

PHYSICS AND ASTRONOMY

The Physics Major

Physics and astronomy are basic natural sciences which attempt to describe and provide an understanding of both our world and our universe. Physics serves as the underpinning of many different disciplines including the other natural sciences and technological areas. Graduates are proficient in the methods of rigorous scientific analysis, relevant mathematical techniques, and modern computational and laboratory methods. They have a broad knowledge of physics, including mechanics, electricity and magnetism, thermodynamics, and modern physics. They are able to communicate clearly and effectively at general and technical levels. They are prepared to pursue a wide range of careers as a professional physicist, astronomer, or science educator. They are also prepared to pursue advanced studies and careers in areas as diverse as engineering, medicine, law, and business administration. Many opportunities exist for students who terminate their studies with a bachelor's degree, especially when combined with technology studies in other areas. Students who meet the necessary scholastic standards often continue their studies in a graduate college, exploring and contributing to new developments in the field.

Faculty have approved a variety of completion pathways for the physics major for students who wish to establish a clear strength in a field of application of physics, such as computer science, science education, mechanical engineering, or even science writing. These pathways make double majors more feasible and are appropriate for students planning to enter the job market with their bachelor's degree.

Student Learning Outcomes

The expected outcomes for students in the program are:

1. A broad knowledge of physics, including mechanics, electricity and magnetism, thermodynamics, wave motion and modern physics.
2. Proficiency in laboratory methods.
3. Proficiency in modern scientific computational methods.
4. A sound foundation in the liberal arts including proficiency in communication skills.

DEGREE REQUIREMENTS

All Physics students complete 49 credits of required classes in Physics and Math and additional credits of Advanced Coursework. For the Advanced Coursework, students choose one of three focus areas selected based on the career goals of the student: Standard Physics, Teacher Preparation, or Physics Applications.

Physics Core

PHYS 1990	Introductory Seminar	1
PHYS 2410	Principles and Symmetries in Classical Physics I *	5
PHYS 2420	Principles and Symmetries in Classical Physics II *	5
PHYS 3210	Introduction to Modern Physics I	3
PHYS 3210L	Introductory Laboratory in Modern Physics I	1
PHYS 3610	Classical Mechanics	3
PHYS 3640	Electricity and Magnetism I	3
PHYS 3040	Thermal Physics	3
PHYS 4800	Quantum Mechanics I	3

* PHYS 2310/PHYS 2310L and PHYS 2320/PHYS 2320L may be substituted for PHYS 2410 and PHYS 2420.

Total Credits 27

Math Core

MATH 1650	Calculus I	4
MATH 1660	Calculus II	4
MATH 2650	Calculus III	4
MATH 2670	Elementary Differential Equations and Laplace Transforms	4
MATH 3850	Introduction to Partial Differential Equations	3
MATH 2070	Matrices and Linear Algebra	3-4
	or MATH 3170 Theory of Linear Algebra	

All physics majors are encouraged to take STAT 3410.

Total Credits 22-23

Advanced Coursework

In addition to the 49-credit core, students choose one of three focus areas: Standard Physics, Teacher Preparation, or Physics Applications.

Standard Physics Focus

Students with the Standard Physics focus will complete these additional 19 credits.

PHYS 3220 & 3220L	Introduction to Modern Physics II and Introductory Laboratory in Modern Physics II	4
PHYS 3620	Intermediate Mechanics	3
PHYS 3650	Electricity and Magnetism II	3
PHYS 3100	Electronic Instrumentation for Experimental Physics	4

A minimum of 2 additional lab credits from the following: 2

ASTRO 3440L	Astronomy Laboratory	
ASTRO 4500L	Undergraduate Research	
PHYS 3110	Intermediate Laboratory	
PHYS 3110T	Intermediate Laboratory for Secondary Physics Teachers	

