survey of Biochemistry.** Credit 3 hours. Prerequisites: Chemistry 261 or 266. A general study of the intermediary metabolism of carbohydrates, fats, and proteins with emphasis on foods. A course designed for students in Applied Sciences and Science Education. This course may not be used for a major or minor in chemistry.

**283. Survey of Biochemistry Laboratory.** Credit 1 hour. Prerequisites: Prior credit for CHEM 263 and registration for or prior credit for CHEM 281. A laboratory to accompany Chemistry 281. Two hours of laboratory a week. Laboratory fee: \$18.00.

**290. Survey of Physical Chemistry.** Credit 3 hours. Prerequisites: Chemistry 122-124, Physics 192-194, and Mathematics 163 or 200. An introduction to the structure and physical states (gaseous, liquid, and solid) of matter, properties of solutions, electrochemistry, kinetics, and chemical thermodynamics.

**306. Special Topics in Science Education.** Credit 1-3 hours per semester. Prerequisites: Students must be education majors or elementary/secondary school teachers who have completed Chemistry 261-263 or have permission of the Department Head. Chemistry 251-254 are strongly recommended. A reading course with topics and credit to be decided by agreement between the department and student. This course may be repeated for credit if different topics are studied.

**335.<sup>1</sup> Chemistry Education Laboratory.** Credit 3 hours. Prerequisite: Students must be science education majors who have completed Chemistry 261-263 or by consent of the Department Head. Chemistry 251-254 are strongly recommended. Experiments will be presented and performed that illustrate the theories of chemistry and that can be used as demonstrations. Theory will be presented and used in conjunction with experiments. Six hours of laboratory per week. Laboratory fee: \$18.00.

<sup>1</sup>May not be used as credit toward a major or minor in Chemistry and may not be used to fulfill prerequisites for any other chemistry course.

**391[397]. Physical Chemistry Laboratory I.** Credit 1 hour. Prerequisites: Chemistry 251-254 and Physics 221 and registration for or prior credit for Chemistry 395. Quantitative physical chemistry measurements, design and construction of apparatus and interpretation of data. Three hours of laboratory a week. Laboratory fee: \$18.00.

**392[398]. Physical Chemistry Laboratory II.** Credit 1 hour. Prerequisites: Chemistry 395, Chemistry Lab 391, and registration for or prior credit for Chemistry 396. A continuation of Chemistry Lab 391. Three hours of laboratory a week. Laboratory fee: \$18.00.

**395. Physical Chemistry I.** Credit 3 hours. Prerequisites: Chemistry 122-124 and Physics 221. A quantitative study of physical chemistry emphasizing gas laws and kinetic theory of gases, thermodynamics of the gaseous and liquid state, chemical and phase equilibria.

**396. Physical Chemistry II.** Credit 3 hours. Prerequisite: Chemistry 395. A continuation of Chemistry 395. A study of chemical kinetics, statistical thermodynamics, and atomic and molecular structure.

**401/502. Chemistry Seminar.** Credit 1 hour. Prerequisite: Senior standing in the Chemistry curriculum or permission of the Department Head. Attendance at departmental seminars, panel discussions, and related professional events and individual presentation of a topic of current research interest.

**404/504. Special Topics in Chemistry.** Credit 1-3 hours per semester. A reading course with topics and credit to be decided by agreement between the Department and student. This course may be repeated for a maximum of 9 credit hours if different topics are studied.

**410/510. Chemical Literature.** Credit 1 hour. Prerequisites: Chemistry 251, 265, and 395 or permission of the Department Head. Familiarization with and review of the chemical literature. Designed to serve as preparation for Chemistry 411.

**411/511. Chemical Research.** Credit 1-4 hours per semester. Maximum credit four hours. Prerequisites: Chemistry 395 and Junior standing in the chemistry curriculum and consent of the faculty mentor and Department Head. Three clock hours per credit hour. Laboratory fee: \$18.00.

