Physics

Physics is the study of matter and energy, and the fundamental forces of nature that govern the interactions between particles. Physicists study a wide range of physical phenomena, from quarks to black holes, from individual atoms to the many-body systems of superconductors. It is the foundation of all the physical sciences. The knowledge and problem-solving skills acquired by physics graduates enable them to pursue careers in a wide range of scientific and professional disciplines.

A Bachelor of Science degree from the Department of Physics prepares students to investigate a variety of problems in the area of physics. The basic core courses, supplemented by courses relevant to each specialized major option, provide a broad scientific education that prepares students for entry into physics-related careers as well as for advanced study in graduate schools in physics, engineering, other sciences, and professions such as law, medicine, and finance.

A master's degree is desirable for research, advancement in secondary school teaching in Indiana, and many positions in government or industry. The Ph.D. degree is required for advancement at a university and higher level positions in research.

The undergraduate program in Purdue's Department of Physics prepares students for participation in the frontiers of discovery in nanotechnology, condensed matter, nuclear physics, high energy particle physics, astronomy, biophysics, medical physics, and other branches of physics.

The Department of Physics emphasizes undergraduate research as an integral part of the learning experience that reinforces and amplifies skills acquired in the classroom. A seminar class is offered in the first semester to introduce freshman students to "Current Topics in Physics Research." The class serves to familiarize students with research being carried out currently in the department and prepares them to become involved in undergraduate research as early as their second semester at Purdue.

In their second year, students are encouraged to enroll in a one-credit-hour seminar class that helps them explore different careers in physics. It offers an opportunity for students to meet with alumni and professors in the Department of Physics and to learn valuable career development skills from these experiences.

The Department of Physics offers a Bachelor of Science with a major in physics with different specializations, including joint programs with the College of Engineering. A physics/math double major is also available to physics majors by taking seven additional courses in math.

A bachelor's degree in physics prepares students to pursue careers in an extraordinary variety of areas, including technical and managerial careers in industry, and basic research in universities, industrial laboratories, and national laboratories. The general problem solving skills developed in physics studies serve students well not only in careers in physics, but also in careers in other sciences, engineering, law, medicine, management, finance, and government.

Some examples of careers chosen by physics majors include: teacher, research scientist, lawyer, physician, architect, technical salesperson, electrical engineer, aeronautical engineer, astronaut, geophysicist, software designer, technical analyst, reliability engineer, and process engineer.

The most recent information can be found at www.physics.purdue.edu

The following courses are required of all Bachelor of Science physics majors. In meeting these requirements, candidates will also automatically fulfill the College of Science graduation requirements listed on pages 27–29. The core courses taken by all physics majors provide a solid foundation in classical mechanics, electricity and magnetism, waves and optics, quantum mechanics, thermal and statistical physics, modern physics, relativity, electronics, and computational physics. Choices are offered in advanced laboratory.

General Degree Requirements

Physics Major Requirements 31–55 credits

Students must complete the requirements for one of the following options:

1. Physics (35-41 credit hours in physics)
2. Physics with Honors (55 credit hours in physics)
3. Applied Physics (31-37 credit hours in physics)
4. Applied Physics - Honors (42 credit hours in physics)
5. Physics Teaching (31-39 credit hours in physics)
6. Dual B.S. degrees in Physics, and Materials Science and Engineering (31 credit hours in physics)

Science Requirements (All Plans) ***14–18 credits***

CHM 115 or 123 or 125 (Chemistry I) *4–5 cr.*
CHM 116 or 124 or 126 (Chemistry II) *4–5 cr.*
Six to eight additional credit hours of two laboratory sciences selected from allowed courses in biology, chemistry, earth and atmospheric science, astronomy, computer science or engineering. *6–8 cr.*