PHYS 4500L	Undergraduate Research	
PHYS 4700L	Applied Physics Laboratory	
And at least 3 credits from:		3
ASTRO 3420	Introduction to Solar System Astronomy	
ASTRO 3460	Introduction to Astrophysics	
ASTRO 4050	Astrophysical Cosmology	
PHYS 4210	Ultrafast Laser Science and Spectroscopy	
PHYS 4220	Foundations of Quantum Computing	
PHYS 4320	Molecular and Cell Biophysics	
PHYS 4810	Quantum Mechanics II *	
PHYS 4960	Modern Optics	
PHYS 5110	Condensed Matter Physics I	
PHYS 5260	Particle and Nuclear Physics	
PHYS 5280	Mathematical Methods for the Physical Sciences	
PHYS 5310	Statistical Mechanics	
PHYS 5340	Symmetry and Group Theory in Physics	
PHYS 5410	General Relativity	

*Students intending to pursue graduate study in physics or astronomy/astrophysics should choose the option PHYS 4810 Quantum Mechanics II.

Total Credits 19

Optional Minor

Students completing the Standard Physics Focus who plan to continue their studies in Astronomy and Astrophysics should complete the Astronomy minor by using the following courses. The department has created a sample four-year plan (<https://www.physastro.iastate.edu/undergraduate-programs/>) for those who want to add this minor to their Physics major.

ASTRO 1500	Stars, Galaxies, and Cosmology	3
ASTRO 3420	Introduction to Solar System Astronomy	3
ASTRO 3440L	Astronomy Laboratory (*)	3
ASTRO 3460	Introduction to Astrophysics	3
ASTRO 4050	Astrophysical Cosmology	3

*ASTRO 3440L can be applied to meet the requirements for the ASTRO Minor and to meet the additional 2 credit lab experience requirement of the major.

Total Credits 15

Teacher Preparation Focus

Students who are preparing to become a teacher meet the advanced coursework requirement of the Physics Major by completing the following 20 credits and meeting the requirements of the Secondary Major in Education. (<http://catalog.iastate.edu/collegeofhumansciences/educationsecondary/#curriculumtext>) Note: Teacher license

requirements are established by the Iowa Department of Education and the Iowa Board of Educational Examiners and are subject to change. Recent changes may not be reflected in this catalog, but advisers and faculty will be aware.

STAT 2010	Introduction to Statistical Concepts and Methods	4
PHYS 3220	Introduction to Modern Physics II	3
PHYS 3110T	Intermediate Laboratory for Secondary Physics Teachers	3
ASTRO 1500	Stars, Galaxies, and Cosmology	3
	or ASTRO 1200 The Sky and the Solar System	
PHYS 3990	Seminar on Secondary School Physics	1-2
EDUC 4180	Secondary Science Methods I	3
EDUC 4190	Secondary Science Methods II	3

Total Credits 20-21

Students who are seeking to add a Math endorsement to their Teacher Preparation program in Physics will also need to complete the following courses in Mathematics.

MATH 3970	Teaching Secondary Mathematics Using University Mathematics	3
MATH 4970	Teaching Secondary School Mathematics	3
MATH 4350	Geometry I	3

Physics Applications Focus

Students who are not planning to attend graduate school in Physics or become teachers, can meet the advanced coursework requirements of the Physics major by completing one of several approved completion pathways for the physics major. This coursework can help a Physics graduate establish a clear strength in a field of application of physics, such as computer science, mechanical engineering, data science, or even science writing. These pathways, ranging from 16 to 24 additional credits, also make double majors with physics more feasible. Contact the Physics advisor for further information concerning programs of study in Physics Applications. Sample Physics with applications programs are listed at the department web site (<https://www.physastro.iastate.edu/undergraduate-programs/>).

Additional Requirements

As majors in the College of Liberal Arts and Sciences, Physics students must meet College of Liberal Arts and Sciences (<http://catalog.iastate.edu/collegeofliberalartsandsciences/#lascollegerequirementstext>) and University-wide requirements (<http://catalog.iastate.edu/collegescurricula/>) for graduation in addition to those stated above for the major. This includes meeting the university-wide Communication Proficiency Grade Requirement (<http://catalog.iastate.edu/academics/#communicationproficiencypolicytext>), by earning credit for ENGL 1500,

a grade of C or better in ENGL 2500 (or ENGL 2500H) and a grade of C- or better in ENGL 3020, ENGL 3050, ENGL 3090 or ENGL 3140.

