Physics

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Physics courses deal mainly with the laws governing fundamental natural phenomena and the applications of those laws. The major study program can provide a sound basis for students going on to graduate work in physics or engineering and for those planning to teach physics or seeking a background in physics for work in other fields.

A student who enters Whitman without any prior college-level preparation in physics or calculus will have to complete 47 credits to fulfill the requirements for the physics major. Courses numbered 300 and above may not be taken P-D-F.

Distribution: Some courses completed in physics apply to the science, science laboratory, and quantitative analysis distribution areas.

Total credits required to complete the Physics major: A student who enters Whitman College with no prior experience in physics will need to complete 31 credits in Physics and 16 credits in Mathematics and Statistics.

Learning Goals: Upon graduation, a student will be able to:

- Solve problems using discipline specific knowledge and techniques.
- Design and conduct an experimental investigation, analyze the data, and assess theoretical models of the system being studied.
- Communicate their results through written and/or oral expression.

The Physics major: A minimum of 31 credits in physics, including Physics 145 or 155, 156, 245, 255, 267, 339; three courses from: 325, 347, 357 or 385. Additional courses to meet credit requirements are to be taken from 300- to 480-level physics offerings, or from BBMB 324 and BBMB 334. In addition, the following mathematics and statistics courses are required: 225, 244, and either 240 or 367.

The Physics minor: A minimum of 18 credits in physics to include Physics 145 or 155, 156, 245, 255, 267, plus three credits in any physics courses numbered from 200-480, or from BBMB 324 and BBMB 334.

The Mathematics and Statistics-Physics combined major: Mathematics 225, 240, 244, 367 or 368, and six additional credits in math/stats courses numbered above 200; Physics 145 or 155,156, 245, 255, 267, two courses from: 325, 339, 347, 357, 385 and one additional physics course numbered from 300-480, or BBMB 324.

Senior assessment consists of the written exam in mathematics and statistics, the written exam in physics, and a combined oral exam scheduled by the physics department.

The Physics-Astronomy combined major: A student who enters Whitman College with no prior experience in astronomy or physics or math will need to complete 22 credits in Astronomy; 23 credits in Physics; 12 credits in Mathematics and Statistics**.**

Astronomy 177, 178, 179, 310, and 320 or 330; at least two credits in any of the following: 320, 330, 350, 360, 380, 391, 392 or 490; Physics 145 or 155, 156, 245, 255, 267, two courses from 325, 339, 347, 357, 385 and one additional physics course numbered from 300-480, or BBMB 324; Mathematics 225 and 244. Additional physics courses, Computer Science 167, Mathematics 240, 367, and 368 are strongly recommended.

The Geology-Physics combined major: A student who enters Whitman College with no prior experience in geology, physics, chemistry and math will need to complete 17 credits in Physics; 25 credits in Geology; 4 credits in Chemistry; 13 credits in Mathematics and Statistics**.**

Physics 145 or 155, 156, 245, 255, 267, two courses form 325, 339, 347, 357, 385; either Geology 110 and 111, 120 and 121, or 125 and 126**;** and 227, 270**,** 310, 405, 420, 470 and a minimum of one credit in 358; Mathematics 225 and 244; Chemistry 125. In the final semester of the senior year, the student must pass a senior assessment consisting of a written exam and a one-hour oral exam.

The Physics-Environmental Studies combined major: The requirements are fully described in the *Environmental Studies* section of the catalog.

The Physics/Pre-engineering (3/2 Engineering) program: The requirements are fully described in the *Combined Plans* section of the catalog.

Program Planning: A typical program of the required physics courses and mathematics and statistics requirements for students taking a physics major with no advanced placement in calculus is as follows:

I. First year: Mathematics 125 (three credits); Physics 155, Mathematics 126 (seven credits).
II. Second year: Physics 156, Mathematics 225 (eight credits); Physics 245, 255, Mathematics 244 (eight credits).
III. Third year: Physics 325, a 2nd 300-level Physics course, Mathematics 240 (nine credits).
IV. Fourth year: Physics 385 (four credits).

