

# Biochemistry

## Shinquin Programs of Chemistry and Biochemistry

Professors J. Byrne, Hoppe (Chair) and McGinnis; Associate Professors Rizzolo, Blank, and Frisbie; Assistant Professor Guth; Lecturers Milius, Hoeltge, and Rutkowski.

The Bachelor of Science in Chemistry and the Bachelor of Science in Biochemistry offer thorough and hands on laboratory oriented curricula. Our graduates are highly desired by industry and government employers for their laboratory skills, as well as being well qualified for admission to graduate and professional schools. The courses and labs required for these degrees assure that graduates are proficient in the fundamental principles of chemistry and prepared to apply these principles to specialized areas such as environmental, forensic, medicinal, and pharmaceutical chemistry.

Attainment of the Bachelor of Science in Chemistry requires at least 122 credits as does the Bachelor of Science in Biochemistry. Course work should conform to the following tables since many advanced chemistry courses have other courses as prerequisites. All courses listed in the tables are required, although the sequence varies somewhat for courses

offered in alternate years. It is difficult for chemistry and biochemistry majors to schedule the required courses unless they follow the outline recommended here and pay special attention to the alternate year courses (designated with the symbol §).

The progress of all students majoring in chemistry and biochemistry will be evaluated by the department at the end of the first and second years. Students receiving an unsatisfactory evaluation will be requested to change majors.

In addition to offering a rigorous, quality curriculum in chemistry and biochemistry, the faculty is committed to providing quality instruction in our introductory courses. All of our 100 level courses are consistent with the General Education Goals of the university. These courses provide the student with an introduction to the scientific method, the correct and effective representation of data, and develop the students' critical thinking skills by allowing the analysis and interpretation of experimental data.

*Chemistry courses taken for 3 credits, without a laboratory, will only satisfy free elective or chemistry minor requirements. Chemistry and biochemistry majors must enroll in the 4 credit option of each course required by their major.*

## B.S. in Biochemistry - Curriculum Map

First Year			
Fall	Credits	Spring	Credits
CH 103 General Chemistry I	4	CH 104 General Chemistry II	4
EN 101 Composition and Literature I	3	EN 102 Composition and Literature II	3
MA 107 Precalculus Mathematics	4	MA 121 Calculus I	4
BI 101 Principles of Biology I	4	BI 102 Principles of Biology II	4
	<b>15</b>		<b>15</b>
Second Year			
Fall	Credits	Spring	Credits
CH 225 Organic Chemistry I	4	CH 226 Organic Chemistry II	4
PS 201 General Physics I <sup>1</sup>	4	PS 202 General Physics II <sup>1</sup>	4
EN 201 World Literature I <sup>2</sup>	3	CH 324 Biochemistry I or 204 Quantitative Analysis <sup>§</sup>	4
BI 202 Genetics	4	MA 122 Calculus II	4
CH 214 Communication in Chemistry (or in 3rd year) <sup>§</sup>	0-1		
	<b>15-16</b>		<b>16</b>
Third Year			
Fall	Credits	Spring	Credits
CH 327 Physical Chemistry I (or Elective) <sup>§</sup>	3-4	CH 328 Physical Chemistry II or 324 Biochemistry I <sup>§</sup>	3-4
CH 325 Biochemistry II (or Elective) <sup>§</sup>	3-4	CH 204 Quantitative Analysis or 314 Instrumental Methods <b>and</b> 315 Analysis Laboratory <sup>§</sup>	4
BI 306 Cell Biology (or HI Elective (except HI 209)) <sup>§</sup>	3-4	EN 202 World Literature II <sup>2</sup>	3
SS Elective <sup>3</sup>	3	BI 304 Physiology (or Elective) <sup>5, §</sup>	3-4
PH Elective in Ethics <sup>4</sup>	3	Elective or in 4th year	0-3
CH 214 Communication in Chemistry (or in 2nd year) <sup>§</sup>	0-1		
	<b>15-19</b>		<b>13-18</b>

Fourth Year			
Fall	Credits	Spring	Credits
CH 327 Physical Chemistry I ( or Elective) <sup>§</sup>	3	CH 328 Physical Chemistry II (or Elective) <sup>§</sup>	3
CH 325 Biochemistry II (or Elective) <sup>§</sup>	3-4	CH 314 & CH 315 (or Elective) <sup>§</sup>	3-4
BI 306 Cell Biology (or HI Elective except HI 209) <sup>§</sup>	3-4	BI 304 Physiology (or Elective) <sup>§</sup>	3-4
CH 413 Chemistry Seminar	1	CH 422 Chemical Synthesis and Examination II	3
Arts or Humanities Elective <sup>6</sup>	3	Elective or in 3rd year	0-3
	<b>13-15</b>		<b>12-17</b>
Total Credits: 114-131			

§ This course is offered in alternate years. Both courses listed are required. For the years these courses are offered, see Course Descriptions.