Mathematics Requirements (All Plans) ***21–23 credits***

Choose one course from each group:
a. MA 161 (Plane Analytic Geometry and Calculus I) (5 cr.), or MA 165 (Analytic Geometry and Calculus I) (4 cr.) *4–5 cr.*
b. MA 162 (Plane Analytic Geometry and Calculus II) (5 cr.), MA 166 (Analytic Geometry and Calculus II) (4 cr.), MA 173 (Calculus and Analytical Geometry II) (5 cr.), or MA 181 (Honors Calculus I) 5 cr.) *4–5 cr.*
c. MA 261 (Multivariate Calculus) (4 cr.), MA 174 (Multivariable Calculus) (4 cr.), MA 182 (Honors Calculus) (5 cr.), or MA 271 (Several Variable Calculus) (5 cr.) *4–5 cr.*
d. MA 262 (Linear Algebra and Differential Equations) (4 cr.), MA 266 (Ordinary Differential Equations) (3 cr.), MA 366 (Ordinary Differential Equations) (4 cr.) *3–4 cr.*
Six additional credit hours of approved courses in mathematics. *6 cr.*

Additional Requirements ***36–41 credits***

English Composition: See page 28 for English composition requirements. *6–7 cr.*
Modern Foreign Language: All College of Science majors are expected to have proficiency in two languages at the fourth-semester college level. (See "Modern Foreign Language Requirements," page 28). *12–16 cr.*
General Education Requirements: You must complete 18 credit hours of study in the humanities, social sciences and behavioral sciences. (See page 29 for requirements.) *18 cr.*

Free Electives: (All Plans) ***0–22 credits***

Free electives can be selected from any department of the University. Students are encouraged to use free electives to broaden their knowledge. However, free elective credit is not allowed for courses that significantly overlap courses taken to fulfill departmental degree requirements. Students must take at least as many free electives as are needed to bring the credit hour total to 124.

A student can also use free electives to acquire a minor in a related field or in other departments in the College of Science.

Grade Requirement

Students majoring in physics or applied physics must have a grade point average of 2.0 or above in all physics courses. For students majoring in honors physics program or in honors applied physics program, grades of "A" or "B" must be maintained in all physics and mathematics courses. For teaching majors, the minimum grade requirement is 2.5 in content areas and 3.0 in professional education courses.

Physics Major – Options

Students wishing to major in physics should complete the "General Degree Requirements" on pages 82–83, plus requirements specific to the physics option.

Physics

This program offers a specialization in physics as the core of a broad general education. By using free electives in the program, a student can include concentrations in condensed matter physics (PHYS 545), nuclear physics (PHYS 556), astrophysics (PHYS 560), particle physics (PHYS 564), and other areas. Students also are encouraged to participate in one or two semesters of individual research projects with a selected faculty member (PHYS 593).

Opportunities for employment in fields related to physics will be enhanced by taking free-electives in other science courses, such as biological sciences, bio-nucleonics, chemistry, computer science, geosciences, geophysics, meteorology, and/or in various branches of engineering. With assistance from an advisor, a student can prepare an individualized program suited to career plans by selecting electives from these areas or from any other area within the University. Normally, these courses are taken as juniors or seniors (see the sample program on pages 88–92).

Physics Major course requirements	**34–43 credits**
One of the following:	
a. PHYS 162 (Particle Kinematics and Conservation Laws) and PHYS 163 (Mechanics, Heat, and Kinetic Theory), or	
b. PHYS 152 (Mechanics)	*4–9 cr.*
One of the following:	
a. PHYS 271 and PHYS 271L (Electricity and Magnetism),	
b. PHYS 241 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal),	
c. PHYS 261 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal)	*5–6 cr.*
PHYS 342 or 344* (Modern Physics)	*3–4 cr.*
PHYS 342L (Modern Physics Laboratory) and PHYS 450 (Optics Laboratory)	*3 cr.*
PHYS 310 or 410* (Intermediate Mechanics)	*3–4 cr.*
PHYS 322 or 422* (Optics)	*3 cr.*
PHYS 330 or 430* (Intermediate Electricity and Magnetism)	*3 cr.*
PHYS 360 or 460* or 550 (Quantum Mechanics)	*3 cr.*
PHYS 515 or 416* (Thermal and Statistical Physics)	*3–4 cr.*
Advanced Physics Laboratory Requirement: Electronic Techniques for Physical Research: PHYS 536; or approved advanced laboratory courses e.g. PHYS 580 (Advanced Computational Physics), or PHYS 670F (Advanced Physics Laboratory)	*3–4 cr.*

Physics: Honors

The honors program offers an intensive concentration in physics that provides a solid foundation for advanced studies. Successful graduates of this challenging program are recognized for both the depth and breadth of their physics education, and they have gone on to the premier graduate schools in the country and ultimately to many different career choices.

