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.

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.

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

The Physics major:

- 30 credits (29 if completing Phys 347 in lieu of Phys 155) and 16 additional credits in mathematics (with no prior experience in physics)
- Required courses
    - Physics 145 or 155 or 347
    - Physics 156, 245, 255, 267, and 339
    - Four additional courses from among 300 to 480 level physics offerings and the course/lab combination of BBMB 324/334. This category's course selection must include at least three of the following: Physics 325, 347, 357, or 385
        - Physics 347 may not be used to satisfy multiple requirements
    - Mathematics 225, 244, and either 240 or 367
- Other notes
    - If students place out of 155 they must take 347
    - Students without prior computer programming experience should consider taking Computer Science 167 within their first two years of study.
    - No courses may be taken P-D-F
- Senior Requirements
  Written and oral exam

- Honors
    - Students submit a Honors in Major Study Application to their department
    - Students must submit a proposal for their thesis or project
        - Must be submitted within the first six weeks of the two-semester period in which student is eligible
    - Accumulated at least 87 credits
    - Completed two semesters of residency at Whitman.
    - Cumulative GPA of at least 3.300 on all credits earned at Whitman College
    - Major GPA of at least 3.500
    - Complete a written thesis or research project prepared exclusively for the satisfaction of this program

    - Earn a grade of at least A- on the honors thesis or project and the honors thesis course.
    - Pass the senior assessment with distinction
    - The department will submit the Honors applications to the Registrar's Office of students pursuing Honors by the specified deadline
    - The department submit "Senior Assessment/Major Study Certificate" to the Registrar's Office no later the Reading Day
    - An acceptable digital copy of the Honors Thesis must be submitted to Penrose Library no later than Reading Day

The Physics minor:

- 18 Credits
- Required Courses
    - Physics 145 or 155, 156, 245, 255
    - Six credits in physics 200-480, or BBMB 324 or 334

The Mathematics-Physics combined major:

- 49 credits (24 credits in Physics and 25 credits in Mathematics, if starting with Physics 155 and Mathematics 124 or 125)
- Required Mathematics courses
    - Mathematics 225, 240, 244, 367 or 368
    - 6 additional credits in Mathematic courses numbered above 200
- Required Physics courses
    - Physics 145 or 155 or 347
    - Physics 156, 245, 255, and 267
    - Three additional courses from among 300 to 480 level physics offerings and the course/lab combination of BBMB 324/334. This category's course selection must include at least two of the following: Physics 325, 339, 347, 357, or 385
        - Physics 347 may not be used to satisfy multiple requirements
- Other notes
    - If students place out of Physics 155 they must take 347
- Senior Requirements
    - Senior assessment
        - Written exam in mathematics
        - Written exam in physics
        - Combined oral exam
            - Scheduled by the physics department
- Honors
    - Students submit a Honors in Major Study Application to their department
    - Students must submit a proposal for their thesis or project
        - Must be submitted within the first six weeks of the two-semester period in which student is eligible
    - Accumulated at least 87 credits
    - Completed two semesters of residency at Whitman.
    - Cumulative GPA of at least 3.300 on all credits earned at Whitman College
    - Major GPA of at least 3.500
    - Complete a written thesis or research project prepared exclusively for the satisfaction of this program
    - Earn a grade of at least A- on the honors thesis or project and the honors thesis course.
    - Pass the senior assessment with distinction
    - The department will submit the Honors applications to the Registrar's Office of students pursuing Honors by the specified deadline
    - The department submit "Senior Assessment/Major Study Certificate" to the Registrar's Office no later the Reading Day

- An acceptable digital copy of the Honors Thesis must be submitted to Penrose Library no later than Reading Day

The Physics-Astronomy combined major:

- 59 Credits
  - 22 credits in astronomy
  - 24 credits in physics
  - 13 credits in mathematics (including Mathematics 125 and 126)
- Required Courses
  - Astronomy 177, 178, 179
  - Two courses form Astronomy 310, 320, 330
  - At least two credits from: Astronomy 310, 320, 330, 350, 360, 380, 391, 392 or 490
  - Physics 145 or 155 or 347
  - Physics 156, 245, 255, and 267
  - Two courses from Physics 325, 339, 347, 357, 385
  - One physics course 300-480 or BBMB 324 and 334
  - Mathematics 225 and 244
- Other notes
  - If students place out of Physics 155, they must take Physics 347
  - Physics 347 may not be used to satisfy multiple requirements
  - Additional physics courses, Computer Science 167, Mathematics 240, 367, and 368 are recommended
  - No courses may be taken P-D-F
- Senior Requirements
  - Senior assessment consisting of a
    - Two-part comprehensive written examination
    - One-hour oral exam conducted jointly

