

2011-2012 Course Catalog

The University Of Montana

Department of Physics and Astronomy

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Andrew S. Ware, Chair

Physics is considered to be the most fundamental of all the disciplines in the natural sciences. In physics we try to describe and understand a myriad of physical phenomena ranging from subatomic to cosmological scales by quantifying the relationships among different physical quantities. Not only does physics have its own merit as a challenging but exciting scientific endeavor, it provides the basis for understanding underlying processes in astronomy, biology, chemistry, geology, computer science, engineering, and even in behavioral sciences. Applications of physics are virtually unlimited: computers, communications, energy production, medical technology, and space flight, to name just a few. The Department of Physics and Astronomy offers a range of physics courses from introductory to advanced undergraduate level in both experimental and theoretical physics with computational methods in mind. In addition, we offer introductory to advanced astronomy and astrophysics courses in which astronomical applications of physics are emphasized. These courses deal with the Universe, from the solar system to clusters of galaxies, both theoretically and observationally. The Department of Physics and Astronomy offers the Bachelor of Arts degree with a major in physics. Graduates with this degree are prepared for further study in physics or related fields at the masters or Ph.D. level, as well as a wide variety of technical positions in industry. In addition, the department offers two other degree paths that combine a solid background in the study of physics with in-depth study in other fields. These options allow for specialization in related fields and provide appropriate background for certain employment opportunities and for continued graduate or professional study:

Astronomy: The astronomy option provides a thorough study of astronomy and astrophysics as well as a solid background in physics and mathematics. Graduates from this program have gone on to graduate programs in astronomy and astrophysics while others have found career opportunities at national astronomical observatories.

Computational Physics: The computational physics option provides a thorough study of computer science and computational physics as well as a solid background in physics and mathematics. Graduates from this program have gone on to graduate programs in physics and computer science while others have found career opportunities in technical fields.

Special Degree Requirements

Refer to graduation requirements listed previously in the catalog. See index.

All majors must meet the Upper-division Writing Expectation by successfully completing PHSX 330 (PHYS 330) or another upper division writing course from the approved list.

Bachelor of Arts with a major in Physics

Forty-three credits in physics must be earned for the Bachelor of Arts degree with a major in physics. Required courses in physics are: PHSX 215-216N-217N-218N (PHYS 211N-212N-213N-214N) or PHSX 205N-206N-207N-208N (PHYS 111N-113N-112N-114N), PHSX 215-216N-217N-218N (PHYS 211N-212N-213N-214N) strongly recommended, PHSX 301, 311, 322, 327, 343, 320, 423 (PHYS 301, 311, 321, 325, 341, 375, 414), PHSX 425 (PHYS 415) strongly recommended), PHSX 444, 461, and 499 (PHYS 444, 461, 480). M 171, 172, 273, 311 (M ATH 152, 153, 251, 311) also must be taken.

Physics majors must satisfy successfully the general education requirements. An additional requirement is in the completion of at least one computer science language course: PSHX 333 (PHYS 331) (strongly recommended), or CSCI 100 or 135 (CS 101, 131). Recommended courses in other departments include M 317, 412, 418 (MATH 317, 412, 418).

Bachelor of Arts with a major in Physics: Astronomy Option

During their first two years, students in the astronomy option should take ASTR 142N (or 132N and 135N), PHSX 215N-216N-217N-218N (PHYS 211N-212N-213N-214N), or 205N-206N-207N-208N (PHYS 111N-113N-112N-114N), PHSX 343 (PHYS 341), and M 171, 172, 273 (MATH 152, 153, and 251), M 151 (MATH 121), if necessary).

Forty-seven credits in astronomy and physics courses are required for the B.A. degree in physics with astronomy option. Required courses in physics are: PHSX 215N-216N-217N-218N, 301, 311, 343, 461, 499 (PHYS 211N-212N or 213N-214N, 301, 311, 341, 461, 480) plus at least three courses from the following: PHSX 327, 320, 423, 425, 446 and 462 (PHYS 325, 375, 414, 415, 446, and 462). Required astronomy courses are: 142N (or 132N and 135N), 353, 363, and 365 (351 and 362 recommended). At least one lab course must be taken from ASTR 362, PHSX 322 or 444 (PHYS 321 or 444). M 171, 172, 273, and 311 (MATH 152, 153, 231, 311) also must be taken. Physics with Astronomy option majors must satisfy successfully the general education requirements. An additional requirement is in the completion of at least one computer science language course: PSHX 333 (PHYS 331) (strongly recommended), or CSCI 100 or 135 (CS 101, 131).

