

purposes and justifiability of economic institutions, cultural influences on the identification and attainment of social values, the possibility of political objectivity or neutrality, and the like. Three credits.

### **PL 280 Thomistic Philosophy**

The works of Thomas Aquinas are generally regarded as the high-water marks of Medieval Scholasticism, and they continue to have far-reaching effects on both philosophy and theology. In this course the students will read selections from some of Aquinas' major works organized, in general, along the lines developed in the *Summa Theologiae*. Some of the topics to be considered from a philosophical perspective are the following: philosophy and theology; the existence of God, the attributes, names, and powers of God; predestination; the human end, human acts, habits, virtues and vices; law in general and the various kinds of law. Three credits.

### **PL 303 Eastern Thought**

This course is designed to provide an overview of the basic teachings and historical development of major streams of Eastern thought including Confucianism, Daoism and Buddhism. Emphasis will be placed on a comparative approach, noting the complex historical and conceptual relationships to be found between and within the systems. The course will also examine the congruencies (as well as the disparities) of these approaches with important developments in Western thought. Three credits.

### **PL 305 Special Topics in Philosophy**

These courses provide an opportunity for faculty and students to work together in advanced study in areas of particular expertise and interest. Accordingly, the specific topic of these courses will vary from semester to semester. For the current topic, students should consult with the department or Office of the Registrar. Prerequisite: two courses in philosophy or the permission of the instructor. Three credits.

### **PL 350 Independent Study**

Independent study is primarily intended for the student who has advanced past a basic understanding of the field. It provides an opportunity to explore in greater depth and sophistication a specific philosophical topic or question of the student's choice. Selection of the topic of study is initiated by the student, while the structuring of the course is done in consultation with the instructor. Variable credit.

### **PL 450 Senior Thesis**

In this independent study course the student works closely with a faculty advisor to fully develop the capstone project in philosophy, the Senior Thesis. This process prepares the student for work beyond the undergraduate, developing the skills of independent scholarship: informed philosophical research, skillful analysis, thoughtful synthesis and fluent written work. PL 450 is taken in the second semester before graduation. Three credits.

### **PL 550 Cooperative Education — Philosophy Internship**

Work experience program extending the learning experience beyond the college into the world of work. Students are employed in an area related to their academic endeavor. Academic credits are awarded according to the extent of the work experience. Students may or may not be paid depending on the site. The purpose of the program is to integrate academic studies and employment activities. May be repeated. Variable credit.

# Physics

*Mohamed Anis Maize, Chairperson*

*Daniel Vanden Berk; Paul Follansbee; David W. Grumbine, Jr.;*

*John J. Smetanka*

*Adjunct Faculty: Diane Turnshek*

*Professor Emeriti: Michael K. Gainer and Jaroslav Slezak*

The overall mission of the Physics Department works in concert with the mission of the College and begins with the cultivation of a love for learning and an appreciation of the inherent beauty in the study of the natural world. The department serves three populations of students each with specific goals; (1) Physics and Physics Education majors, (2) majors in the departments of Biology, Chemistry, Mathematics, and Computer and Information Science, as well as students in the 3-2 Engineering program, and (3) non-science majors. The Department's mission is to prepare Physics and Physics Education majors by developing skills in experimental, theoretical and computational physics so our students are prepared to enter graduate programs in Physics and related fields (for example, Astrophysics, Material Science, and Engineering), obtain a professional and/or technical position in industry, or teach at the high school level.

For students majoring in other departments within the Herbert W. Boyer School of Natural Science, Mathematics, and Computing, the Department's mission is to develop the ability to apply the experimental, theoretical and computational principles of Physics to their specific disciplines. The Department's mission is to fulfill the goals of the core curriculum for students who are non-science majors by promoting scientific literacy, developing a familiarity with the scientific method and creating an awareness of the impact of science on society. For all students, the Department's mission is to stress the conceptual understanding of Physics through discussion, demonstration and experimentation and to develop the ability of the students to effectively communicate their understanding to others.

Two alternative programs are available. The program leading to a B.S. degree in Physics is for students who wish to continue their education in graduate school or to directly pursue careers in the private sector. The Physics Education program certifies students for careers as secondary school physics teachers. Students must contact the Education Department Chairperson for admission to the certification program.

