

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 199	Introductory Seminar	1
PHYS 241	Principles and Symmetries in Classical Physics I *	5
PHYS 242	Principles and Symmetries in Classical Physics II *	5
PHYS 321	Introduction to Modern Physics I	3
PHYS 321L	Introductory Laboratory in Modern Physics I	1
PHYS 361	Classical Mechanics	3
PHYS 364	Electricity and Magnetism I	3
PHYS 304	Thermal Physics	3
PHYS 480	Quantum Mechanics I	3

* PHYS 231/PHYS 231L and PHYS 232/PHYS 232L may be substituted for PHYS 241 and PHYS 242.

Total Credits 27

Math Core

MATH 165	Calculus I	4
MATH 166	Calculus II	4
MATH 265	Calculus III	4
MATH 267	Elementary Differential Equations and Laplace Transforms	4
MATH 385	Introduction to Partial Differential Equations	3
MATH 207	Matrices and Linear Algebra	3-4
or MATH 317	Theory of Linear Algebra	

All physics majors are encouraged to take STAT 341.

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 322	Introduction to Modern Physics II & 322L	4
PHYS 362	Intermediate Mechanics	3
PHYS 365	Electricity and Magnetism II	3
PHYS 310	Electronic Instrumentation for Experimental Physics	4

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

ASTRO 344L	Astronomy Laboratory	
ASTRO 450L	Undergraduate Research	
PHYS 311	Intermediate Laboratory	
PHYS 311T	Intermediate Laboratory for Secondary Physics Teachers	

PHYS 450L	Undergraduate Research	
PHYS 470L	Applied Physics Laboratory	
And at least 3 credits from:		3
ASTRO 342	Introduction to Solar System Astronomy	
ASTRO 346	Introduction to Astrophysics	
ASTRO 405	Astrophysical Cosmology	
PHYS 421	Ultrafast Laser Science and Spectroscopy	
PHYS 422	Foundations of Quantum Computing	
PHYS 432	Molecular and Cell Biophysics	
PHYS 461	Physics of Biomolecules	
PHYS 481	Quantum Mechanics II *	
PHYS 496	Modern Optics	
PHYS 511	Condensed Matter Physics I	
PHYS 526	Particle and Nuclear Physics	
PHYS 528	Mathematical Methods for the Physical Sciences	
PHYS 531	Statistical Mechanics	
PHYS 534	Symmetry and Group Theory in Physics	
PHYS 541	General Relativity	
*Students intending to pursue graduate study in physics or astronomy/astrophysics should choose the option PHYS 481 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 150	Stars, Galaxies, and Cosmology	3
ASTRO 342	Introduction to Solar System Astronomy	3
ASTRO 344L	Astronomy Laboratory (*)	3
ASTRO 346	Introduction to Astrophysics	3
ASTRO 405	Astrophysical Cosmology	3
*ASTRO 344L 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/previouscatalogs/2023-2024/>

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 201	Introduction to Statistical Concepts and Methods	4
PHYS 322	Introduction to Modern Physics II	3
PHYS 311T	Intermediate Laboratory for Secondary Physics Teachers	3
ASTRO 150	Stars, Galaxies, and Cosmology	3
or ASTRO 120	The Sky and the Solar System	
PHYS 399	Seminar on Secondary School Physics	1-2
EDUC 418	Secondary Science Methods I	3
EDUC 419	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 397	Teaching Secondary Mathematics Using University Mathematics	3
MATH 497	Teaching Secondary School Mathematics	3
MATH 435	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/previouscatalogs/2023-2024/collegeofliberalartsandsciences/#lascollegerequirementstext>) and University-wide requirements (<http://catalog.iastate.edu/previouscatalogs/2023-2024/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/previouscatalogs/2023-2024/academics/#communicationproficiencypolicytext>), by earning credit for ENGL 150, a grade of C or better in ENGL 250 (or ENGL 250H) and a grade of C- or better in ENGL 302 (<http://catalog.iastate.edu/previouscatalogs/2023-2024/search/?P=ENGL%20302>), ENGL 305 (<http://catalog.iastate.edu/previouscatalogs/2023-2024/search/?P=ENGL%20305>), ENGL 309 (<http://catalog.iastate.edu/previouscatalogs/2023-2024/search/?P=ENGL%20309>) or ENGL 314 (<http://catalog.iastate.edu/previouscatalogs/2023-2024/search/?P=ENGL%20314>).

