Physics

Department Location
Science Center – Room 327

Goals
The primary goal of the physics program is to lay a strong foundation in the knowledge, practice, and applications of physics so that the student will be motivated for further studies and will be scientifically competent in all her endeavors. The courses strongly support majors in other fields such as chemistry, computer science, mathematics, and engineering.

Objectives
The Physics Department seeks to produce competent, productive physics graduates, as well as to contribute to the science education of all students. Upon successful completion of the prescribed program, the student will be able to

1. demonstrate a breadth and depth of knowledge of physics that would lead to a successful career in a physics-related profession such as engineering or education;
2. demonstrate a breadth and depth of knowledge of physics that would allow her to begin a graduate program in physics;
3. apply her analytical skills to such diverse professions as law, medicine, finance, telecommunications, etc.;
4. demonstrate proficiency in the application of physics to problems of science, technology and society.

General Core Requirements
- PHY 101 (Astronomy), PHY 102 (Physics and the Arts)

International/Women's Studies Requirement
Courses that satisfy the International/Women's Studies requirement are listed in the Course Sequence Booklet or on the Spelman Web page.

Major Requirements
The student majoring in physics will complete the core courses and one of the options to complete the major. The options leading to a bachelor of science degree are advanced theory and experiment, suitable for students who will use physics heavily in their careers; chemical physics, suitable for students leaning toward a career in industry, materials science, or professional school; applications in engineering for students in the dual degree program. The option leading to a Bachelor of Arts degree is suitable for students wanting a broader liberal arts experience or those interested in careers such as patent law or business. It is also suitable for teaching at the secondary level.

The core courses are PHY 151, 241, 251, 261, 302, 311, 362 and 411; two of PHY 100, 200 and/or 300, 400. Required cognates are MATH 231, 232, and 324; CHE 111 and 111L; a CIS elective (programming language).

The remaining courses for each option are listed below:

- **Bachelor of Science: Advanced Theory and Experiment Option**
  PHY 312, 322, , 462, and one physics elective 300 or greater, and one physics elective 400 or greater (not including PHY 300 or 400); a CIS elective (programming language).
- **Bachelor of Science: Chemical Physics Option**
  PHY 322 (or CHE 345), 356, and one physics elective 300 or greater (not including PHY 300 or 400). Other cognates for this option are CHE 112, 112L, 231, 232, 233, 234, one chemistry elective 300 or greater.
- **Bachelor of Science: Pre-Health Option**
  PHY 343, 462, two physics electives 300 or higher (not including PHY 300 or 400). Other cognates are CHE 112, 112L, 231, 232, 233, 234; BIO 115 and 120; biology elective; a CIS elective (programming language).
- **Bachelor of Science: Dual Degree Engineering Option**
  PHY 312, 322, 362, one physics elective 300 or greater, and one physics elective 400 or greater (or two physics electives 300 or greater; not including PHY 300 or 400); a CIS elective (programming language). Other cognates are CHE 112, 112L, and other pre-engineering courses – Introduction to Engineering, Engineering Graphics, Statistics, and Dynamics. The student must also complete an engineering major in the Dual Degree Engineering program; however, some physics courses may be substituted using the engineering courses. See the Physics Department for a list.
- **Bachelor of Arts**
  One Physics elective 300 or greater (not including PHY 300 and 400), PHY 462. Other cognates are: either CHE 112 and 112L, or BIO 115, or BIO 120, or ESS 211; two 4-credit courses outside Mathematics and natural science, not taken to fulfill core college requirements, level 200 or greater.
- **Bachelor of Arts, Secondary Education**
  Physics elective (301 or greater); Physics for secondary education (TBD); one of CHE 112 and 112L, BIO 115, or BIO 120, or ES 211 and ES 211L (CHE 112 and 112L plus a second course from the list is strongly recommended); See the Education Studies Department for the list of education courses.

Minor Requirements
The minor in Physics consists of seven courses, some of which have prerequisites. They are PHY 151, 241, 251, 261, and three elective physics courses at the 300 level or greater (not PHY 300 or 400). One of these electives must be laboratory-based (PHY 356, 362, or a course approved by the department).