### **Physics/Physics Education Learning Objectives**

- Knowledge of the fundamental theoretical fields of physics.
- Understanding and practice of experimental nature of physical science.
- Capability to perform independent research.
- Entrance to and performance in graduate and professional schools
- Successful education certification and procurement of positions in secondary schools
- Other Science Majors: Knowledge and understanding of a broad variety of fundamental physics topics.
- Other Science Majors: Understanding and practice of experimental nature of physical science in fundamental areas corresponding to broad survey of topics.
- Non-Science Majors: Satisfy Tier 1 and 2 core requirements and provide conceptual and knowledge and experimental practice specific to the individual courses.

## Culminating Activity

Students in each program must complete the culminating activity listed as course PH 381. This activity consists of a research project under the direction of a faculty member or an approved internship. Several projects in recent years have been awarded student research grants, students have traveled to present their results at regional and national conferences, while some projects have resulted in a publication in a scientific journal. Successful completion of this activity, typically including a senior thesis, is required.

## Requirements for a Bachelor of Science Degree in Physics and Physics Education.

(See Core Curriculum requirements.)

### Major Requirements (B.S. in Physics) (66 credits):

PH 100	Physics Seminar	1
PH 111	General Physics I	3
PH 112	General Physics II	3
PH 113	General Physics I Laboratory	1
PH 114	General Physics II Laboratory	1
PH 211	Modern Physics	3
PH 213	Modern Physics Laboratory	1
PH 215	Thermodynamics	3
PH 221	Classical Mechanics	3
PH 241	Optics	3
PH 243	Optics Laboratory	1
PH 244	Advanced Laboratory	1
PH 251	Electrical Circuits and Electronics	2
PH 252	Electromagnetic Fields	3
PH 311	Nuclear Physics	3
PH 322	Quantum Mechanics	3
PH 341	Condensed Matter Physics	3
PH 370	Mathematical Physics	3
PH 381	Research	1
MA 111-113	Calculus I-III	12
MA 114	Differential Equations	4
CH 101, 103	General Chemistry I and Laboratory	4
CH 102, 104	General Chemistry II and Laboratory	4

A thesis is required in the senior year.

### Major Requirements (B.S. in Physics Education) (66 credits):

PH 100	Physics Seminar	1
PH 106	Physical Geology	3
PH 107	Physical Geology Laboratory	1
PH 111	General Physics I	3
PH 112	General Physics II	3
PH 113	General Physics I Laboratory	1
PH 114	General Physics II Laboratory	1
PH 151	Astronomy	3
PH 153	Astronomy Laboratory	1
PH 211	Modern Physics	3
PH 213	Modern Physics Laboratory	1
PH 215	Thermodynamics	3
PH 221	Classical Mechanics	3
PH 241	Optics	3
PH 243	Optics Laboratory	1
PH 244	Advanced Laboratory	1
PH 251	Electrical Circuits and Electronics	2
PH 322	Quantum Mechanics	3
PH 381	Research	1
MA 111-113	Calculus I-III	12
MA 114	Differential Equations	4
CH 101, 103	General Chemistry I and Laboratory	4
CH 102, 104	General Chemistry II and Laboratory	4
BL 150-151	General Biology and Laboratory	4

A thesis is required in the senior year.

See Education Department section of *Bulletin* for Education course requirements.

### Requirements for a Physics Minor: 19 credits

PH 111	General Physics	3
PH 112	General Physics II	3
PH 113	General Physics Laboratory I	1
PH 114	General Physics Laboratory II	1

and a minimum of 11 credits selected from courses numbered above PH 200, of which at least one must be PH 243, PH 244, PH 213 or PH 251. MA 111-112 Calculus I-II are prerequisites for General Physics. MA 113-114 Calculus III-IV are recommended electives.

### Typical First-Year Schedule: 32 credits

#### Fall Semester

PH 100	Physics Seminar	1
MA 111	Calculus I*	4
CH 101	General Chemistry I*	3
CH 103	General Chemistry I Laboratory*	1
TH 119	Exploring Religious Meaning	3
or		
EL 102	Language and Rhetoric	3
Core Curriculum Course		3

All students will take one course designated as a First-Year Seminar which will satisfy a Core Curriculum requirement.