- 1 PS 211 - PS 212 may be substituted for PS 201 - PS 202.
- 2 EN 112 - EN 204 may be substituted for one semester of EN 201 - EN 202.
- 3 Social Science Elective; may enroll in any course in Sociology, Economics, Psychology or Political Science.
- 4 A Philosophy (PH) course in ethics. Use the General Education Ethics list for one of the ethics requirements.
- 5 Recommended Science courses as electives: CH 438.
- 6 An Arts or Humanities course. Use the Arts and Humanities list for this requirement.

## Biology Courses

### BI 101 Principles of Biology I 4 Credits

This course is the prerequisite for all biology courses and satisfies general education laboratory science requirements for both majors and non-majors. This course gives an introduction to biochemistry, cell structure, metabolism, and protein synthesis, as well as human anatomy and physiology. Dissection of living and preserved animals is required. Classroom 3 hours, laboratory 2 hours. Offered fall and spring semesters.

### BI 102 Principles of Biology II 4 Credits

This course is a prerequisite for most biology courses and satisfies general education laboratory science requirements for both majors and non-majors. This course explores genetics, evolutionary theory, diversity of life on earth, history of life on earth, and ecology. Dissection of preserved animals is required. Classroom 3 hours, laboratory 2 hours. Prerequisite: BI 101 or permission of the instructor. Offered spring semesters.

### BI 122 Concepts in Biology 4 Credits

A lab science course designed exclusively for non-science majors that aims to give students an appreciation of the major concepts and current topics in biology. Concepts may include cell structures, photosynthesis, cellular respiration, genetics and ecology as well as human anatomy and physiology. Current topics may include stem cell research, nutrition, diseases, steroid abuse, traumatic brain injury, global climate change, and other pertinent issues. The course meets the general education requirement for laboratory science, but cannot be counted towards a biology major or minor. Credit may not be earned for both BI 101 and BI 122. Classroom 3 hours, laboratory 2 hours. Offered spring semesters.

### BI 202 Genetics 4 Credits

The physical and chemical basis of inheritance, expression, and interaction of the hereditary units, linkage, and variation. The application of Mendelian principles to plants and animals. Consideration is also given to microbial and viral genetics and genetic engineering. Classroom 3 hours, laboratory 2 hours. Prerequisites: BI 101, BI 102. Offered fall semesters.

### BI 203 Introduction to Scientific Method & Bioscientific Terminology 1 Credit

An introduction to the philosophy of science, the scientific method and bioscientific terminology. Analysis of data and interpretation of scientific and science-related popular press articles is stressed. Includes exposure to various forms of scientific communication and data collection and analysis. Prepares the student for the rigors of majoring in the biological sciences. Classroom 1 hour. Prerequisites: Sophomore standing, major in Biology.

### BI 215 Human Anatomy and Physiology 4 Credits

This is the first half of a two semester course exploring human anatomy and physiology. It covers cellular metabolism, tissues, and the following body systems: skeletal, muscle, coetaneous, and nervous. Dissection of preserved animals is required. Classroom 3 hours, laboratory 2 hours. Prerequisite: BI 101 or permission of the instructor. Offered fall semesters.

### BI 216 Human Anatomy and Physiology 4 Credits

This is the second half of a two semester course exploring human anatomy and physiology. It investigates the following body systems: endocrine, digestive, respiratory, circulatory, lymphatic (including the immune response), urinary, and reproductive. Dissection of preserved animals is required. Classroom 3 hours, laboratory 2 hours. Prerequisite: BI 215 or permission of the instructor. Offered spring semesters.

### BI 220 Introductory Microbiology 4 Credits

A survey of the field of microbiology with emphasis on those microorganisms of medical significance. Fundamentals of microbial structure, physiology and control are considered along with the role of pathogenic organisms in the infectious and disease processes. Laboratory exercises are designed to provide facility in visualizing, staining, culturing, enumerating, isolating, maintaining, and identifying micro organisms. Classroom 3 hours, laboratory 2 hours. Prerequisite: BI 101 or permission of the instructor. Offered spring semesters.