All Physics majors and minors must take all physics and cognate courses at Spelman College unless it is pre-approved by the Chair of the Physics Department.

Students in the dual-degree engineering program may substitute one engineering course from an approved list for one of the electives.

Course Descriptions
PHY 100 – SEMINAR (1)
One of the problems with any physics major curriculum is that the most recent physics one usually sees is almost a century old. This is an unfortunate but necessary byproduct of establishing a basis for understanding more

recent developments. In addition, though formal papers are the primary means of communication among working scientists, most students have had little or no experience with that sort of text. This course therefore has two goals: to develop the skills necessary to critically read and understand the physics research literature and to develop some familiarity with current research in physics. The specific skills will be those identified by cognitive research into the actual practices of working scientists. The content of this course will largely be determined by the students based on their personal interests. The course will consist of discussion one hour per week.

PHY 101 – INTRODUCTION TO ASTRONOMY (4)
An introduction to important phenomena of astronomy and how they follow from universal physical law and apply to local circumstances, drawing on principles from physics, chemistry, geology and biology. The course covers aspects of planetary, stellar and galactic astronomy, and cosmology as they all relate to determining the age of the universe. This course contains a laboratory component and will fulfill the natural sciences requirement. Lecture three hours per week, laboratory two hours per week.

PHY 102 – PHYSICS AND THE ARTS (4)
An introduction to the connections and interplay between two very divergent disciplines: physics and art. It considers physical phenomena relevant to artistry, the creative and scientific processes, and ways to interpret the universe. The course contains a laboratory component and fulfills the natural sciences requirement. Lecture three hours per week, laboratory two hours per week.

PHY 111 – GENERAL PHYSICS I (4)
An introduction to the physics of motion and forces, solids and fluids, wave phenomena and thermal processes. The focus is on kinematics and Newtonian dynamics, conservation of energy and momentum, rotational motion and its relation to forces, oscillation and wave (including sound), elastic properties of solids, properties of fluids at rest and in motion, and thermodynamics. Lecture three hours per week; laboratory two hours per week; recitation discussion one hour per week. Prerequisite: MATH 116 or equivalent (algebra and trigonometry); Biology 115 or 120 or permission of instructor

PHY 112 – GENERAL PHYSICS II (4)
An introduction to electricity and magnetism, optics and modern physics. The focus is on electrical fields and energy, electrical circuits, magnetic fields and induction, lenses and mirrors, wave phenomena of light, atomic and nuclear physics. Lecture three hours per week; laboratory two hours per week; recitation discussion one hour per week. Prerequisite: PHY 111.

PHY 151 – PHYSICS I: MECHANICS (4)
An introductory study of the principles underlying the motion of particles, systems of particles and rigid bodies. The focus is on Newton's theory of motion, the work-energy principle, the laws of conservation of energy, momentum and angular momentum, and Newton's theory of gravitation. Other topics include rotational motion, simple harmonic motion and equilibrium. Lecture three hours per week; laboratory three hours per week. Prerequisite: MATH 231 or equivalent.

PHY 200 – SEMINAR (1)
One of the problems with any physics major curriculum is that the most recent physics one usually sees is almost a century old. This is an unfortunate but necessary byproduct of establishing a basis for understanding more recent developments. In addition, though formal papers are the primary means of communication among working scientists, most students have had little or no experience with that sort of text. This course therefore has two goals: to develop the skills necessary to critically read and understand the physics research literature, and to develop some familiarity with current research in physics. The specific skills will be those identified by cognitive research into the actual practices of working scientists. The content of this course will largely be determined by the students based on their personal interests. The course will consist of discussion one hour per week.

PHY 241 – PHYSICS II: ELECTRICITY AND MAGNETISM (4)
An introductory study of the laws of electromagnetism. The emphasis is on Coulomb's law and the Lorentz force law. Gauss' law, Ampere's law, Faraday's law, and basic circuit analysis are also presented. Basic circuit analysis are also presented. Lecture three hours per week; laboratory three hours per week. Prerequisite: PHY 151, and MATH 232 or equivalent.