**452/552. Modern Instrumental Analysis.** Credit 3 hours. Prerequisites: Chemistry 251, 254, 266, and 396. A course designed to study instruments used in modern chemical analysis, focusing on instrument design, origin and quality of signal, methods of detection, spectral interpretation, and computer integration.

**453/553. Instrumental Analysis Laboratory.** Credit 2 hours. Prerequisites: Chemistry Lab 254, CHEM 266, Chemistry Lab 268 and concurrent enrollment or prior credit for CHEM 396/596 and CHEM 452/552. Experiments designed to demonstrate current analytical instrumental methods including spectroscopy, chromatography, and electroanalytical methods. Six hours of laboratory per week. Laboratory fee: \$18.00.

**462/562. Physical Organic Chemistry.** Credit 3 hours. Prerequisites: Chemistry 266-268 and 396. Quantitative mathematical approaches to organic mechanisms; structure related to reactivity.

**471/571. Inorganic Chemistry.** Credit 3 hours. Prerequisite: Chemistry 266 and Chemistry 395. Modern interpretation utilized to present the principles of inorganic chemistry at an advanced level.

**473/573. Inorganic Chemistry Laboratory.** Credit 1 hour. Prerequisites: Chemistry 266, Chemistry 268, and Chemistry 395 and registration for or prior credit for Chemistry 471. A course designed to acquaint the student with important laboratory operations and techniques in inorganic and organometallic chemistry. Three hours of laboratory a week. Laboratory fee: \$18.00.

**481/581. Biochemistry I.** Credit 3 hours. Prerequisites: Chemistry 266-268. A study of the structure and function of biological macromolecules with emphasis on proteins, enzymes, lipids, carbohydrates, and nucleic acids. A course designed for majors in biology and chemistry.

**482/582. Biochemistry II.** Credit 3 hours. Prerequisite: Chemistry 481/581. A continuation of Chemistry 481/581 with emphasis on gene expression and metabolism. A course designed for majors in biology and chemistry.

**485/585. Biochemistry Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Chemistry 481. A laboratory to accompany Chemistry 481. Experiments are designed to demonstrate the properties of amino acids, proteins, carbohydrates, lipids, and nucleic acids with emphasis on enzyme kinetics and protein purification. Three hours of laboratory a week. Laboratory fee: \$18.00. Students taking this course for graduate degree credit must complete an independent research project and a written research paper summarizing the project.

**486/586. Biochemistry Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Chemistry 482 and prior credit for Chemistry 485. A laboratory to accompany Chemistry 482. Experiments are designed to demonstrate some of the major metabolic pathways with emphasis on energy considerations and interrelationships of the pathways. It also emphasizes the flow of genetic information through replication, transcription, and translation. Three hours of laboratory a week. Laboratory fee: \$18.00. Students taking this course for graduate degree credit must complete an independent research project and a written research paper summarizing the project.

**491/591. Theoretical Chemistry.** Credit 3 hours. Prerequisites: Chemistry 396 and Physics 222-224. Advanced treatment of fundamental principles of physical chemistry. Selected topics chosen from electro-chemistry, photochemistry, surfaces and colloids, solid state chemistry, crystallography, solutions (ideal and real), and statistical thermodynamics.

**492/592. Quantum Chemistry.** Credit 3 hours. Prerequisite: Chemistry 491. Fundamental concepts of quantum mechanics with application to atomic and molecular structure, the chemical bond, symmetry, and spectroscopy.

**554. Chemical Analysis for Teachers.** Credit 3 hours. Prerequisites: Chemistry 122-124 and permission of the Department Head. A laboratory course to help science teachers understand the concepts of quantitative chemical analysis as used in the laboratory. The course is open only to secondary school teachers. Credit will not be given for both this course and Chemistry 254. Six hours of laboratory per week. Laboratory fee: \$18.00.