**BI 240 Environmental and Food Microbiology 4 Credits**

A course designed to develop an awareness of the essential role of microbes in maintaining the biosphere and the quality of life of its human inhabitants. The role of microorganisms as degraders, bioremediators and recyclers of essential elements will be presented and reinforced through laboratory exercises. The dependence of humans on microorganisms for health, food transformation, pharmaceutical production and genetic engineering will be explored in lecture and lab. Controversies surrounding the use of biotechnology to produce genetically engineered foods and animals as well as agents for bioterrorism, will be discussed. Classroom 3 hours, laboratory 2 hours. Prerequisites: BI 101, BI 102 or permission of the instructor. Offered even-numbered fall semesters.

**BI 253 Foods and Nutrition 4 Credits**

A course designed to provide the student with a background in organizational structure and activities that emphasize the physiological basis of nutrition with an analysis of nutritional needs at various age levels. Consideration given to the relationship of nutrition to health and fitness, principles of food selection, metabolism of nutrients, vitamins and minerals, energy balance and obesity, food safety and technology. Classroom 3 hours, Field Experience/Laboratory 2 hours. Prerequisite: BI 101. Offered spring semesters.

**BI 260 Ornithology 4 Credits**

A survey of avian biology and ecology to include evolution, the anatomical and physiological adaptations for flight, migration, behavior, reproduction and identification of birds and their songs. Integrated classroom, laboratory, and field studies will emphasize Vermont birds. Dissection of the pigeon during the spring semester is an integral part of the spring course's laboratory component. The summer course features a nesting study in lieu of dissection. Classroom 3 hours, laboratory 2 hours. Offered spring semesters.

**BI 275 Environmental Biology 4 Credits**

An introduction to the interaction of man and the environment with emphasis on contemporary problems and their possible solutions. Local and global forms of pollution, detrimental environmental practices, and other relationships will be explored in the classroom and the laboratory. Classroom 3 hours, laboratory 2 hours. Prerequisites: BI 101, BI 102 or permission of the instructor. Offered even-numbered spring semesters.

**BI 302 Embryology 4 Credits**

A study of the fundamental principles of development through the establishment of the major organs and systems, exemplified in the laboratory by study of representative embryonic forms. May require dissection of living and preserved animals. Classroom 3 hours, laboratory 2 hours. Prerequisite: BI 101, BI 102 or permission of instructor. Offered even-numbered spring semesters.

**BI 304 Physiology 4 Credits**

A study of the comparative physiology of animals. Physical and chemical principles, cell physiology, with emphasis on homeostatic mechanisms and the study of functions of organ systems. May require dissection of living animals. Classroom 3 hours, laboratory 3 hours. Prerequisites: BI 101, BI 102, and 1 year of college chemistry. Offered even-numbered spring semesters.

**BI 305 Biomedical Techniques 4 Credits**

Students are familiarized with the theories and applications of the new technologies that pervade the fields of biotechnology and molecular biology. Laboratory exercises illustrate key concepts and provide hands-on experience in the use of instrumentation essential to molecular biologists. Classroom 2 hours, laboratory 4 hours. Prerequisites: BI 101, BI 102 or BI 215, BI 216, and CH 103, CH 104. Offered odd numbered fall semesters.

**BI 306 Cell Biology 4 Credits**

A molecular level examination of the ultrastructure and function of the cytoplasm, intracellular components, cell membrane, extracellular structures and formation, and excretion of extracellular products. Recent developments in molecular biology will be stressed, including the implications for the biotechnology industry. The laboratory component will include state-of-the-art procedures and will emphasize hands-on experimental techniques. May require dissection of living animals. Classroom 3 hours, laboratory 3 hours. Prerequisites: BI 101, BI 102 and one year of college chemistry. Offered even-numbered fall semesters.

**BI 316 Plant Taxonomy 4 Credits**

A general survey of the taxonomy and evolution of vascular plants, emphasizing herbaceous plants. Recognition of plant families, identification of species, and principles of collecting and preserving are stressed. Classroom 3 hours, laboratory 3 hours. Prerequisite: BI 102 or permission of instructor. Offered even-numbered fall semesters.

**BI 325 Invertebrate Zoology 4 Credits**

A fundamental course designed to give the student a general knowledge of the structure, physiology, life histories, and ecology of the invertebrate animals. Requires dissection of living and preserved animals. Classroom 3 hours, laboratory 2 hours. Prerequisites: BI 101, BI 102. Offered even-numbered fall semesters.

**BI 326 Natural History of the Vertebrates 4 Credits**

A study of the classification, identification, and ecology of the vertebrates with special emphasis on the local fauna. Collection and preservation of organisms is an integral part of the course. Classroom 3 hours, laboratory 3 hours. Prerequisites: BI 101, BI 102. Offered odd-numbered fall semesters.