The honors program provides a solid theoretical and experimental background in mechanics, electromagnetism, optics, thermal physics, quantum mechanics, and the micro-structure of matter. See the sample program on page 89).

A very important feature of this plan is a senior-year research project (PHYS 593) in some area of modern physics, such as condensed matter physics, nuclear physics, elementary particle physics, biophysics, geophysics, etc. Students receive individual supervision and guidance from a faculty member whose specialty matches the area of their research project. PHYS 593 introduces students to the type of research atmosphere they later might encounter as professional physicists, and it promotes self-motivation and independence in their work.

Students interested in the honors program typically start by taking PHYS 162 and 163 as freshmen. Students from other majors who have taken PHYS 152 and 241/261 may switch into the Honors Physics major. However, it is advisable that all students pursuing the honors program take PHYS 344, 422, and 450 during the second semester of the sophomore year. Admission to, and continuation in, the honors program requires a grade of "A" or "B" in all physics and mathematics courses or special permission from the Physics Undergraduate Committee.

Physics: Honors course requirements	**54–55 credits**
PHYS 162 (Particles, Kinematics, and Conservation Laws)	*4 cr.*
PHYS 163 (Mechanics, Heat, and Kinetic Energy)	*5 cr.*
PHYS 271 and 271L (Electricity and Magnetism)	*6 cr.*
PHYS 344 (Modern Physics: Honors)	*4 cr.*
PHYS 422 (Optics: Honors)	*3 cr.*
PHYS 342L and PHYS 450 (Intermediate Laboratories)	*3 cr.*
PHYS 410 and PHYS 411 (Physical Mechanics I, II: Honors)	*5 cr.*
PHYS 430 and PHYS 431 (Electricity and Magnetism I, II: Honors)	*5 cr.*
PHYS 460 and PHYS 461 (Quantum Mechanics I, II)	*6 cr.*
PHYS 416 (Thermal and Statistical Physics: Honors)	*4 cr.*

**Required for Honors. May be used as substitute with the permission of the department.*

Advanced Physics Laboratory Requirement

PHYS 536 (Electronic Techniques for Physical Research) or approved advanced laboratory courses, e.g. PHYS 580 (Advanced Computational Physics) or PHYS 670F (Advanced Physics Laboratory) *3–4 cr.*

Senior Honors Project: PHYS 593, two semester-total of 6 credits or approved by the department. *6 cr.*

Applied Physics

The applied physics plan of study is especially geared toward providing the physics graduate with specific expertise in preparation for immediate employment in the corporate research world or in government laboratories, in addition to further graduate study. Students obtain a solid physics background plus significant experience in one or more specialties of their own choosing, selected from a wide range of choices from Purdue's Science and Engineering colleges.

The basic plan of study combines about 29-39 credit hours of physics with 30 credit hours of applied electives.

Applied Physics course requirements **59–69 credits**

PHYS 162 (Particle Kinematics and Conservation Laws) and PHYS 163 (Mechanics, Heat, and Kinetic Theory), or PHYS 152 (Mechanics) *4–9 cr.*

Electricity and Magnetism:

One of the following:

a. PHYS 271 and PHYS 271L (Electricity and Magnetism, and Laboratory) (6 cr.)

b. PHYS 241 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal) (5 cr.)

c. PHYS 261 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal) (6 cr.) *5–6 cr.*

Modern Physics: PHYS 342 (3 cr.) or 344* (4 cr.) *3–4 cr.*

Intermediate Laboratories: PHYS 450 (Optics Laboratory) (2 cr.) and PHYS 342L (Modern Physics Laboratory) (1 cr.) (if PHYS 342 is taken) *2–3 cr.*

Intermediate Mechanics: PHYS 310 (4 cr.) or 410* (3 cr.) *3–4 cr.*

Intermediate Optics: PHYS 322 or 422* *3 cr.*

Intermediate Electricity and Magnetism: PHYS 330 or 430* *3 cr.*

Quantum Mechanics: PHYS 360 or 460* or 550 *3 cr.*

Thermal and Statistical Physics: PHYS 515 or 416* *3–4 cr.*

Applied physics elective courses totaling 30 credit hours are required in addition to above courses. These must be approved and signed by the advisor. A number of recommended specialties for this major have been listed below. New combinations are also possible to arrange in consultation with the department. Each student is required to have a major concentration in one specialty (14 credit hours or more), or a minor concentration in two specialties (9 credit hours or more each). Four of the elective courses must involve laboratory work.