Note that additional physics courses must be taken during the third and fourth years to meet the minimum credit requirement. Every effort will be made to offer courses required for the major and combined majors every year. Upper-level electives will typically be offered in alternate years. Students seriously considering graduate studies in physics or a physics-related field are encouraged to consult with their major adviser to design a course of study that will be best suited to their goals.

Among other electives for the physics major, Computer Science 167 is highly recommended. A year of chemistry also is recommended. Chemistry 345, Mathematics 349, 368, or 467 can be especially useful for physicists.

In the final semester of the senior year, the student must pass a senior assessment consisting of a written exam and a one-hour oral exam.

Non-major Courses: Courses numbered below 110 are intended for students majoring in fields other than science.

General Physics: There are two versions of the introductory general physics sequence. Physics 145/146 is intended for students planning no further study in physics. Physics 155/156 is intended for students planning to take upper level physics courses, including physics majors, physics combined majors, 3-2 engineering majors and BBMB majors.

101, 102 Special Topics
3 credits

Course designed for nonscience majors to explore some basic concepts of physics and their applications through readings, discussion, problem-solving, and occasional laboratory activities. Possible course titles include: How Things Work, Light and Color, and Physical Science. The topic for each course will be designated prior to registration for the semester in which the course will be taught. Students with AP credit for physics at Whitman or who have received credit for Whitman's Physics 145 or higher cannot receive credit for Physics 101 or 102. Any current offerings follow.

103 Sound and Music
Not offered 2019-20 **3 credits**

This course will provide students with conceptual, quantitative, and laboratory based analysis of sound, musical instruments, music recording and storage, and room acoustics. Through detailed analysis of musical instruments as physical systems, students will develop an understanding of important physical concepts including sound waves, harmonic oscillators, energy, standing waves, resonance, and more. The course will culminate in student projects that may include building an instrument, designing and executing an experimental investigation related to acoustics, or extending course material to a new area of inquiry through a research paper. The course will meet four hours a week with two of those hours typically devoted to laboratory based learning.

104 Quantum Physics: What Gives?
Not offered 2019-20 **3 credits**

Quantum physics is the most precisely tested physical theory yet produced. It can explain the behavior of elementary particles, atoms, lasers, electronic circuits and nuclear reactors. Quantum physics promises to yield unbreakable encryption and ultrafast computation. Yet, its predictions often defy common sense; objects can be in multiple places at once and they appear to influence each other instantaneously over great distances. This course will provide an introduction to the concepts of quantum physics with no prerequisites beyond algebra and trigonometry. Students with AP credit for physics at Whitman or who have received credit for Whitman's Physics 145 or higher cannot receive credit for Physics 104.

105 Energy and the Environment
Spring **Sanborn** **3 credits**
This course examines the physical principles that govern energy transformations. It will focus on the use of energy in the world, specifically its production, transportation, consumption and the implications this use has for the environment. Topics addressed will range from the mechanical to electricity and magnetism and from thermodynamics to atomic/nuclear physics. Energy resources both new and traditional (fuel cells versus oil) will be addressed as well as environmental issues ranging from global warming to the disposal of radioactive waste. This course assumes a basic familiarity with algebra.

115, 116 Contemporary Issues in Physics
Not offered 2019-20 **1 credit**
This course serves as an introduction to contemporary issues and topics in physics. Through readings and discussions, students will explore the activities of modern-day physicists. Although this course is intended for students planning to continue toward a physics or physics-related major, it is an excellent course for students wanting a better understanding of what physics is "all about" and how it is done, as a profession, at the beginning of the 21st century. *Corequisites:* for Physics 115: Physics 155; for Physics 116: Physics 156; or consent of instructor. Physics 115 and 116 each may be taken once for a total of two credits. No examinations. Graded credit/no credit only. Does not fulfill science or quantitative analysis distribution.

145 General Physics I – with Applications to Life and Earth Sciences
Fall **Zajac** **4 credits**
This course focuses on classical mechanics: kinematics, Newton's Laws, energy and momentum conservation, torques, fluids, and waves. Examples and problems will focus on applications of physical principles to life and earth science fields to a greater extent than in Physics 155. Students enrolling in this course also will be required to enroll in an associated laboratory course (Physics 145L). Three 50-minute or two 80-minute class meetings and two 90-minute laboratory meetings per week. Evaluation based on homework, laboratory reports, and examinations. *Pre-* or *corequisite:* Mathematics 125.