**BI 330 Immunology 4 Credits**

A course presenting the basic principles of immunology, including antigen-antibody characteristics, the role of the immune system in defense and disease, and the application of fundamental concepts in the development of new technologies and immunodiagnosis. Classroom 3 hours, laboratory 3 hours. Prerequisites: BI 101, BI 102 or BI 215, BI 216, and 1 year of college chemistry. Offered odd-numbered spring semesters.

**BI 341 Plant Anatomy 4 Credits**

[CAB1 (A), CAB2 (B), CAB5 (S)] The anatomy of vascular plants analyzed from an evolutionary viewpoint. Cell structure, tissues, their distribution in roots, stems, leaves and reproductive organs, and plant development are stressed. Classroom 3 hours, laboratory 3 hours. Prerequisite: BI 102 or permission of instructor. Offered odd-numbered spring semesters.

**BI 351 Dendrology and Silvics 4 Credits**

An introduction to major woody plant species in the Northeast, including taxonomic characteristics, life histories, habitat requirements, and economic importance. Classroom 3 hours, laboratory and/or field work 3 hours. Prerequisite: BI 102 or permission of instructor. Offered odd-numbered fall semesters.

**BI 360 Pathophysiology 3 Credits**

The study of human illness with primary emphasis on the pathogenesis of disease, its disruption of normal physiology, and the body's mechanism for restoring the steady state. The biology of the disease process is examined at the molecular, cellular, tissue, organ, and organ system level. Classroom 3 hours. Prerequisites: minimum "C" grade in BI 215, BI 216 or permission of instructor. Offered fall semesters.

**BI 364 Pathophysiology in Sports Medicine 4 Credits**

The study of human pathology with primary emphasis on the pathogenesis of those pathological states most commonly encountered in sports medicine, their disruption of normal physiology and the body's mechanism for restoring the steady state (homeostasis). The biology of the disease process is examined at the molecular, cellular, tissue, organ and organ system level. Classroom 3 hours, laboratory 2 hours. Prerequisites: BI 215 & BI 216 with "C" or higher, or permission of instructor. Offered even-numbered spring semesters.

**BI 370 Introduction to Neuroscience 4 Credits**

An interdisciplinary course designed to introduce the structure and function of the mammalian nervous system. Topics include, but are not limited to, neuronal development, sensory and motor systems, chemical control of the brain and behavior, and the underlying mechanisms of neurodegenerative disease. May require dissection of living animals. Classroom 3 hours, laboratory 2 hours. Prerequisites: BI 101 and either BI 215 or PY 230. Offered fall semesters.

**BI 399 Topics in Biology 4 Credits****BI 401 Senior Seminar 3 Credits**

This is the capstone course that integrates reading, writing, speaking and critical thinking skills. It includes instruction in scientific writing, use of contemporary scientific biological literature, library research techniques, and requires a major paper considering ethics in science and research. Students will prepare research papers on current topics using primary sources and give oral presentations on their topics to the department faculty. Classroom 3 hours. Prerequisites: senior class standing or permission of the instructor. Offered fall semesters.

**BI 402 Evolution 4 Credits**

This course is designed to introduce the student to Darwinian and Non-Darwinian mechanisms of evolutionary change, a history of life in the context of contemporary biology, and scientific and cultural controversies surrounding this topic. Offered Fall semesters. Classroom: 4 hours. Prerequisites - BI 101, BI 102 and BI 202 or permission of the instructor. This class can fulfill the CAB1 (anatomy) or CAB5 (systematic) requirements.

**BI 405 Ecology 4 Credits**

The interrelationships between living organisms and their total environment are studied through a combination of lecture, laboratory and field studies. Major concepts include ecosystem structure and function, community development, species diversity, succession, interspecific and intraspecific relationships, competition, predation, behavior, population growth and regulation. Collection and preservation of plants and animals may be required. Classroom 3 hours. If taken for four credits also laboratory and/or field work 3 hours. Prerequisites: BI 101, BI 102. Offered fall and spring semesters.

**BI 418 Medical Microbiology 4 Credits**

A study of pathogenic microorganisms including their general characteristics, physiology, pathogenesis, pathology, diagnosis, treatment, immunity, prevention, and control. Laboratory exercises are designed to familiarize students with diagnostic procedures used in the clinical microbiology laboratory. Classroom 2 hours, laboratory 4 hours. Prerequisite: BI 220 or BI 240. Offered even-numbered spring semesters.

**BI 424 Woodland Ecology and Management 4 Credits**

A review of biotic and abiotic factors controlling the forest environment, methods for determining vegetation structure and succession, introduction to major forest associations in the Northeast, and consequences of various harvesting and management techniques. Classroom 3 hours, field studies 3 hours. Prerequisites: BI 351 or BI 316, or permission of instructor. Offered even-numbered spring semesters.