**555. Qualitative Analysis for Teachers.** Credit 3 hours. Prerequisites: Chemistry 122-124 and permission of the Department Head. A laboratory course designed to help science teachers understand the concepts of inorganic solution chemistry. This course is open only to secondary school teachers. Credit will not be given for both this course and Chemistry 253. Six hours of laboratory per week. Laboratory fee: \$18.00.

**610. Chemical Processes.** Credit 3 hours. Prerequisite: CHEM 266 or equivalent. A course designed to study important chemical processes in industry. Examples from the commodity chemical, polymer, pharmaceutical and agricultural industries will be studied. The content will include basics in the scientific, legal, and economic issues associated with the industry such as petrochemical processing, costs, associated with raw materials, scale-up marketing, energy, and process waste.

**621. Conceptual Frameworks in Introductory Chemistry I.** Credit 3 hours. Prerequisite: Permission of the Department Head. This course will provide a rigorous treatment of conceptual frameworks in chemistry while modeling appropriate technologies and teaching methodologies. Three major themes will guide the course; the process of science, the relationship between molecular structure and physical/chemical properties; and the relationship between the macroscopic, microscopic, and symbolic representations of matter. Topics covered include atomic structure, molecular structure, solids and liquids, and stoichiometry.

**622. Conceptual Frameworks in Introductory Chemistry II.** Credit 3 hours. Prerequisite: CHEM 621. This course will provide a rigorous treatment of conceptual frameworks in chemistry while modeling appropriate technologies and teaching methodologies. Three major themes will guide the course; the process of science, the relationship between molecular structure and physical/chemical properties; and the relationship between the macroscopic, microscopic, and symbolic representations of matter. Topics covered include equilibrium, acids and bases, oxidation-reduction, thermodynamics, and kinetics.

**650. Environmental Chemistry.** Credit 3 hours. Prerequisite: CHEM 251 or equivalent. Critical phenomena in the environment will be studied. Topics include redox equilibria in natural waters, complexation in natural water, environmental chemistry of soil, atmospheric pollutants, and techniques for monitoring these phenomena. There will be a field component to this course.

## EARTH SCIENCE (EASC & ESLB)

**101. Earth Science I.** Credit 3 hours. Prerequisite: Registration for or prior credit for Earth Science 103. An elementary treatment of Earth/space relationships and the solar and stellar system.

**102. Earth Science II.** Credit 3 hours. Prerequisite: Prior credit for Earth Science 101 and registration for or prior credit for Earth Science 104 or permission of the Department Head. An elementary study of geology and oceanography.

**103. Earth Science Laboratory I.** Credit 1 hour. Prerequisites: Registration for or prior credit for Earth Science 101. A series of selected experiments to aid students in their understanding of celestial mechanics. Two hours of laboratory a week.

**104. Earth Science Laboratory II.** Credit 1 hour. Prerequisites: Prior credit for Earth Science 103 and registration for or prior credit for Earth Science 102 or permission of the Department Head. A series of activities to aid students in their understanding of geological formations and processes. Two hours of laboratory a week.

**201. Earth Science III.** Credit 3 hours. Prerequisite: Earth Science 101 and 103. A continuation of Earth Science 101. Emphasis will be on stars and stellar systems, stellar evolution, galactic structure and basic cosmology.

**205. Special Topics in Earth Science.** Credit 4 hours. Prerequisites: A 100 level Earth Science lecture and lab and permission of the Department Head. Selected topics in Earth Science that are new or unique and are not covered in existing courses. This course is designed primarily for education majors. This course is a guided inquiry approach to learning and also integrates a service-learning component. It is comparable to a three hour lecture/two hour laboratory per week course. This course may not be used to satisfy the General Education sequence requirement in the Natural Sciences. This course may be repeated, as topics vary, for a maximum of 12 credit hours.

## PHYSICS (PHYS & PLAB)

**100. Acoustics for Musicians.** Credit 3 hours. Prerequisites: Mathematics 160 or 161, or Math ACT score of 20 or higher. The fundamentals of sound, waves and related phenomena for music majors. Three hours of lecture per week.