#### Spring Semester

CH 102	General Chemistry II*	3
MA 112	Calculus II*	4
CH 104	General Chemistry II Laboratory*	1
EL 102	Language and Rhetoric	3
or		
TH 119	Exploring Religious Meaning	3
CS 110	Computing and Information Science I	3
A Core Course		3

\*These courses fulfill the Core Curriculum requirements.

## Course Descriptions

### PH 100 Physics Seminar

Discussions of topics in contemporary physics. One credit.

### PH 103 Introduction to Physics (Tier 2)

This course introduces students to the methods and techniques used to scientifically describe the world around us. Special emphasis is placed on the field of mechanics – the study of motion. Students become comfortable solving general problems such as projectile motion, energy, and momentum. These problems are solved using only algebra – neither trigonometry nor calculus is a prerequisite. Other topics may include modern physics, optics, electricity and magnetism, and fluid motion. Offered spring semester. Prerequisite: Tier 1 natural science course. Three credits.

### PH 104 Introduction to Physics Laboratory (Tier 2)

This course consists of hands-on laboratory exercises chosen to illustrate concepts of classical and modern physics. Topics may include falling objects, the motion of a pendulum, collisions, projectile motion, the physics of flight, and simple optics. Offered in conjunction with PH 103 Introduction to Physics. One credit.

### PH 108 Our Dynamic Planet (Tier 1)

This seminar studies the ever-changing earth, our home in space, from an Earth's systems perspective. Three topics in particular are investigated in detail: plate tectonics, the development of life and its evolution, and global climate change. Scientific issues such as

the determination of the age of the earth, biological evolution, the mass extinction of the dinosaurs, and the emission of greenhouse gases causing global warming will be examined. Students will also explore how the scientific study of the earth impacts public policy. PH 108 is designed to give an overview of the scientific process and is targeted to fulfill the objectives of a Tier 1 natural science course for non-science majors. Three credits.

#### **PH 109 Our Dynamic Planet Laboratory (Tier 1)**

This course consists of hands-on laboratory exercises chosen to illustrate and reinforce the topics presented in PH 108 Our Dynamic Planet. These exercises may include rock and mineral identification, geological history, climate modeling, mapping and remote sensing, plate tectonics and plate boundaries, stream erosion and deposition, and local fossil identification. Some laboratory exercises will include field trips to off-campus locations. Offered in conjunction with PH 108. One credit.

#### **PH 111 General Physics I**

This is the basic course for those majoring in the physical and biological sciences, mathematics and engineering. Vector methods, mechanics, and energy are studied. Prerequisite: MA 111. Offered fall semester. Three credits.

#### **PH 112 General Physics II**

A continuation of PH 111. Electricity and magnetism, wave motion, optics and topics from modern physics are covered. Prerequisite: PH 111. Offered spring semester. Three credits.

#### **PH 113 General Physics I Laboratory**

Laboratory to accompany PH 111. Laboratory experiments include applications to kinematics, Newton's Laws, and energy. One credit.

#### **PH 114 General Physics II Laboratory**

Laboratory to accompany PH 112. Laboratory experiments include applications to optics, electricity, magnetism, and wave mechanics. One credit.

#### **PH 131 Life and the Universe (Tier 1)**

Are we alone in the universe, or is the universe teeming with life? How does the search for life in the universe help us understand the world around us, our origins, and our purpose? These and related questions will be addressed using insights from the physical sciences, life sciences, history, and other disciplines. Science topics will be introduced assuming only basic mathematical skills. Three credits.

#### **PH 133 Life and the Universe Laboratory (Tier 1)**

A variety of simple experiments and observations will be performed that will add to our understanding of the universe, life on Earth, and the possibility of life elsewhere in the universe. Offered in conjunction with PH 131. One credit.