**BI 440 Reading and Research 3,4 Credits**

Independent study under the supervision of a department faculty member. Open to junior and senior majors with permission of instructor. BI 440 may be taken no more than twice, for a maximum of 7 credits. Students requesting this course must have a 3.0 GPA in biology courses or departmental approval. An approved topic, a brief outline of the research to be conducted, and a signature from a biology mentor must be submitted to the department chair before the end of the drop-add period of the enrolled semester.

**BI 450 Internship in Biology 3,4 Credits**

Internship in Biology.

**BI 499 Evolution 4 Credits****Chemistry Courses****CH 100 Introduction to Forensic Science 4 Credits**

An introductory survey course of Forensic Science/Criminalistics. The course will focus on scientific principles behind the recognition, collection, preservation, analysis, and interpretation of physical evidence found at a crime scene. The emphasis will be put on providing students with an understanding of the capabilities and limitations of forensic science as it is currently practiced. Lecture 3 hours, laboratory 3 hours. Recommended for students not majoring in science and engineering. Offered fall and spring semesters.

**CH 101 Introduction to General Chemistry 4 Credits**

CH 101 is the first of a two semester course series in chemistry covering topics in General, Organic and Biochemistry (GOB). It is a fundamental course in general chemistry, introducing students to the principles of chemical structure and reactivity. Topics include accuracy and precision in measurement, atomic and molecular structure, chemical bonding and reactions, and chemical equilibrium. The laboratory element complements the lecture material with emphasis placed on collaborative problem solving. This course is not recommended for students majoring in science or engineering. Prerequisite: a college level mathematics course or equivalent as determined by departmental placement testing. Not more than one of CH 101 or CH 103 may count as degree credit. Lecture 3 hours, laboratory 3 hours. Offered spring semesters.

**CH 102 Introduction to Organic and Biochemistry 4 Credits**

CH 102 is the second part of a two semester course series in chemistry covering topics in General, Organic and Biochemistry (GOB). This course introduces students to the nomenclature, structure and reactivity of organic compounds and the structure and function of the major classes of biological compounds and their role in metabolic pathways. Laboratory exercises compliment the lecture material. This course is not recommended for students majoring in science or engineering. Prerequisites: CH 101 or CH 103. Not more than one of CH 102 or CH 104 may count as degree credit. CH 102 may not be taken for credit after successful completion of CH 205. Lecture 3 hours, laboratory 3 hours. Offered fall semesters.

**CH 103 General Chemistry I 4 Credits**

Introduction to chemical characteristics and behavior, stressing atomic structure, stoichiometry, chemical equilibrium and kinetics, and descriptive chemistry of important elements. Laboratory includes qualitative and quantitative exercises, and syntheses. Lecture 3 hours, laboratory 3 hours. Credit will not be granted for more than one of the following sequences: CH 103 - CH 104, CH 111 - CH 112, or CH 103 - CH 112. Prerequisites: One year of high school chemistry and a score of 2 or better on the Norwich University Mathematics Placement Test or a "C" or better in MA 103. Offered fall semesters.

**CH 104 General Chemistry II 4 Credits**

Continuation of the study of chemical characteristics and behavior, stressing atomic structure, stoichiometry, chemical equilibrium and kinetics, and descriptive chemistry of important elements. Laboratory includes qualitative and quantitative exercises, and syntheses. Lecture 3 hours, laboratory 3 hours. Credit will not be granted for more than one of the following sequences: CH 103 - CH 104, CH 111 - CH 112, or CH 103 - CH 112. Prerequisites: CH 103. Offered spring semesters.

**CH 204 Quantitative Analysis 4 Credits**

A course on the general principles and laboratory practices of quantitative analysis, applied principally in colorimetric and volumetric determinations. Studies of theory and practical procedures associated with gravimetric analysis, potentiometric titrations, and use of pH-meters. Lecture 3 hours, laboratory 4 hours. Prerequisites: CH 103, CH 104. Offered spring semesters of odd numbered years.

**CH 205 Survey of Organic Chemistry 4 Credits**

An introduction to the covalent compounds of carbon. Laboratory work involves elementary manipulation of organic laboratory equipment, preparation and identification of typical organic compounds, and the characteristics of the major functional groups. Lecture 3 hours, laboratory 2 hours. Prerequisites: CH 103 - CH 104. Offered fall semesters of odd numbered years.

**CH 214 Communication in Chemistry 1 Credit**

This course illustrates the organization of the chemical literature, the efficient search of the literature and a formal introduction to scientific writing. Offered fall semesters of even years.