Bachelor of Arts with a major in Physics: Computational Physics Option:

The purpose of the computational physics option is to provide a thorough background in both physics and computer science and to inculcate a deeper understanding of their goals and methods. A student earns the computational physics option by completing at least 50 credits in the two disciplines, 30 of these credits in physics courses and 20 of these in computer science courses. The following courses are required: Physics 215N-216N-217N-218N (PHYS 211N-212N-213N-214N), or 205N-206N-207N-208N

(PHYS 111N-113N-112N-114N), PHSX 301, 311, 333,343,320,423, and 499 (PHYS 301, 311, 331, 341, 375, 414, and 480) (PHSX 322, 444 and 423 (PHYS 321, 444, and 415) are highly recommended); Computer Science 135-136, 232, 332 (CS 131-132, 241, 332), and seven credits of computer science electives selected from courses numbered 200 and above CSCI 205, 361, 415, and 477 (CS 242, 281, 315E and 477) recommended); M 171, 172, 273, 311 and 325 (MATH 152, 153, 251,311, 325) M 307, STAT 458 and STAT 341 (Math 305, 448 and 341) recommended). Physics with Computational Physics option majors must satisfy successfully the general education requirements.

Teacher Preparation in Physics

Major Teaching Field of Physics: For an endorsement in the major teaching field of Physics, a student must complete the following course requirements: 35 credits in Physics including Physics 205N-206N-207N-208N or 215N-216N-217N-218N (PHYS 111N-113N-112N-114N or 211N-214N) and PHSX 301, 327, 330, 343, 320, 423, 461, and 499 (301, 325, 330, 341, 375, 414, 461, and 480). Also required are Astronomy 131N-132N; M 171, 172, 273, 311, STAT 216 or 341 (MATH 152, 153, 251, 311, 241 or 341); Computer Science 100 or 135 (CS 101 or 131); EDU 497 (C&I 426); CHMY 121N and 485 (CHEM 151N and 485); BIOB 170N or 160N (BIOL 108N or 110N) or BIOO 105N (BIOL120N) or BIOE 172N (BIOL 221N); GEO 101N-102N (GEOS 100N-101N); and EVST 101 or Science 350 or GEO 301 (GEOS 301). Students also must gain admission to Teacher Education Program and meet the requirements for teaching licensure (see the College of Education section of this catalog).

Minor Teaching Field of Physics: For an endorsement in the minor teaching field of Physics, a student must complete Physics 205N-206N-207N-208N or 215N-216N-217N-218N (111N-113N-112N-114N or 211N-212N-213N-214N), PHSX 327, 330, 343 and 320 (PHYS 325, 330, 341 and 375). Also required are Astronomy 131N or 132N; BIOB 170N or 160N (BIOL 108N or 110N) or BIOO 105N (BIOL120N) or BIOE 172N (BIOL 121N); CHMY 121N, 485 (CHEM 151N, 485); M 171, 172, 273, 311, STAT 216 or 341 (MATH 152, 153, 251, 311, 241 or 341); CSCI 100 135, (CS 101, 131); and EDU 497 (C&I 426). Students also must gain admission to Teacher Education Program and meet the requirements for teaching licensure (see the College of Education section of this catalog).

Suggested Course of Study

Bachelor of Arts with a Major in Physics

For physics majors with four years of college preparatory mathematics or exemption from M 151 (MATH 121) by examination:

First Year	A	S
PHSX 101 Freshman Physics Experience	1	-
*WRIT 101 (ENEX 101) College Writing I	3	-
M 171-172 (MATH 152-153) Calculus I, II	4	4

PHSX 215N-216N, 217N-218N (PHYS 211N-212N, 213N-214N) Fundamentals of Physics	5	5
Electives and General Education	2	6
Total	15	15

*Semester of enrollment depends on beginning letter of student's last name.

Second Year	A	S
M 273 (MATH 251) Multivariable Calculus	4	-
PHSX 301 (PHYS 301)Introduction to Theoretical Physics	-	3
PHSX 311 (PHYS 311) Oscillations and Waves	2	-
PHSX 327 (PHYS 325) Optics	-	3
PHSX 343 (PHYS 341) Modern Physics	3	-
Foreign Language*	5	5
Electives and General Education	1	4
Total	15	15

*Can be waived with appropriate testing through MCLL.

Third Year	A	S
M 311, 412 (MATH 311, 412) Ordinary Differential Equations/Systems, Partial Differential Equations	3	3
PHSX 322 (PHYS 321) Electronics for Scientists	3	-
PHSX 330 (PHYS 330) Communicating Physics	-	3
PHSX 320 (PHYS 375) Classical Mechanics	-	3
PHSX 423-425 (PHYS 414-415) Electromagnetism	3	3
PHSX 446 (PHYS 446) Thermodynamics and Statistical Mechanics *	3	-
Electives and General Education	3	3

* PHSX 446 (PHYS 446) and PHSX 330 (PHYS 330) are offered every other year and may be taken in the third or fourth year.