PHY 251 – OSCILLATIONS AND WAVES (3)
A study of oscillations and waves in various physical systems, including development of mathematical theory, computer simulations, and experimental investigation. The course focuses on the pendulum, an LRC circuit, coaxial cable, and a finite quantum well. Topics include driven damped oscillators, use of the Fourier series and Fourier transform, reflection and transmission of waves, and quantum states. Two two-hour class sessions per week. Prerequisite: PHY 241; Co-requisite: MATH 324.

PHY 261 – OPTICS (1)
A laboratory-based course in introductory optics. Topics include laws of geometric and physical optics. Basic applications of optics and optical phenomena are presented. One two-hour lab session per week. Prerequisite: PHY 241.

PHY 300 – SEMINAR (1)
One of the problems with any physics major curriculum is that the most recent physics one usually sees is almost a century old. This is an unfortunate but necessary by-product of establishing a basis for understanding more recent developments. In addition, though formal papers are the primary means of communication among working scientists, most students have had little or no experience with that sort of text. This course therefore has two goals: to develop the skills necessary to critically read and understand the physics research literature, and to develop some familiarity with current research in physics. The specific skills will be those identified by cognitive research into the actual practices of working scientists. The content of this course will largely be determined by the students based on their personal interests. The course will consist of discussion one hour per week.

PHY 302 – INTRODUCTION TO THEORETICAL PHYSICS (4)
A course designed to be a bridge between the introductory physics courses in mechanics and electromagnetism. Includes advanced mathematical topics – complex variables, ordinary and particle differential equations, vector calculus, Fourier series, and some special functions that are required for a foundation of intermediate mechanics and Maxwell equations. Prerequisite: PHY 241 Physics II: Electricity and Magnetism; Co-requisite: MATH 324 Calculus III. Lecture four hours per week.

PHY 311 – CLASSICAL MECHANICS (4)
A study of the laws of mechanics including Newton's Theory and the formalism of Lagrange and Hamilton. Topics include generalized coordinates, oscillations, two-body motion and collisions. Lecture four hours per week. Prerequisite: PHY 251 and 302.

PHY 312 – ELECTROMAGNETIC THEORY (4)
An advanced study of electric fields, magnetic fields, Maxwell's equations and electromagnetic waves. The course focuses on the use of vector calculus for electrostatics and magnetostatics, analytical and computational methods for solving Laplace's equation and Poisson's equation, fields in matter, electrodynamics and Maxwell's equations, the interaction of electromagnetic waves with matter and electromagnetic radiation. Lecture three hours per week; computer lab one hour per week. Prerequisite: PHY 251 and PHY 302, or permission of the department.

PHY 322 – THERMAL AND STATISTICAL PHYSICS (4)
A study of the fundamental concepts of classical thermodynamics and statistical mechanics. Topics include temperature, work, heat, entropy, heat capacity, the laws of thermodynamics and distribution functions. The kinetic theory, energy transformation and applications of simple systems are included. Lecture three hours per week; lab activities one hour per week. Prerequisite: PHY 241; Co-requisite: MATH 324 Calculus III

PHYSICS 343 – BIOPHYSICS (3)
An introduction to the physical principles behind a variety of important biological and biophysical phenomena. Interdisciplinary in nature, the course combines physical and biological perspectives to explore a wide range of topics and to provide a solid foundation for further study in the fields of biophysics and biotechnology. This course will offer a detailed study of significant biomolecules and their structure-function relationships. Participants will develop an understanding of the fundamental concepts of quantum mechanics in relation to spectroscopic methods, and a mastery of the structural aspects of biomolecules with and without a transition metal ion. Topics also include the interactions of biological systems with electromagnetism, such as the eye (physics of vision) and cellular membranes (transport mechanisms and electrical signaling in

neurons); biomechanics of the musculoskeletal system. Lecture three hours per week. Prerequisite: PHY 251 and 261.

PHY/CHEM 356 – LASERS, OPTICS AND SPECTROSCOPY (4)
A laboratory-based, in-depth study of the applications of lasers in Physics and Chemistry with emphasis on the scientific method. Areas covered include optics, light, light-matter interaction, lasers, spectroscopy and applications of mathematics in Chemistry and Physics. Prerequisite: either PHY 251 and 261, or CHEM 346; or permission of the instructor(s).