**CH 225 Organic Chemistry I 4 Credits**

An introduction to the study of carbon compounds; preparation and identification of typical compounds. Lecture 3 hours, laboratory 3 hours. Prerequisites: CH 103 - CH 104 or by petition. Offered fall semesters.

**CH 226 Organic Chemistry II 4 Credits**

A continuation of the study of carbon compounds; preparation and identification of typical compounds. Lecture 3 hours, laboratory 3 hours. Prerequisite: CH 225. Offered spring semesters.

**CH 314 Instrumental Methods 3 Credits**

A course on the Theory of Modern Instrumental Methods. Lecture 3 hours. Prerequisites: CH 204 required, CH 327 - CH 328 recommended. Offered spring semesters of even numbered years.

**CH 315 Analysis Laboratory 1 Credit**

A course that provides upper class laboratory experience in chemical methods of measurement and analysis. Laboratory 3 hours. Prerequisite: CH204. Offered spring semesters of even numbered years.

**CH 324 Biochemistry I 4 Credits**

A course on the chemical phenomena and energy effects in life processes. Topics include structure and function of biomolecules, metabolism (catabolism and anabolism), photosynthesis and recombinant DNA technologies. Lecture 3 hours, laboratory 3 hours. Prerequisites: CH 103 - 104, and either CH 205 or co-requisite of CH 226. Offered even numbered spring semesters.

**CH 325 Biochemistry II 4 Credits**

A continuation of the study of the chemical phenomena and energy effects in life processes. Topics include structure and function of biomolecules, metabolism (catabolism and anabolism), photosynthesis and recombinant DNA technologies. Lecture 3 hours, laboratory 3 hours. Prerequisite: CH 324. Offered even numbered fall semesters.

**CH 327 Physical Chemistry I 3 Credits**

A course on the physical properties and structure of matter; general principles and theories of chemical interaction. Major areas studied are chemical applications of thermodynamics; phase equilibria; electrochemistry; reaction kinetics; description of electronic structure of atoms and molecules. Lecture 3 hours. Prerequisites: CH 103 - CH 104; co-requisite; MA 224 and college physics (recommended). Offered even numbered fall semesters.

**CH 328 Physical Chemistry II 3 Credits**

A continuation of the study of the physical properties and structure of matter; general principles and theories of chemical interaction. Major areas studied are chemical applications of thermodynamics; phase equilibria; electrochemistry; reaction kinetics; description of electronic structure of atoms and molecules. Lecture 3 hours. Prerequisite: CH 327. Offered odd numbered spring semesters.

**CH 337 Physical Chemistry Laboratory I 1 Credit**

Laboratory investigations with written formal reports on the physical properties and chemical behavior of substances. Laboratory 3 hours. Prerequisite or co-requisite: CH 327. Offered even numbered fall semesters.

**CH 338 Physical Chemistry Laboratory II 1 Credit**

Laboratory investigations with written formal reports on the physical properties and chemical behavior of substances. Laboratory 3 hours. Prerequisite or co-requisite: CH 328. Offered odd numbered spring semesters.

**CH 413 Chemistry Seminar 1 Credit**

Part of a capstone experience that provides individual assignments, written reports, oral reports, and class discussions on chemical topics of current interest. Reading, writing, speaking and critical thinking skills are emphasized. Lecture 1 hour. Prerequisites: CH 225 - CH 226, CH 327 - CH 328.

**CH 421 Chemical Synthesis and Examination I 3 Credits**

A capstone experience in which organic, inorganic and compounds of biological interest are synthesized and examined with respect to purity and properties. The objectives are to develop an integrated perspective on the general field of chemistry and to develop proficiency in practical laboratory procedures and in reporting results. Laboratory and occasional lectures 8 hours. Prerequisites or co-requisites: CH 225 - CH 226, CH 327 - CH 328. Offered fall semesters.

**CH 422 Chemical Synthesis and Examination II 3 Credits**

A capstone experience in which organic, inorganic and compounds of biological interest are synthesized and examined with respect to purity and properties. The objectives are to develop an integrated perspective on the general field of chemistry and to develop proficiency in practical laboratory procedures and in reporting results. Laboratory and occasional lectures 8 hours. Prerequisites or co-requisites: CH 225 - CH 226, CH 327 - CH 328. Offered spring semesters.

**CH 425 Thesis 1-3 Credit**

This course allows the student to conduct research on a project approved by the faculty of the chemistry and biochemistry programs. The student can be expected to perform the necessary experiments, organize and interpret the data and to communicate the results of the project with a comprehensive report. Prerequisites: CH 225 - CH 226. Co-requisites: CH 327 - CH 328, CH 438. Permission of the program faculty is also required. The student may re-enroll in CH 425 for up to 6 credits.