Total	15		15	
Fourth Year		A		S
PHSX 333 (PHYS 331) Computational Physics*	3		-	
PHSX 444 (PHYS 444) Advanced Physics Laboratory	-		3	
PHSX 461-462 (PHYS 461-462) Quantum Mechanics I & II	3		3	
PHSX 491 (PHYS 463) Selected Topics or PHSX 462 (PHYS 462) Quantum Mechanics II	-		3	
PHSX 499 (PHYS 480) Senior Capstone Seminar	1		-	
Electives and General Education	8		9	

* PHSX 446 (PHYS 446) and PHSX 333 (PHYS 330) are offered every other year and may be taken in the third or fourth year.

Total	15		15	
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Physics majors with fewer than four years of college preparatory mathematics (students who begin M 171 (MATH 152) in the second semester) can use this suggested course of study for physics courses:

First Year		A		S
PHSX 101 Freshman Physics Experience	1		-	
PHSX 141N (PHYS 141N) Relativity: From Galileo to Einstein and Beyond	-		3	
CSCI 100 (CS 101) or CSCI 135 (CS 131) Fundamentals of Computer Science	-		3	
*WRIT 101 (ENEX 101) College Writing I	3		-	

M 151 (MATH 121) Precalculus	4	-
M 171 (MATH 152) Calculus I	-	4
Foreign language+	5	5
Electives and General Education	2	-
Total	15	15

* Semester of enrollment depends on beginning letter of students last name.

+Can be waived with appropriate testing through MCLL.

Second Year	A	S
M 172 (MATH 153) Calculus II	4	-
M 273 (MATH 251) Calculus III	-	4
PHSX 215N-216N, 217N-218N (PHYS 211N-212N, 213N-214N) Fundamentals of Physics	5	5
Electives and General Education	6	6
Total	15	15

Third Year	A	S
M 311, 412 (MATH 311, 412) Ordinary Differential Equations/Systems, Partial Differential Equations	3	3
PHSX 311 (PHYS 311) Oscillations and Waves	2	-
PHSX 322 (PHYS 321) Electronics for Scientists	3	-
PHSX 327 (PHYS 325) Optics	-	3
PHSX 330 (PHYS 330) Communicating Physics	-	3
PHSX 343 (PHYS 341) Modern Physics	3	-
PHSX 301 (PHYS 301) Mathematical Methods for Physical Scientists	-	3
Electives and General Education	3	-
* PHSX 330 (PHYS 330) is offered every other year	4	3

and may be taken in the third or fourth year.

Total	15		15	
Fourth Year		A		S
PHSX 320 (PHYS 375) Classical Mechanics	-		3	
PHSX 423-425 (PHYS 414-415) Electromagnetism	3		3	
PHSX 444 (PHYS 444) Advanced Physics Laboratory	-		3	
PHSX 446 (PHYS 446) Thermodynamics and Statistical Mechanics *	3		-	
PHSX 461-462 (PHYS 461-462) Quantum Mechanics I, II	3		3	
PHSX 499 (PHYS 480) Senior Capstone Seminar	1		-	
Electives and General Education	5		3	
Total	15		16	

* PHSX 446 (PHYS 446) is offered every other year and may be taken in the third or fourth year.

Bachelor of Arts with a Major in Physics and an Option in Astronomy

For physics with astronomy option majors with four years of college preparatory mathematics or exemption from M 151 (MATH 121) by examination:

First Year		A		S
ASTR 142N The Evolving Universe	-		4	
PHSX 101 Freshman Physics Experience	1		-	
PHSX 215N-216N, 217N-218N (PHYS 211N-212N, 213N-214N) Fundamentals of Physics	5		5	
WRIT 101 (ENEX 101) Composition*	3		-	
M 171-172 (MATH 152-153) Calculus I, II	4		4	
Electives and General Education	2		2	

Total	15	15
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* WRIT 101 (ENEX 101) is required unless exempted by testing. Semester of enrollment depends on beginning letter of student's last name.

Second Year		A	S
PHSX 311 (PHYS 311) Oscillations and Waves	2	-	
PHSX 343 (PHYS 341) Modern Physics	3	-	
PHSX 301 (PHYS 301) Introduction to Theoretical Physics	-	3	
PHSX 327 (PHSX 325) Optics	-	3	
M 273 (MATH 251) Multivariable Calculus	4	-	
Foreign language+	5	5	
General Education	7	5	
Total	15	15	

*+Can be waived with appropriate testing through MCLL.