- Honors
  - Students submit a Honors in Major Study Application to their department
  - Students must submit a proposal for their thesis or project
    - Must be submitted within the first six weeks of the two-semester period in which student is eligible
  - Accumulated at least 87 credits
  - Completed two semesters of residency at Whitman.
  - Cumulative GPA of at least 3.300 on all credits earned at Whitman College
  - Major GPA of at least 3.500
  - Complete a written thesis or research project prepared exclusively for the satisfaction of this program
  - Earn a grade of at least A- on the honors thesis or project and the honors thesis course.
  - Pass the senior assessment with distinction
  - The department will submit the Honors applications to the Registrar's Office of students pursuing Honors by the specified deadline
  - The department submit "Senior Assessment/Major Study Certificate" to the Registrar's Office no later the Reading Day
  - An acceptable digital copy of the Honors Thesis must be submitted to Penrose Library no later than Reading Day

The Geology-Physics combined major

- 61-62 total credits (with no credit for prior experience)
  - 25 credits in geology
  - 21-22 credits in physics
  - 13 credits in mathematics
  - 4 credits in chemistry

- Required geology courses:
    - Introductory geology: Geology 110 and 111, or 120 and 121, or 125 and 126
    - Geology 227, 270, 310, 358, 405, 420, and 470
- Required physics courses:
    - Physics 145 or 155 or 347
    - Physics 156, 245, 255, and 267
    - Two of the following: Physics 325, 339, 347, 357, or 385
        - Physics 347 may not be used to satisfy multiple requirements
- Required supporting science courses:
    - Chemistry 125 and 135
    - Mathematics 225 and 244
- Other Notes:
    - No courses taken P-D-F may be applied to the major
    - If students place out of Physics 155, they must take Physics 347
- Senior requirements:
    - Geology 470
    - Senior assessment:
        - Comprehensive written exams in both geology and physics
        - One-hour oral exam by physics and geology faculty
- Honors
    - Students submit a Honors in Major Study Application to their department
    - Students must submit a proposal for their thesis or project
        - Must be submitted within the first six weeks of the two-semester period in which student is eligible
    - Accumulated at least 87 credits
    - Completed two semesters of residency at Whitman.
    - Cumulative GPA of at least 3.300 on all credits earned at Whitman College
    - Major GPA of at least 3.500
    - Complete a written thesis or research project prepared exclusively for the satisfaction of this program
    - Earn a grade of at least A- on the honors thesis or project and the honors thesis course.
    - Pass the senior assessment with distinction
    - The department will submit the Honors applications to the Registrar's Office of students pursuing Honors by the specified deadline
    - The department submit "Senior Assessment/Major Study Certificate" to the Registrar's Office no later the Reading Day
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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 124 or 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 267 (fall) and two 300-level Physics courses, including at least one of 325, 339, 347, 357, and 385; Mathematics 240 (nine credits).
IV. Fourth year: Two or more 300-level physics courses.

*Students with strong high school physics background (AP Physics C, Calculus-based physics, College level Physics) should consider stepping directly into Phys 156 during the fall of their first or second year. If interested, contact a physics professor about the placement exam prior to the fall semester.

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 advisor to design a course of study that will be best suit their goals.

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. To get course equivalency for Phys 145 or 155, the course must be calculus-based and have a lab component. The department administers placement exams during the summer for students with strong high school physics background who might be prepared to skip Phys 155 and begin the physics sequence with Phys 156 in the fall. A score of 5 on the Physics C advanced placement test transfers as credit for the lecture component of Phys 155; to obtain full credit for Phys 155, students must additionally take the 1-credit Phys155L course.

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 2023-24 **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.

105 Energy and the Environment
Spring **Hoffman** **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 2023-24 **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.