#### **PH 151 Astronomy (Tier 2)**

This course provides an introduction to the study of Astronomy focusing on the development of our understanding of the universe. Subjects of emphasis include the development of classical mechanics as an explanation of the motion of the planets; the structure, formation and evolution of the sun and other stars; and our modern understanding of cosmology. This course provides a more advanced application of the scientific process and, when taken with PH 153 Astronomy Laboratory, is targeted to fulfill the objectives of a Tier 2 natural science course for non-science majors. Prerequisites: Tier 1 natural science course and MA 104. Three credits.

#### **PH 153 Astronomy Laboratory (Tier 2)**

This course consists of hands-on laboratory exercises chosen to illustrate topics in modern astronomy. Topics of the exercises may include stellar photometry, observation and measurement of star clusters and galaxies, and observation of the Moon and planets. Offered in conjunction with PH 151 Astronomy. One credit.

#### **PH 171 It's Not Rocket Science (Tier 1)**

This course introduces the physical principles involved in the design and flight of rocket propelled vehicles with hands-on experience building and flying model rockets. The course covers Newton's description of motion, aerodynamics, the operating principles of rocket motors, the history of space flight, and the legal issues surrounding hobby rocketry. Must be taken in conjunction with PH 173. Three credits.

#### **PH 173 It's Not Rocket Science Laboratory (Tier 1)**

Laboratory course to accompany PH 171. Students develop a working knowledge of the measurement techniques and design strategies necessary to test, launch, and recover model rockets. Students work in groups to design, build, and test a model rocket to meet a challenge goal similar to the Team America Rocketry Challenge. Must be taken in conjunction with PH 171. One credit.

#### **PH 191 Physics of Sound and Music (Tier 2)**

This course studies the production of sound waves, the propagation of sound, interference and resonance. The course investigates how loudness, pitch and quality are applied to musical instruments. The difference between materials in reflecting, refracting and absorbing sound will be discussed. We will listen to music of a variety of diverse cultures. Application of physical concepts will lead to an understanding of the relationship between physics and music. Basic knowledge of trigonometry and algebra is required. Prerequisites: Tier 1 natural science course and MA 104. Three credits.

#### **PH 193 Physics of Sound and Music Laboratory (Tier 2)**

Experiments will be performed to study the properties of waves and musical instruments. We will listen to music of a variety of diverse cultures. Students who are taking the course and play musical instruments will be encouraged to perform. Application of physical concepts will lead to an understanding of the relationship between physics and music. Taken in conjunction with PH 191. One credit.

#### **PH 195 History of Vision (Tier 2)**

This course investigates the development of models for light and vision as it took place in three civilizations: the ancient Greeks, the Middle East, and Renaissance Europe. Attention is given to the relationship between science and history, philosophy, psychology and religion. Special attention will be given to the work of the Arab scholar Alhasan ibn al-Hytham. No previous knowledge of optics is required. Interest in writing, reading and class discussion is necessary to succeed in this course. Prerequisites: Tier 1 natural science course and MA 104. Three credits.

#### **PH 197 History of Vision Laboratory (Tier 2)**

This laboratory examines the experimental physics that is associated with the fundamentals of light and optics. Experiments will cover topics on the movement and nature of light, reflection, refraction, radiation, optical properties of matter and more. To be taken with PH 195. One credit.

#### **PH 211 Modern Physics**

A survey of atomic and nuclear physics including quantum physics. Prerequisites: PH 112, MA 114. Must be taken with PH 213. Offered fall semester. Three credits.

**PH 213 Modern Physics Laboratory**

Laboratory to accompany PH 211. Laboratory experiments stress basic subjects such as atomic and classical scattering, the particle and wave nature of both radiation and matter, radioactivity, and spectroscopy. One credit.

**PH 215 Thermodynamics**

A study of the basic concepts of both classical and statistical thermodynamics. Topics include work, energy and entropy, the laws of thermodynamics, the Carnot cycle, heat engines, kinetic theory, and classical and quantum statistics. Prerequisites: PH 112 and MA 114. Offered every other spring. Three credits.

**PH 221 Classical Mechanics**

A study of the fundamental principles of the motion of particles and rigid bodies, including vibrational motion, an introduction to the equations of Lagrange and Hamilton, and the two-body problem. Prerequisites: PH 112, MA 112. Offered alternate years. Three credits.