**121. Elementary Modern Electronics.** Credit 3 hours. Prerequisite: Registration for or prior credit for Physic 123. A course emphasizing circuit design with modern integrated circuit chips.

**123. Elementary Modern Electronics Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Physics 121. A laboratory course involving the construction of radios, digital counters, clocks, frequency meters and other devices for electronic measurement and control.

**130. Contemporary Physics Seminar.** Credit 1 hour. This course is designed to convey an understanding of and appreciation for physics and science by finding their applications to specific objects of everyday experience, and their role in current events. Instead of starting with physics principles and working outward to the real world, students start by looking at familiar real-world objects. Seminars, reviews, and discussions by guest speakers, faculty, and students will be presented.

**142. Elementary Physics.** Credit 4 hours. Prerequisites: Education majors, inservice teachers, or permission of the Department Head. This course is designed to prepare preservice and inservice K-12 teachers to teach physical science as a process of inquiry. The curriculum will focus on small number of topics in elementary physics, and students will actively engage in a process of hands-on investigation and discovery in a laboratory setting. The central objective is to provide an active learning environment that promotes critical thinking skills, collaborative learning, and an understanding and appreciation of the process of scientific investigation. Three hours of lecture and two hours of laboratory per week.

**191. General Physics.** Credit 3 hours. Prerequisites: Mathematics 162, or 165, or 200, or permission of the Department Head. A study of the fundamentals of mechanics, heat and sound for students in the biological sciences, industrial technology, and other areas where a knowledge of calculus is not required.

**191H. General Physics Honors.** Credit 3 hours. Prerequisites: Enhanced ACT mathematics standard score of 27 or higher or completion of Mathematics 162, or 165, or 200 with a grade of C or higher; and registration for PLAB 193H. A study of the fundamentals of mechanics, heat and sound for students in disciplines where a knowledge of calculus is not required.

**192. General Physics.** Credit 3 hours. Prerequisite: Physics 191. A study of the fundamentals of electricity, magnetism, light, and modern physics for students in the biological sciences, industrial technology, and other areas where a knowledge of calculus is not required.

**193. General Physics Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Physics 191. Selected laboratory experiments designed to supplement the lecture in Physics 191. Two hours of laboratory a week.

**193H. General Physics Honors Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Physics 191H. Selected laboratory experiments designed to supplement the lecture in Physics 191H. Two hours of laboratory a week.

**194. General Physics Laboratory.** Credit 1 hour. Prerequisites: PLAB 193 and registration for or prior credit for PHYS 192. Selected laboratory experiments designed to supplement the lecture in Physics 192. Two hours of laboratory a week.

**221. General Physics.** Credit 3 hours. Prerequisites: Registration or prior credit for Mathematics 201. Basic principles of mechanics, heat and sound for technical students only.

**222. General Physics.** Credit 3 hours. Prerequisite: Physics 221. Basic principles of electricity, magnetism, and light for technical students only.

**223. General Physics Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Physics 221. A corresponding laboratory course for Physics 221. Three hours of laboratory a week.

**224. General Physics Laboratory.** Credit 1 hour. Prerequisites: PLAB 223 and registration for or prior credit for Physics 222. A corresponding laboratory course for Physics 222. Three hours of laboratory a week.

**241. Engineering Statics.** Credit 3 hours. Prerequisites: PHYS 221 and PHYS 222 and MATH 201. Vectors; two-dimensional and three-dimensional force system; equilibrium; friction; centroids; mass moments of inertia; second moments of areas.

**242. Engineering Circuits.** Credit 3 hours. Prerequisites: PHYS 221 and PHYS 222 and MATH 201. Introduction to linear, time-invariant and jumped circuits. Kirchoff's laws, analysis of resistive circuits and steady-state and analysis of R,L,C and transformer circuits.

**301. Electricity and Magnetism.** Credit 3 hours. Prerequisite: Physics 222. Advanced study of the fundamentals of electricity and magnetism.