PHY 362 – ADVANCED LAB (4)
A course in modern experimental physics including use of advanced techniques and instrumentation, data analysis, and electronics. Experiments will include nuclear spectroscopy, Mössbauer effect, lasers and electro-optical effects, chaotic systems, and magnetic resonance. Two three-hour lab sessions per week. Prerequisite: PHY 251 and 261.

PHY 400 – SEMINAR (1)
One of the problems with any physics major curriculum is that the most recent physics one usually sees is almost a century old. This is an unfortunate but necessary by-product of establishing a basis for understanding more recent developments. In addition, though formal papers are the primary means of communication among working scientists, most students have had little or no experience with that sort of text. This course therefore has two goals: to develop the skills necessary to critically read and understand the physics research literature, and to develop some familiarity with current research in physics. The specific skills will be those identified by cognitive research into the actual practices of working scientists. The content of this course will largely be determined by students based on their personal interests. The course will consist of discussion one hour per week, as well as a reflective essay on changes in their approach to reading scientific text productively over the course of their undergraduate studies. Prerequisites: Students must have passed at least two of Physics 100, 200, and/or 300.

PHY 411 – QUANTUM MECHANICS (4)
An introductory course to the basic concepts, postulates and principles of quantum mechanics, and to their experimental bases. The formalism includes a mathematical framework of linear operators, Hilbert spaces, probability interpretation and perturbation theory. The basic principles include Schroedinger's equation and Heisenberg's Uncertainty Principle. The theory is applied to various systems such as free particle, infinite and square wells, harmonic oscillator and hydrogen atom. Lecture four hours per week. Prerequisite: PHY 311 and 302

PHY 415 Computational Physics
This course engages the student in computational methods to solve physics problems and predict measurable quantities. It builds on computational modules in previous courses and familiarizes the student with tools such as numerical integration, numerical solution to differential equations, simulation, and Monte Carlo methods. It also familiarizes the student with programming with a variety of platforms such as MatLab, Maple, Mathematica, VPython, and C++. The student will use these tools and platforms to solve more advanced physics problems based on physics content from the core courses for physics majors. Lecture four hours per week. Prerequisites: CIS elective (programming language) and two of the following with a grade C or better: PHY 311, PHY 312, PHY 322, PHY 411.

PHYSICS 420 – RELATIVITY (4)
This course introduces the modern theory of gravity. It surveys Newtonian gravitation and the basic concepts of special relativity, and then develops the ideas, phenomena and experimental evidence in support of the general theory of relativity. The course emphasizes the physical meaning and structure of curved spacetimes and covers the most important examples in stellar astrophysics, cosmology, and gravitational radiation. Lecture three hours per week. Prerequisite PHY 311. Corequisite PHY 312.

PHY 431 – INDEPENDENT STUDY/ UNDERGRADUATE RESEARCH IN PHYSICS (3)
An in-depth study or research on a topic in physics not normally covered in the curriculum under the direction of a member of the faculty or designate. The student does independent study or research and meets weekly with her advisor. A written paper or public presentation is required. Prerequisite: Junior standing and consent of the Physics Department and prospective advisor.

PHY 462 – ADVANCED EXPERIMENTS, THEORY, AND MODELING (4)
A capstone course for physics majors that applies theories learned and the core intermediate courses to modern experiments involving sophisticated techniques, equipment and analysis. The course focuses on understanding the theoretical basis of experimental apparatus, performing complex experiments, analyzing data, and applying theoretical models of the systems studied to the experimental results. The course also includes the planning of experiments, the mechanical or electronic construction of apparatus, use of computers, and scientific communication. Experiments include x-ray crystallography, surface physics, lasers and polarization and superconductivity. Two three-hour lab sessions per week. Prerequisite: PHY 362 (Advanced Lab) and completion of two of the following: PHY 311 (Classical Mechanics), PHY 322 (Thermal and Statistical Physics), PHY 312 (Electromagnetic Theory), PHY 411 (Quantum Mechanics).

PHY 491 – HONORS THESIS, RESEARCH (4)
Departmentally supervised research for the Honors Program. Prerequisites: Member of the Honors Program; consent of the Department.