Note: Only six credit hours of foreign language are required for regular or honors applied physics programs. Applied electives with laboratory components may be used to satisfy part of the College of Science Laboratory Science requirement (See the sample program on page 89).

Applied Physics — Specialties

The specialties under the applied physics curriculum include nanoscience and nanotechnology, nuclear engineering, aeronautical and astronautical engineering, biophysics and biomedical engineering, medical physics, computer science, electrical and computer engineering, and geophysics. Individually tailored specialties may be chosen by the student in consultation with an advisor.

Materials Specialty. This program of study is based on the currently existing model for the Bachelor of Science with the Applied Physics Specialization. It incorporates a core of nine physics (31 credits) courses and seven MSE (20 credits) courses and, in addition, provides for 16 credits of technical electives for building a strong background in the area of materials and applied physics. The sample study plan requires a total of 132 credits for graduation. See the sample program on page 90.

**Required for Honors*

Applied Physics with Honors

A Bachelor of Science degree with a major in applied physics with honors can be obtained by replacing several required courses in the regular applied physics program with the corresponding honors courses. All other applied physics requirements must still be met. In addition, grades of "A" or "B" must be maintained in all physics and mathematics courses.

Applied Physics: Honors course requirements	**70-71 credits**
PHYS 162 (Particles, Kinematics, and Conservation Laws) (4 cr.)	*4 cr.*
PHYS 163 (Mechanics, Heat, and Kinetic Energy) (5 cr.)	*5 cr.*
One of the following options:	
a. PHYS 271 and PHYS 271L (Electricity and Magnetism)	
b. PHYS 241 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal)	
c. PHYS 261 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal)	*5–6 cr.*
PHYS 344 (Modern Physics) (4 cr.)	*4 cr.*
PHYS 422 (Optics) (3 cr.)	*3 cr.*
PHYS 430 (Intermediate Electricity and Magnetism) (3 cr.)	*3 cr.*
PHYS 460 (Quantum Mechanics) (3 cr.)	*3 cr.*
PHYS 416 (Thermal and Statistical Physics) (4 cr.)	*4 cr.*
PHYS 450 (Intermediate Laboratory) (2 cr.)	*2 cr.*
PHYS 461 (Quantum Mechanics II: Honors) (4 cr.)	*4 cr.*
PHYS 410 (Physical Mechanics I: Hon.) 3 cr.	

Applied physics elective courses totaling 30 credit hours are required in addition to above courses. This must be approved and signed by the advisor. A number of recommended specialties for this major were listed in the previous section. New combinations are also possible to arrange in consultation with the department. Each student is required to have a major concentration in one specialty (14 credit hours or more), or a minor concentration in two specialties (9 credit hours or more each). Four of the elective courses must involve laboratory work.

Note: Only six credit hours of foreign language are required for regular or honors applied physics programs. Applied electives with laboratory components may be used to satisfy part of the College of Science laboratory science requirement.

Physics Teaching

This degree provides a strong background in physics, in addition to a license to teach physics at a high school and middle school level. The requirements for this degree are listed below. Additional guidelines are available at the College of Science Counseling Office (www.science.purdue.edu/counseling/) and the Office of Professional Preparation and Licensure (http://admin2.soe.purdue.edu/oppl/program.html).

Since teacher certification requirements are determined by each individual state, a student will need to contact the state education licensing agency in state(s) where he or she plans to teach. This information is available online at www.nasdtec.org/state-info.tpl. Prospective teachers are exempt from the second year of the foreign language requirement, provided they successfully complete the professional semester within the baccalaureate program. The professional semester is the one that includes six weeks of a methods course at Purdue and 10 weeks of teaching. To receive a Bachelor of Science with a major in physics teaching, a student must maintain a grade-point average of 2.5 or above in all physics courses, and 3.0 or above in education courses required to meet licensing requirements.