**303. Electricity and Magnetism Laboratory.** Credit 1 hour. Prerequisites: PLAB 224 and registration for or prior credit for Physics 301. Selected experiments in advanced electricity and magnetism. Three hours of laboratory a week.

**312. Optics.** Credit 3 hours. Prerequisites: Physics 222-224 and registration for or prior credit for Physics 314. Advanced study of the fundamentals of geometric and physical optics.

**314. Optics Laboratory.** Credit 1 hour. Prerequisite: Registration for or prior credit for Physics 312. A laboratory course designed to introduce the student to the operational techniques of advanced optical instruments. Two hours of laboratory a week.

**321. Thermodynamics.** Credit 3 hours. Prerequisites: Physics 222-224 and Mathematics 201. An introduction to the principles of thermodynamics, kinetic theory, and statistical mechanics.

**331. Mathematical Physics.** Credit 3 hours. Prerequisites: Physics 222-224 and Mathematics 201. A study of vectors, complex variables, and other selected topics that have application in mechanics, electromagnetic wave theory, and vibratory motion.

**332. Intermediate Mechanics.** Credit 3 hours. Prerequisite: Physics 331. A study of the fundamentals of mechanics.

**335. Physics Education Laboratory.** Credit 3 hours. Prerequisite: This course can only be taken by science education majors or by consent of the Department Head of Chemistry and Physics. A laboratory course designed for secondary and/or elementary school science teachers. Experiments will be presented and performed that illustrate the theories of physics and that can be used as demonstrations. Theory will be presented and used in conjunction with experiments. Six hours of laboratory per week.

**336. Physical Science Laboratory.** Credit 4 hours. This course may be taken only by elementary education majors and elementary school teachers or by consent of the Department Head of Chemistry and Physics. A laboratory course designed for elementary education majors or elementary school teachers. Experiments will be presented and performed that illustrate physical theories and that can be used as demonstrations. Theory and concepts will be presented and used in conjunction with experiments. Six hours of laboratory per week.

**351. Atomic and Nuclear Physics.** Credit 3 hours. Prerequisites: Physics 222-224. A study of atomic and nuclear structure, nuclear radiation, and applications.

**381. Intermediate Mechanics for Science Education.** Credit 3 hours. Prerequisite: PHYS 222. A study of the fundamentals of mechanics. A course designed for students in Science Education. This course may not be used for a major or minor in physics. Credit may not be given for both Phys 332 and 381.

**382. Electricity and Magnetism for Science Education.** Credit 3 hours. Prerequisite: PHYS 222. Advanced study of the fundamentals of electricity and magnetism. A course designed for students in Science Education. This course may not be used for a major or minor in physics. Credit may not be given for both PHYS 382 and 301.

**401/501. Vibratory Motion.** Credit 3 hours. Prerequisites: Physics 331 and Mathematics 350. An advanced analytical study of vibrating systems and the transmission of sound waves.

**402/502. Electromagnetic Wave Theory.** Credit 3 hours. Prerequisites: Physics 301-303 and Mathematics 402. A theoretical treatment of electromagnetic waves.

**411/511. Physics Seminar.** Credit 1 hour. Prerequisite: Permission of the Department Head. Reviews and discussion of current research topics by students, faculty, and industrial personnel.

**412/512. Physics Seminar.** Credit 1 hour. A continuation of Physics 411/511.

**421/521. Modern Physics.** Credit 3 hours. Prerequisites: Physics 301-303 and Mathematics 350. A survey of the modern physical theories of relativity, quantum mechanics, the solid state, molecular structure, astrophysics, and elementary particles.

**422/522. Modern Physics.** Credit 3 hours. Prerequisites: Physics 421/521 and Mathematics 402. A continuation of Physics 421/521.