146 General Physics II – with Applications to Life and Earth Sciences
Spring **Zajac** **4 credits**
This course is a continuation of the course Physics 145. Topics studied include electricity and magnetism, circuits, optics, nuclear and atomic physics. Examples and problems will focus on applications of physical principles to life and earth science fields to a greater extent than in Physics 156. Not intended for students planning to take upper level physics or biophysics. Students enrolling in Physics 146 also will be required to enroll in an associated laboratory course (Physics 146L). Three 50-minute or two 80-minute class meetings and two 90-minute laboratory meetings per week. Evaluation based on homework, laboratory reports, and examinations. *Prerequisites:* Physics 145, 155; Mathematics 125.

155 General Physics I
Spring **Juers** **4 credits**
This course focuses on classical mechanics: kinematics, Newton's laws of motion, energy and momentum conservation, and waves. Students enrolling in this course also will be required to enroll in an associated laboratory course (Physics 155L). Three 50-minute or two 80-minute class meetings and two 90-minute laboratory meetings per week. Evaluation based on homework, laboratory reports, and examinations. *Pre-* or *corequisite:* Mathematics 125.

156 General Physics II
Fall **Gresham** **4 credits**
This course is a continuation of the course Physics 155. Topics studied include electricity and magnetism, circuits, optics, plus brief introductions to more contemporary topics such as special relativity or quantum physics. Students enrolling in Physics 156 also will be required to enroll in an associated laboratory course (Physics 156L). Three 50-minute or two 80-minute class meetings and two 90-minute laboratory meetings per week. Evaluation based on

homework, laboratory reports, and examinations. *Prerequisite:* Physics 145 or 155. *Pre-* or *corequisite:* Mathematics 126.

200-203 Special Topics
1-4 credits
Any current offerings follow.

245 Twentieth Century Physics I
Spring **Gresham** **3 credits**
Topics include thermodynamics, special relativity, nuclear decay and radiation, wave nature of particles, introduction to the Schrodinger Equation: infinite well. Mathematical methods relevant to these areas of inquiry will be discussed: probability theory, differential equations. *Prerequisites:* Physics 156; Mathematics 126. *Corequisite:* Mathematics 225.

255 Twentieth Century Physics Laboratory
Spring **Hoffman** **1 credit**
Experimental investigations of a variety of phenomena relating to the Physics 245 course. Experimental topics studied include: thermodynamics, nuclear decay and radiation, photoelectric effect and standing waves. Emphasis on experimental technique, problem-solving, data analysis, and scientific writing. No examinations. One three-hour laboratory per week.

267 Analog & Digital Electronics and Instrumentation
Not offered 2019-20 **3 credits**
This is a semester long course/laboratory combination that serves as an in-depth introduction to the theory and practice of analog/digital electronics and instrumentation. The course content may include: combinational logic, Boolean algebra, Karnaugh maps, sequential logic, digital circuit design, AC signals, equivalent circuits, filter theory and implementation, transistor theory and implementation, and operational amplifier circuits. Meets for one 80 minute class and one 3-hour lab per week (two sections of lab offered). *Prerequisite*: Physics 245.

300-303 Special Topics
1-4 Credits
Any current offerings follow:

300 ST: Soft Matter Physics
Spring **Juers** **3 credits**
The physics of squishy stuff. Colloidal dispersions, polymers, surfactants, liquid crystals, gels, foams, and granular materials all share the characteristic of being easily deformed by external stresses. Many of these materials are common in everyday life, including biological materials, foods, and silly putty. They often run against, or straddle, conventional classifications of matter. A key aspect of soft matter is that interactions between a relatively small number of particles at nanometer lengths (i.e. thousands of particles) can cause complex behavior which has real impacts at human length scales. We will explore the phenomenology of a variety of soft matter as well as models which attempt to account for the complex behavior. The topic is interdisciplinary and should be of interest to students in a variety of fields. Problem sets, exams, and one project/report. *Prerequisite:* Physics 156. *Pre or Co-Requisite*: Mathematics 225. Distribution area: None.