Physics Teaching Course Requirements	**63–71 credits**
Physics courses	***31–39 credits***
One of the following options:	
a. PHYS 162 (Particle Kinematics and Conservation Laws) and PHYS 163 (Mechanics, Heat, and Kinetic Theory)	
b. PHYS 152 (Mechanics)	*4–9 cr.*
One of the following options:	
a. PHYS 271 and PHYS 271L (Electricity and Magnetism)	
b. PHYS 241 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal)	

**Required for Honors*

c. PHYS 261 (Electricity and Optics) and PHYS 252 (Electricity and Optics Laboratory) and PHYS 290D (Heat and Thermal) *5–6 cr.*

d. PHYS 251 (Heat, Electricity, and Optics), PHYS 252 (Electricity and Optics Laboratory), and PHYS 290D (Heat and Thermal) *5–6 cr.*

PHYS 342 (Modern Physics) or 344* (Modern Physics: Honors) (3-4 cr.) *3–4 cr.*

PHYS 342L (Modern Physics Laboratory) and PHYS 450 (Optics Laboratory I: Honors) (3 cr.) *3 cr.*

PHYS 310 (Intermediate Mechanics) or 410* (Physical Mechanics I: Honors) (3-4 cr.) *3–4 cr.*

PHYS 322 (Intermediate Optics) or 422* (Intermediate Optics: Honors) (3 cr.) *3 cr.*

PHYS 330 (Intermediate Electricity and Magnetism) or 430* (Intermediate Electricity and Magnetism: Honors) (3 cr.) *3 cr.*

One of: PHYS 360 (Quantum Mechanics), PHYS 460* (Quantum Mechanics: Honors), PHYS 550 (Introduction to Quantum Mechanics) (3 cr.) *3 cr.*

One of: PHYS 536 (Electronics Techniques for Research), PHYS 580 (Computational Physics), PHYS 670F (Advanced Physics Laboratory) (3-4 cr.) *3–4 cr.*

Professional Education courses ***32 credits***

EDCI 270 (Introduction to Educational Technology and Computing) (2 cr.), EDFA 200 (History and Philosophy of Education) (3 cr.), EDCI 205 (Exploring Teaching as a Career) (3 cr.), EDCI 285 (Multiculturalism and Education) (3 cr.), EDPS 235 (Learning and Motivation) (3 cr.), EDPS 265 (The Inclusive Classroom) (3 cr.), EDCI 425 (Teaching of Mathematics in Secondary Schools) (3 cr.), EDCI 428 (Teaching Mathematics in the Middle and Junior High School) (2 cr.), EDCI 498M (Supervised Teaching in Secondary Mathematics Education) (10 cr.) *32 cr.*

Bachelor of Science with a major in Physics and Bachelor of Science in Materials Science and Engineering

This is a five-year joint program for the dual degree of Bachelor of Science with a major in Physics and Bachelor of Science in Materials Science and Engineering. The program requires 10 semesters and is designed to satisfy the accreditation requirements for both degrees. As indicated in the sample plan, a total of 159 credits is required (see the sample program on page 91). Students need to complete the requirements of the Physics core major and those courses required for the Materials Science and Engineering.

Special Programs and Opportunities

Fifth-Year M.S. Option. Many positions for physicists require a Master of Science in physics. Students who complete the Bachelor of Science requirements in Applied Physics at Purdue with at least a 3.0 grade-point average can apply for admission to the Graduate School as a Master's candidate in Applied Physics. The Master's degree requirements (12 credit hours in physics and 18 credit hours in applied electives) can be completed in one year under the usual rules of the Graduate School.

Cooperative Education Program. The Department of Physics participates in the Cooperative Education Program. Interested students can contact the Cooperative Education Coordinator, Department of Physics, Physics Building at 765-494-5383.

Under the physics or applied physics honors programs, a student with a grade index of 2.8 or better, or under the physics or applied physics regular programs, a student with a grade index of 3.0 or better (or in the upper half of class) is eligible to apply for the Cooperative Education Program. Normally, a student would complete the curriculum through the third or fourth semester before leaving campus for a work period.

The department also encourages students to participate in study abroad, summer internship programs, and summer undergraduate research opportunities offered across the world.

**Required for Honors*