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 300/400 level**. You must also complete the LAS world language and career proficiency requirements (LAS 203 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 150	3 PHYS 242	5
PHYS 199	R MATH 265	4
PHYS 241	5 Social Science Choice	3
MATH 166	4 Natural Science Choice	5
Humanities Choice	3	
LIB 160	1	
16		17

Sophomore

Fall	Credits Spring	Credits
ENGL 250	3 PHYS 361	3
PHYS 321	3 PHYS 322	3
PHYS 321L	1 PHYS 322L	1
MATH 267	4 MATH 385	3
Humanities Choice	3 LAS 203	1
Natural Science Choice	3 Social Science Choice	3
	Humanities Choice	3
17		17

Junior

Fall	Credits Spring	Credits
PHYS 362	3 PHYS 304	3
PHYS 364	3 PHYS 365	3
ENGL 302, 305, 309, or 314	3 Social Science Choice	3
MATH 317 or 207	3-4 Humanites Choice	3
World Language (or Elective)	4-3 World Language (or Elective)	4-3
16		16-15

Senior

Fall	Credits Spring	Credits
PHYS 310	4 PHYS 311 ¹	2
PHYS 480	3 PHYS 481 ²	3
Elective	3 Elective	3
ASTRO 344L ¹	3 Elective	3
	Elective	3
13		14

¹ Students must earn a minimum of two laboratory credits from PHYS 311, 311T, 450L, 470L; ASTRO 344L, 450L.

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 241	Principles and Symmetries in Classical Physics I *	5
PHYS 242	Principles and Symmetries in Classical Physics II *	5
PHYS 321	Introduction to Modern Physics I	3
One of the following		
PHYS 321L	Introductory Laboratory in Modern Physics I	
PHYS 322L	Introductory Laboratory in Modern Physics II	
PHYS 310	Electronic Instrumentation for Experimental Physics	
PHYS 311	Intermediate Laboratory	

PHYS 311T Intermediate Laboratory for Secondary Physics
Teachers

Other acceptable courses

PHYS 304	Thermal Physics
PHYS 306	Physics of Wave Motion
PHYS 322	Introduction to Modern Physics II
PHYS 361	Classical Mechanics
PHYS 362	Intermediate Mechanics
PHYS 364	Electricity and Magnetism I
PHYS 365	Electricity and Magnetism II
PHYS 421	Ultrafast Laser Science and Spectroscopy
PHYS 432	Molecular and Cell Biophysics
PHYS 461	Physics of Biomolecules
PHYS 480	Quantum Mechanics I
PHYS 481	Quantum Mechanics II
PHYS 496	Modern Optics

*PHYS 231/231L and PHYS 232/232L may be substituted for
PHYS 241 and PHYS 242

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 300 level or higher. Note that only ASTRO 344L may be used to satisfy both the requirements of a physics major and an astronomy minor.

ASTRO 344L	Astronomy Laboratory	3
ASTRO courses*		9-12
3 credits from the following (if only 9 Astro credits)		3
PHYS 304	Thermal Physics	
PHYS 321	Introduction to Modern Physics I	
PHYS 361	Classical Mechanics	
PHYS 362	Intermediate Mechanics	
PHYS 364	Electricity and Magnetism I	
PHYS 365	Electricity and Magnetism II	
PHYS 480	Quantum Mechanics I	
PHYS 481	Quantum Mechanics II	
PHYS 496	Modern Optics	
AER E 351	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 531	Statistical Mechanics	3
PHYS 564	Advanced Classical Mechanics	3
PHYS 571	Electricity and Magnetism I	3
PHYS 572	Electricity and Magnetism II	3
PHYS 591	Quantum Physics I	4
PHYS 592	Quantum Physics II	4

Candidates for an advanced degree in astrophysics should complete:

PHYS 531	Statistical Mechanics	3
or PHYS 564	Advanced Classical Mechanics	
PHYS 571	Electricity and Magnetism I	3
PHYS 591	Quantum Physics I	4
ASTRO 505	Astrophysical Cosmology	3
ASTRO 510	Observational Astrophysics	3

Astrophysics Ph.D. candidates must take at least three of the 580 level Astro courses, while candidates for the M.S. must take at least two 580 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 699 but no credits of 599 toward the minimum 30 credits. Students choosing a degree without thesis should apply 2 credits of 599, but may not apply any credits of 699, 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 500 or 600 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.