325 Electricity and Magnetism
Fall **Gresham** **3 credits**
Electrostatics, electric and magnetic properties of materials, electromagnetic theory. Maxwell's equations, electromagnetic waves, boundary value problems. Includes mathematical methods of wide use in physics. Lectures and problems. *Prerequisites:* Physics 245 and Mathematics 244.

339 Advanced Laboratory
Spring **Moore** **3 credits**
Experimental investigations of sophisticated analog and digital circuitry and the fundamental physics underpinning their operation. Students will employ programming tools to automate and enhance aspects of experimental techniques and subsequent analysis of data. Students will design and implement extensions to experiments in classical and modern physics with an emphasis on laboratory technique, technical and scientific writing, and analysis. The course will be a combination of lecture and laboratory activities meeting two days a week. *Prerequisite:* Physics 267.

347 Classical Mechanics
Not offered 2019-20 **3 credits**
Non-inertial coordinate systems, systems of particles, rigid body motion. Lagrangian mechanics, normal modes of vibration, and Hamiltonian mechanics. Includes mathematical methods of wide use in physics. Lectures and problems. Three lectures per week. *Prerequisite:* Physics 245.

348 Optics
Not offered 2019-20 **3 credits**
Modern physical optics including a study of the propagation of light, coherence and interference, diffraction, image formation. Fourier optics, spatial filtering, polarization, the optical activity of solids, the quantum nature of light, lasers, and holography. Lectures and problems. Three lectures per week. *Prerequisite:* Mathematics 244. *Corequisite:* Physics 245.

357 Thermal Physics
Fall **Gresham** **3 credits**
Thermodynamics, entropy, thermodynamic potentials, phase changes, chemical reactions, kinetic theory, distributions, phase space, transport phenomena, fluctuations; classical and quantum statistical mechanics, application to solids, radiation, superfluids, lasers, and astrophysics. Lectures, discussion, and problems. *Prerequisite:* Mathematics 244. *Corequisite:* Physics 245.

377 Particle Physics
Not offered 2019-20 **3 credits**
From electrons to quarks to neutrinos to the Higgs mechanism, this course centers on a quantitative introduction to the Standard Model of particle physics---the well-tested model that describes all elementary particles and non-gravitational forces discovered up until the present. A significant portion of the class will be dedicated to learning and using the Feynman Calculus to calculate observable properties of elementary particle interactions. The course will end with a description of the Higgs mechanism and a discussion of some of the most pressing outstanding questions in particle physics. *Prerequisite:* Physics 245. *Recommended corequisite:* Mathematics 240.

385 Quantum Mechanics I
Fall **Sanborn** **4 credits**
This course begins with the quantum description of some two-dimensional systems (photon polarization and spin-1/2 particles) using the formalism of matrix mechanics. The course then moves on to cover two-particle systems, time evolution, and continuous systems (e.g., the harmonic oscillator). Three hours of lecture each week, and three hours of laboratory every other week. Laboratories include single photon interference, and tests of local realism (e.g., Bell inequalities). *Prerequisites:* Physics 245 and Mathematics 244. *Recommended prerequisite:* Mathematics 240 or 367.

451, 452 Advanced Topics in Physics
1-3 credits
Specialized topics in physics such as: spectroscopic techniques, semiconductor physics, laser physics, plasma physics, advanced instrumentation techniques. *Prerequisite:* consent of instructor. Any current offerings follow.

481, 482 Seminar
Not offered 2019-20 **1 credit**
Oral reports by students on individual reading and research, talks by faculty and visiting physicists, group discussion of readings of general interest. Students submit notes on talks and their own lecture notes. No examinations. One meeting per week. Graded credit/no credit. *Prerequisite:* consent of instructor.

483, 484 Independent Study
Fall, Spring **Staff** **1-3 credits**
Experimental or theoretical research or reading in an area of physics not covered in regular courses, under supervision of a faculty member. Maximum six credits. *Prerequisite:* consent of instructor.

490 Thesis
Fall, Spring **Staff** **3 credits**
Preparation of a thesis.

498 Honors Thesis
Fall, Spring **Staff** **3 credits**
Designed to further independent research or projects leading to the preparation of an undergraduate thesis or a project report. Required of and limited to senior honors candidates in physics. *Prerequisite:* admission to honors candidacy.