Students in all ISU majors must complete a three-credit course in U.S. diversity and a three-credit course in international perspectives. Check (<http://www.registrar.iastate.edu/courses/div-ip-guide.html>) for a list of approved courses. Discuss with your advisor how the two courses that you select can be applied to your graduation plan.

LAS majors require a minimum of 120 credits, **including a minimum of 45 credits at the 3000/4000 level**. You must also complete the LAS world language and career proficiency requirements (LAS 2030 Professional Career Preparation).

Physics, B.S

The plan below is a sample program of study for a student completing the Standard Physics Focus.

Freshman

Fall	Credits	Spring	Credits
ENGL 1500	3	PHYS 2420	5
PHYS 1990	4	R MATH 2650	4
PHYS 2410	3	5 Social Science Choice	3
MATH 1660	5	4 Natural Science Choice	5
Humanities Choice	3		
LIB 1600	1		
	16		17

Sophomore

Fall	Credits	Spring	Credits
ENGL 2500	3	PHYS 3610	3
PHYS 3210	3	PHYS 3220	3
PHYS 3210L	1	PHYS 3220L	1
MATH 2670	3	4 MATH 3850	3
Humanities Choice	1	3 LAS 2030	1
Natural Science Choice	3	3 Social Science Choice	3
		Humanities Choice	3
	17		17

Junior

Fall	Credits	Spring	Credits
PHYS 3620	3	PHYS 3040	3
PHYS 3640	3	PHYS 3650	3
ENGL 3020, 3050, 3090, or 3140	3	3 Social Science Choice	3
MATH 3170 or 2070	3	3-4 Humanites Choice	3
World Language (or Elective)	4-3	4-3 World Language (or Elective)	4-3
	16		16-15

Senior

Fall	Credits	Spring	Credits
PHYS 3100	4	PHYS 3110 ¹	2
PHYS 4800	3	PHYS 4810 ²	3
Elective	3	Elective	3
ASTRO 3440L ¹	3	Elective	3
		Elective	3
	13		14

¹ Students must earn a minimum of two laboratory credits from PHYS 3110, 3110T, 4500L, 4700L; ASTRO 3440L, 4500L.

² Recommended but not required. Highly recommended for those students planning gradate study.

Four year plans for advanced coursework options to complete the Physics major are listed at <https://www.physastro.iastate.edu/undergraduate-programs> (<https://www.physastro.iastate.edu/undergraduate-programs/>).

Students in all ISU majors must complete a three-credit course in U.S. diversity and a three-credit course in international perspectives. Check (<http://www.registrar.iastate.edu/courses/div-ip-guide.html>) for a list of approved courses. Discuss with your advisor how the two courses that you select can be applied to your graduation plan.

Minor in Physics

The department offers a minor in physics which may be earned by completing 20 credits in physics courses chosen as follows:

PHYS 2410	Principles and Symmetries in Classical Physics I *	5
PHYS 2420	Principles and Symmetries in Classical Physics II *	5
PHYS 3210	Introduction to Modern Physics I	3

One of the following

PHYS 3210L	Introductory Laboratory in Modern Physics I	
PHYS 3220L	Introductory Laboratory in Modern Physics II	
PHYS 3100	Electronic Instrumentation for Experimental Physics	
PHYS 3110	Intermediate Laboratory	
PHYS 3110T	Intermediate Laboratory for Secondary Physics Teachers	

Other acceptable courses

PHYS 3040	Thermal Physics	
PHYS 3060	Physics of Wave Motion	
PHYS 3220	Introduction to Modern Physics II	
PHYS 3610	Classical Mechanics	
PHYS 3620	Intermediate Mechanics	

PHYS 3640	Electricity and Magnetism I
PHYS 3650	Electricity and Magnetism II
PHYS 4210	Ultrafast Laser Science and Spectroscopy
PHYS 4320	Molecular and Cell Biophysics
PHYS 4800	Quantum Mechanics I
PHYS 4810	Quantum Mechanics II
PHYS 4960	Modern Optics

*PHYS 2310/231L and PHYS 2320/232L may be substituted for PHYS 2410 and PHYS 2420

Minor in Astronomy

The department offers a minor in astronomy which may be earned by completing 15 credits as laid out below. 12 or more credits must be at the 3000 level or higher. Note that only ASTRO 3440L may be used to satisfy both the requirements of a physics major and an astronomy minor.