**425. Advanced Undergraduate Laboratory.** Credit 2 hours. Prerequisites: Physics 301, 303, and Physics 351. An advanced laboratory for all majors in physics. Selected experiments in modern physics will be performed with an emphasis on data acquisition and error analysis. Six hours of laboratory per week.

**430/530. Special Topics in Physics.** Credit 1-3 hours per semester. Prerequisite: Senior standing in physics or permission of the Department Head. A reading course with topics and credit to be decided by agreement between the Department Head and the student. This course may be repeated for a total of six credit hours if different topics are studied.

**621. Conceptual Frameworks in Introductory Physics I.** Credit 3 hours. Prerequisites: Physics 221 and permission of the Department Head. This is a three credit-hour graduate course that will provide a rigorous treatment of the conceptual frameworks of introductory physics. Three major themes will guide the course: the process of science, motion as explained by force, and motion as explained by energy. The course will consist of textbook-supported guided inquiry exercises that lead students through their own development of the conceptual frameworks of physics by constructing, applying, evaluating, and/or revising theories and models in light of empirical evidence.

**622. Conceptual Frameworks in Introductory Physics II.** Credit 3 hours. Prerequisites: Physics 222, Physics 621, and permission of the Department Head. This is a three credit-hour graduate course that will provide a rigorous treatment of the conceptual frameworks of introductory physics. Three major themes will guide the course: the process of science, motion as explained by force, and motion as explained by energy. The course will consist of textbook-supported guided inquiry exercises that lead students through their own development of the conceptual frameworks of physics by constructing, applying, evaluating, and/or revising theories and models in light of empirical evidence.

## PHYSICAL SCIENCE (PHSC)

**101. Physical Science.** Credit 4 hours. Prerequisites: Prior credit for Mathematics 160 or 161. A survey course in selected topics of physical science designed for non-science majors. This course may not be used to satisfy the General Education sequence requirement in the Natural Sciences. Course consists of four hours of lecture and demonstrations a week.

**631. Computational Modeling in Physical Science.** Credit 3 hours. Prerequisites: PHYS 622 or CHEM 622. A course designed to address introductory level topics in physical science with high performance computational modeling. Three major themes will guide the course: helping students clearly understand the tools and techniques of computational science to better understand how they are used in both modern research and teaching; providing students with an opportunity to deepen their content knowledge in a manner very different than traditional education in physical science, and providing students with alternate strategies that enable them to more effectively teach conceptual topics in physical science. Numerical modeling, systems dynamics modeling, agent modeling, and molecular modeling software tools and techniques will be used for a variety of physics and chemistry topics.

**635. Curriculum Design for Physical Science.** Credit 3 hours. Prerequisites: PHYS 621/622 or CHEM 621/622 and PHSC 631. A graduate-level capstone course that explores the elements of research-based curriculum design and their application for physical science. The three themes of the course include: identifying the key elements of research-based curricula, investigating and evaluating the application of these elements in the existing pool of research-based curricula for physical science, and the application of these elements toward the creation of original lessons and curriculum units for physical science. Key elements that will be surveyed include how people learn, teaching for understanding, assessment and its role in "backwards design", as well as the role of content standards, inquiry, nature of science, instructional models, technology, and various pedagogical structures (i.e. cooperative learning, questioning, science talk) in curriculum design.

## SCIENCE EDUCATION (SCIE)

**300. Teaching Methods for Science Teachers.** Credit 4 hours. Prerequisites: GBIO 151, 152, BIOL 153, 154, CHEM 121, 122, CLAB 123, 124, PHYS 191, 192 and PLAB 193, 194 (or 24 hours of equivalent courses, with 8 hours each in biology, chemistry, and physics). Eight hours of lecture/laboratory per week including a total of forty hours of participation in secondary science classroom teaching or tutoring. This capstone course is designed for teacher candidates who will be teaching science, particularly at the secondary level. Pedagogy content centers on effectively developing, delivering, and assessing science knowledge in a secondary school classroom based on national and state teaching standards. The science content is designed to reflect current issues and research in science.