**CH 438 Advanced Inorganic Chemistry 3 Credits**

A course on the chemistry of the elements: properties, characteristics, and behavior. Lecture 3 hours. Prerequisites: CH 327 - CH 328. Offered fall semesters of odd numbered years.

**CH 439 Advanced Organic Chemistry 3 Credits**

An advanced and thorough development of topics introduced in CH 225 - CH 226. Lecture 3 hours. Prerequisites: CH 225 - CH 226. Offered fall semesters of even numbered years.

**CH 450 Topics in Chemistry 3 Credits**

A course in which a selected limited topic in advanced chemistry is covered in depth. Offered on occasion. Prerequisite: permission of the instructor.

**Physics Courses****PS 100 Elementary Physics 4 Credits**

A selection of topics from kinematics, dynamics, fluids, energy, acoustics, electricity, optics, and modern physics required of an informed citizenry. Classroom: 3 hours; laboratory: 2 hours. Note: Credit cannot be received for PS100 if credit has been earned in PS 201 or PS 211.

**PS 107 Introductory Solar System Astronomy 4 Credits**

A descriptive study of the solar system, including the sun, planets, asteroids, comets and interplanetary space. The role of observation in the evolution of astronomy is emphasized. Classroom: 3 hours; laboratory: 2 hours. Does not count as a lab science if taken for 3 credits.

**PS 108 Stellar and Galactic Astronomy 4 Credits**

A descriptive introduction to the universe, including stars, galaxies, and recent deep space discoveries. Discussions survey the techniques used by astronomers to interpret the wide variety of observed phenomena in the cosmos. Classroom: 3 hours; laboratory: 2 hours. Does not count as a lab science if taken for 3 credits.

**PS 110 Physics of Continuous Media 3 Credits**

An introduction to fluid mechanics, sound and thermal physics. Open only to first year students or by permission of department. Classroom: 3 hours. Pre- or Co-Requisite: MA 108 or MA 121. Offered spring semesters only.

**PS 201 General Physics I 4 Credits**

An algebra-based study of mechanics, sound and heat, with correlated laboratory experiments. Classroom 3 hours, laboratory 2 hours. Prerequisite: MA107. Note: No student will receive credit for both PS201 and PS211, or for both PS202 and PS212.

**PS 202 General Physics II 4 Credits**

An algebra-based study of magnetism, electricity, light, and atomic physics, with correlated laboratory experiments. Classroom: 3 hours; laboratory: 2 hours. Prerequisite: PS 201. Note: Credit cannot be received for both PS 202 and PS 212. Offered spring semesters only.

**PS 205 Basic Instrumentation in the Natural Sciences 4 Credits**

An introduction to instrumentation theory and measurement technique. Emphasis on identification of and models for the behavior of measuring system components, the combinations of components in typical research equipment and the statistical analysis necessary for interpretation of measurements. Classroom: 3 hours; laboratory: 3 hours. Prerequisite: permission of instructor. Offered fall semester of odd-numbered years only.

**PS 207 Meteorology and Climatology 3,4 Credits**

A first study of atmospheric processes, elementary forecasting, and the major climatic classes. Particular emphasis is placed on the effects of these phenomena on human activities. Laboratory practice includes elementary forecasting techniques, observations, calculations, and theoretical analysis of weather and climate patterns. Classroom: 3 hours; laboratory: 2 hours. Prerequisite: PS 201 or PS 202 or permission of the instructor. Does not count as a lab science if taken for 3 credits.

**PS 211 University Physics I 4 Credits**

A calculus-based study of vectors; Newton's laws; uniform, accelerated, rotational and harmonic motion; conservation laws; fluid mechanics; elasticity. Classroom: 3 hours; laboratory: 2 hours. Prerequisite: MA 121. Note: Credit cannot be received for both PS 201 and PS 211. Offered fall semesters only.

**PS 212 University Physics II 4 Credits**

A calculus-based study of topics in electricity, magnetism, waves and optics. Classroom: 3 hours; laboratory: 2 hours. Prerequisite: PS 211; Pre- or Co-requisite: MA 122. Note: Credit cannot be received for both PS 202 and PS 212. Offered spring semesters only.

**PS 232 University Physics III 3 Credits**

A study of topics from quantum phenomena, spectroscopy, relativity, nuclear and solid state physics. Classroom 3 hours. Prerequisite: PS212 or permission of instructor.