ASTRO 3440L	Astronomy Laboratory	3
ASTRO courses*		9-12
3 credits from the following (if only 9 Astro credits)		3
PHYS 3040	Thermal Physics	
PHYS 3210	Introduction to Modern Physics I	
PHYS 3610	Classical Mechanics	
PHYS 3620	Intermediate Mechanics	
PHYS 3640	Electricity and Magnetism I	
PHYS 3650	Electricity and Magnetism II	
PHYS 4800	Quantum Mechanics I	
PHYS 4810	Quantum Mechanics II	
PHYS 4960	Modern Optics	
AERE 3510	Astro dynamics I	

The department has a set of recommended courses for Physics students interested in pursuing graduate school in Astronomy and Astrophysics.

The minor must include at least 9 credits that are not used to meet any other department, college, or university requirement.

Graduate Study

The department offers studies for the degrees Master of Science and Doctor of Philosophy with majors at both levels in astrophysics, condensed matter physics, high energy physics, nuclear physics, and physics; and minor credit courses for students majoring in other departments.

Facilities of various research groups of the department and the Ames Laboratory are available for research.

Students with bachelor's degrees in physics or astronomy from other institutions ordinarily will qualify for graduate study at Iowa State University provided they have satisfactorily completed course work similar to that suggested for undergraduate majors here intending to go on to graduate school. In some cases, additional instruction at the intermediate level may be required.

Graduates have a broad understanding of physical science, as well as mastery of state-of-the-art methods in their area of specialization. They are able to communicate effectively to a wide range of audiences, from the general public to research colleagues. Their skills in rigorous scientific thinking prepare them for leadership in the broader community. They are skilled in carrying out research, communicating research results, and soliciting research support. They have considerable teaching experience. They have developed problem solving skills that prepare them for careers in either industry or academia.

All candidates for an advanced degree in physics are expected to complete:

PHYS 5310	Statistical Mechanics	3
PHYS 5640	Advanced Classical Mechanics	3
PHYS 5710	Electricity and Magnetism I	3
PHYS 5720	Electricity and Magnetism II	3
PHYS 5910	Quantum Physics I	4
PHYS 5920	Quantum Physics II	4

Candidates for an advanced degree in astrophysics should complete:

PHYS 5310	Statistical Mechanics	3
or PHYS 5640	Advanced Classical Mechanics	
PHYS 5710	Electricity and Magnetism I	3
PHYS 5910	Quantum Physics I	4
ASTRO 5050	Astrophysical Cosmology	3
ASTRO 5100	Observational Astrophysics	3

Astrophysics Ph.D. candidates must take at least three of the 5800 level Astro courses, while candidates for the M.S. must take at least two 5800 level Astro courses.

A thesis is always required for all Ph.D. majors. The degree Master of Science is offered both with and without thesis. For all graduate majors the basic requirements for the M.S. are the same: at least 30 credits of acceptable graduate work must be completed, not less than 21 of which must be in physics or astronomy. Students choosing a M.S. degree with thesis may apply up to 8 credits of 6990 but no credits of 5990 toward the minimum 30 credits. Students choosing a degree without thesis should apply 2 credits of 5990, but may not apply any credits of 6990, toward the minimum 30 credits.

In addition to course work in the major area of study, all candidates for the Ph.D. degree must complete 9 credits of graduate course work outside this area including at least one 5000 or 6000 level introductory course in another area of physics. Each candidate for the Ph.D. degree is required to teach one year of elementary physics or astronomy.

Graduate students interested in a physics minor should contact the department for requirements.