135 Introduction Physics Laboratory

Fall, Spring **Staff** **1 credit**

A course option specifically for students who score a 5 on the AP Physics C: Mechanics exam or who have taken calculus-based introductory physics without a laboratory at another institution; such students may complete Phys 135 to receive College credit equivalent to Phys 155. The course is a series of exercises and problems requiring the manipulation of physical apparatuses and use of data collection and computation tools. Laboratory exercises and problems are designed to deepen student understanding of physical phenomena addressed in General Physics 155. Phys 135 students enroll in a Phys 155L laboratory section alongside Phys 155 students. Graded credit/no credit only. Does not fulfill science or quantitative analysis distribution. *Prerequisite*: consent of instructor.

145 General Physics I – with Applications to Life and Earth Sciences

Fall **Staff** **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 124 or 125.

146 General Physics II – with Applications to Life and Earth Sciences

Spring **Gresham** **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 and Mathematics 124 or 125.

155 General Physics I

Spring **Juers, Singh** **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 124 or 125.

156 General Physics II

Fall **Gresham, Singh** **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 and Mathematics 124 or 125.

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

245 Twentieth Century Physics I
Spring **Singh** **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 **Staff** **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
Fall **Staff** **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 156.

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

300 ST: Computational Methods in Physics
Fall **Singh** **3 credits**
Computational tools and techniques are used ubiquitously in physics, and are integral to how physics is currently practiced. This course combines mathematical methods and computational tools relevant for modeling, solving and visualizing physical systems that cannot be solved by conventional analytical techniques. Topics from classical and quantum mechanics will be analyzed, along with applications to other areas of student interest. Methods taught include numerical solution of system of equations, differential equation solvers, Fourier transforms, optimization techniques, eigenvalue and other matrix problems in linear algebra. It will also focus on data analysis using linear regression. Students will use Python as the primary programming language, though syntaxial skills developed in computer programming can be translated to other languages as well. The course will consist of lectures and hands-on computational sessions, structured around individual and collaborative problem solving, and mini-projects. *Prerequisite:* Physics 245.

324 Biophysics
Spring **Juers** **3 credits**
The application of concepts and approaches from physics and mathematics (e.g. mechanics, thermodynamics, electromagnetism, quantum physics, probability) to deepen understanding of molecular and cell biology. We will focus on simplified models that capture the salient features of biological systems. Example topics include diffusion, hydrodynamics and cellular locomotion, free energy transduction, ligand binding, entropic forces, molecular motors, macromolecular conformation, signal propagation in neurons, gene expression, and vision. Includes

exercises in computation; no prior coding experience assumed. Three one-hour lectures per week; weekly problem sets; exams. May be elected as BBMB 324. *Prerequisites:* Physics 156 and Mathematics 225.

325 Electricity and Magnetism
Not offered 2023-24 **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.

334 Biophysics Laboratory
Spring **Juers** **1 credit**
Laboratory exercises on a range of biophysical topics. Experimental testing of models developed in BBMB 324. Study of macromolecules using techniques that may include absorption spectroscopy, fluorescence spectroscopy, circular dichroism, NMR, crystallization and structure determination via X-ray diffraction. One three- to four- hour laboratory per week. May be elected as BBMB 334. *Corequisite:* Physics 324. Open to non-BBMB/Physics majors only with consent of instructor.

339 Advanced Laboratory
Not offered 2023-24 **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. *Prerequisites:* Physics 245 and 267.

347 Classical Mechanics
Not offered 2023-24 **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 2023-24 **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.

350 Soft Condensed Matter
Fall **Juers** **3 credits**
Soft condensed matter is a rapidly growing area of study, focusing on the behavior of easily deformed materials. Colloids, polymers, surfactants, liquid crystals, gels, foams, and granular materials are all easily deformed by relatively weak external stresses including mechanical forces, electric or magnetic fields, fluid flow and thermal energy. Soft matter materials include biological materials, foods, and silly putty, and often confound, or straddle, conventional classifications of matter. We will investigate the behavior of several types of soft matter, and explore how models that incorporate self-assembly, mesoscopic length scales and coarse graining, viscoelasticity, thermal energy and entropy, and universality help us to understand their complex behavior. Assignments will include problem sets, exams, in-class lab activities and one project/report. *Prerequisite*: Physics 156. *Pre or Corequisite*: Mathematics 225.

357 Thermal Physics
Fall **Staff** **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 2023-24 **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
Spring **Gresham** **3-4 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). Lectures, discussion, problems. In years when the Quantum Mechanics laboratory is offered as a corequisite with the course experiments will include single photon interference, and tests of local realism (e.g., Bell inequalities). The course will be 3-credits with no lab, and 4-credits with the lab. *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
Spring **Singh** **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.