**PS 331 Mechanics 4 Credits**

Newtonian Mechanics applied to a particle including rectilinear and general motion, linear oscillations, non-inertial reference frames, gravitation, and central forces. Non-linear oscillators and chaos. Classroom: 3 hours; laboratory: 3 hours. Prerequisites: PS 212 and MA 224 or permission of instructor. Offered fall semester of odd-numbered years only.

**PS 332 Mechanics II 4 Credits**

Newtonian Mechanics applied to a system of particles including planar and general motion of rigid bodies, and oscillating systems. Lagrangian and Hamiltonian dynamical formulations. Introduction to relativistic dynamics. Classroom: 3 hours; laboratory: 3 hours. Prerequisite: PS 331. Offered spring semester of even-numbered years only.

**PS 354 Thermodynamics 4 Credits**

A study of first and second laws of thermodynamics with applications; thermodynamic potentials and applications to systems in equilibrium; introduction to statistical mechanics including Boltzmann statistics, quantum statistics, and statistical interpretation of entropy. Classroom: 3 hours; laboratory: 3 hours. Prerequisites: PS 110, PS 212 and MA 224 or permission of instructor. Offered fall semester of even-numbered years only.

**PS 363 Optics 4 Credits**

A study of the nature and propagation of light; reflection and refraction, thick lenses, lens aberrations, and optical instruments. Interference, dispersion, diffraction, polarization, and color phenomena. Classroom: 3 hours; laboratory: 3 hours. Prerequisites: PS 212 or permission of instructor. Offered spring semester of odd-numbered years only.

**PS 421 Advanced Laboratory I 1-4 Credit**

A laboratory investigation in a specific area of experimental physics designed in consultation with physics faculty. Prerequisite: Permission of the instructor. Offered fall semesters only.

**PS 422 Advanced Laboratory II 1-4 Credit**

A laboratory investigation in a specific area of experimental physics designed in consultation with physics faculty. Prerequisite: Permission of the instructor. Offered spring semesters only.

**PS 423 Electricity and Magnetism I 4 Credits**

A study of electrical circuits, electrostatic fields, application of Gauss' Law and Laplace's equation; dielectric theory; magnetic fields, induced electric fields and currents; theory of magnetic materials; Maxwell's equations and electromagnetic waves. Classroom 3 hours, laboratory 3 hours. Prerequisites: PS212 and MA224; Pre- or Co-requisite: MA223; or permission of instructor. Offered even numbered fall semesters.

**PS 424 Electricity and Magnetism II 4 Credits**

A continuation of PS 423, studying electrical circuits, electrostatic fields, application of Gauss' Law and Laplace's equation; dielectric theory; magnetic fields, induced electric fields and currents; theory of magnetic materials; Maxwell's equations and electromagnetic waves. Classroom: 3 hours; laboratory: 3 hours. Prerequisites: PS 423. Offered spring semester of odd-numbered years only.

**PS 441 Modern Physics I 4 Credits**

An introduction to special relativity, quantum mechanics, structure and spectra of atoms and molecules, nuclear models, and nuclear interactions. Classroom: 3 hours; laboratory: 3 hours. Prerequisites: PS 212 and MA 224 or permission of instructor. Offered fall semester of odd-numbered years only.

**PS 442 Modern Physics II 4 Credits**

A continuation of PS 441, introducing special relativity, quantum mechanics, structure and spectra of atoms and molecules, nuclear models, and nuclear interactions. Classroom: 3 hours; laboratory: 3 hours. Prerequisite: PS 441. Offered spring semester of even-numbered years only.

**PS 451 Seminar I 1 Credit**

A study of special topics of current interest. This capstone course integrates reading, writing, speaking and critical thinking skills. Classroom: 1 hour. Prerequisite: permission of the instructor. Offered fall semesters only.

**PS 452 Seminar II 1 Credit**

A continuation of PS 451, investigating special topics of current interest. This capstone course integrates reading, writing, speaking, and critical thinking skills. Classroom: 1 hour. Prerequisite: permission of the instructor. Offered spring semesters only.

**PS 461 Senior Project I 1 Credit**

A project-oriented capstone experience that integrates reading, writing, speaking and critical thinking. The senior student chooses a project with faculty advice and takes charge of its execution to a satisfying conclusion. The course requires oral and written presentations of the project results. Prerequisites: senior class standing and permission of the instructor. Offered fall semesters only.

**PS 462 Senior Project II 1 Credit**

A project-oriented capstone experience that integrates reading, writing, speaking and critical thinking. The senior student chooses a project with faculty advice and takes charge of its execution to a satisfying conclusion. The course requires an oral and written presentation of the completed project. Prerequisites: senior class standing and permission of the instructor. Offered spring semesters only.