**PH 223 Mechanics: Statics**

Forces in a plane and in space. Equivalent systems of forces. Equilibrium of rigid bodies. Centroids and centers of gravity. Moments of inertia. Analysis of structures. Friction. Vectors used extensively. Prerequisites: PH 111 and MA 112. Cross-listed as MA 223. Offered fall semester. Three credits.

**PH 224 Mechanics: Dynamics**

Kinematics of particles. Kinetics of particles by: (a) force, mass and acceleration, (b) work and energy, (c) impulse and momentum. Kinematics of rigid bodies. Plane motion of rigid bodies by: (a) forces and accelerations, (b) energy and momentum methods. Mechanical vibrations. Vectors used extensively. Prerequisite: MA 223. Cross-listed as MA 224. Offered spring semester. Three credits.

**PH 225 Strength of Materials**

Strength of Materials is an introductory materials science and engineering course. Students learn about the influence of the structure of materials and inherent defects in materials on ultimate properties and performance. The emphasis is on strength and failure of metals, ceramics, and polymers, but electrical and thermal properties are also considered. Case studies are used to illustrate many of the instructional modules. Prerequisites: CH 102, MA 111. Three credits.

**PH 241 Optics**

A study of the basic principles of physical optics. Studies in refraction, polarization, interference, and diffraction based on the theory of electro-magnetic radiation. Prerequisites: PH 112, MA 114. Offered alternate years. Three credits.

**PH 243 Optics Laboratory**

Laboratory to accompany PH 241. Topics include lenses, mirrors, and prisms, as well as reflection, refraction, polarization, interference, diffraction, and holography. One credit.

**PH 244 Advanced Laboratory**

Experiments in various fields of physics focused on developing and applying a variety of common data acquisition and analysis skills. One credit.

**PH 251 Electrical Circuits and Electronics**

A study, with laboratory, of the fundamental aspects of electrical and electronic circuits. The course includes an overview of impedance, discrete semiconductor devices, operational amplifiers, sequential and programmable logic, memory devices, and microcontrollers. It also includes fabrication of printed circuit boards and soldering techniques for both through-hole and surface-mount components. Offered fall semester. Prerequisites: PH 112 and MA 112. Two credits.

**PH 252 Electromagnetic Fields**

An intermediate course in electromagnetic field theory. Extensive use is made of vector calculus. The differential forms of Maxwell's equations are developed and investigated. Prerequisites: PH 111, PH 112, MA 111, MA 112, MA 113 and MA 114. Offered every other spring. Three credits.

**PH 311 Nuclear Physics**

This course concentrates on the study of nuclear properties, nuclear models, conservation laws of nuclear reactions, and the solution of the three dimensional Schrödinger equation. Prerequisites: PH 211 and MA 114. Offered every other spring. Three credits.

**PH 322 Quantum Mechanics** An introduction to quantum theory. The Schrödinger equation is solved for various simple potentials. Includes a study of identical particles, angular momentum, and spin. Prerequisites: PH 211, MA 114. Offered alternate years. Three credits.

**PH 341 Condensed Matter Physics**

A study of the thermal, electrical, magnetic and optical properties of solids. Prerequisite: PH 211. Offered every other spring. Three credits.

**PH 350 Independent Study**

May be repeated. Variable credit.

**PH 360 Honors Course**

The subject and content will be specified when offered.

**PH 370 Mathematical Physics**

An advanced course in the mathematical analysis of physical systems. Methods using linear algebra, complex variables, Fourier analysis, Laplace transforms, and other special functions are studied. Analytical software, such as Mathematica, may be used. Prerequisites: PH 111, PH 112, PH 213, and MA 114. Offered every other spring. Three credits.

**PH 381 Research**

Investigation and experimentation or an approved internship leading to the completion of the required senior thesis. One credit.

**PH 550 Cooperative Education — Physics Internship**

Work experience program extending the learning experience beyond the college into the world of work. Students are employed in an area related to their academic endeavor. Academic credits are awarded according to the extent of the work experience. Students may or may not be paid depending on the site. The purpose of the program is to integrate academic studies and employment activities. May be repeated. Variable credit.