Third Year		A	S
ASTR 362 Observational Astronomy*	3	-	
ASTR 363-365 Stellar Astronomy and Astrophysics*	3	3	
M 311, 412 (MATH 311, 412) Ordinary Differential Equations/Systems, Partial Differential Equations	3	3	
PHSX 330 (PHYS 330) Communicating Physics*	-	3	
Physics electives, chosen from PHSX 320 (PHYS 375), PHSX 327 (PHYS 320), PHSX 423-425 (PHYS 414-415), or PHSX 446 (PHYS 446)	3	3	
General Education or electives	3	3	
Total	15	15	

Fourth Year		A	S
ASTR 351 Planetary Science*	3	-	

ASTR 353 Galactic Astrophysics and Cosmology*	-	3
PHSX 333 (PHYS 331) Computational Physics+	3	-
PHSX 461 (PHYS 461) Quantum Mechanics I	3	-
Physics electives, chosen from PHSX 320 (PHYS 375), PHSX 327 (PHYS 320), PHSX 423-425 (PHYS 414-415), PHSX 446 (PHYS 446)	-	3
PHSX 499 (PHYS 480) Senior Capstone Seminar	1	-
General Education or electives	8	9
Total	15	15

*Upper-division astronomy courses can be taken in a different order, as they are offered only in alternate years.

+PHSX 333 (PHYS 330) is offered every other year and may be taken in the third or fourth year.

Physics with astronomy option majors with fewer than four years of college preparatory mathematics (students who begin M 171 (MATH 152) in the second semester) can use this suggested course of study for physics courses:

First Year	A	S
ASTR 142N The Evolving Universe	-	4
PHSX 101 Freshman Physics Experience	1	-
CSCI 100 or 135 (CS 101 or 131) Intro to Programming or Fundamentals of Computer Science I	3	-
WRIT 101 (ENEX 101) Composition*	3	-
M 151 (MATH 121) Precalculus	4	-
M 171 (MATH 152) Calculus I	-	4
Electives and General Education	2	2
Total	15	15

* WRIT 101 (ENEX 101) is required unless exempted by testing. Semester of enrollment depends on beginning letter of student's last name.

Second Year		A		S
M 172, 273 (MATH 153, 251) Calculus II, Multivariable Calculus	4		4	
PHSX 215N-216N, 217N-218N (PHYS 211N-212N, 213N-214N) Fundamentals of Physics with Calculus	5		5	
Foreign language+	5		5	
Electives and General Education	1		1	
Total	15		15	

+Can be waived with appropriate testing through MCLL.

Third Year		A		S
ASTR 351 Planetary Science or *	3		-	
ASTR 353 Galactic Astrophysics and Cosmology*	-		3	
ASTR 362 Observational Astronomy*	3		-	
M 311 (MATH 311) Ordinary Differential Equations/ Systems	3		-	
PHSX 301 (PHYS 301) Introduction to Theoretical Physics	-		3	
PHSX 327 (PHYS 325) Optics	-		3	
PHSX 311 (PHYS 311) Oscillations and Waves	2		-	
PHSX 330 (PHYS 330) Communicating Physics*	-		3	
PHSX 343 (PHYS 341) Modern Physics	3		-	
Electives and General Education	1		3	
Total	15		15	

Fourth Year		A		S
ASTR 363-365 Stellar Astronomy and Astrophysics*	3		3	
PHSX 461 (PHYS 461) Quantum Mechanics I	3		-	

Physics electives, chosen from PHSX 320 (PHYS 375), PHSX 327 (PHYS 320), PHSX 423-425 (PHYS 414-415), PHSX 446 (PHYS 446) and PHSX 462 (PHYS 461)	3	3
PHSX 499 (PHYS 480) Senior Capstone Seminar	1	-
General Education or electives	5	9
Total	15	15

*Upper-division astronomy courses can be taken in a different order, as they are offered only in alternate years.

Bachelor of Arts with a Major in Physics with an Option in Computational Physics

For physics with computational physics option majors with four years of college preparatory mathematics or exemption from M 151 (MATH 121) by examination:

First Year	A	S
CSCI 135-136 (CS 131-132) Fundamentals of Computer Science I, II	3	3
WRIT 101 (ENEX 101) College Writing I*	-	3
M 171, 172 (MATH 152-153) Calculus I, II	4	4
PHSX 101 Freshman Physics Experience	1	-
PHSX 215N-216N, 217N-218N (PHYS 211N-212N, 213N-214N) Fundamentals of Physics with Calculus*	5	5
Electives and General Education	2	-
Total	15	15

* Semester of enrollment depends on beginning letter of student's last name.

Second Year	A	S
CSCI 232 (CS 241) Data Structure and Algorithms	4	-
M 225 (MATH 225) Introduction to Discrete Math	3	-
M 273 (MATH 251) Multivariable Calculus	-	4

PHSX 301 (PHYS 301)	-	3
Introduction to Theoretical Physics		
PHSX 343 (PHYS 341)	3	-
Fundamentals of Modern Physics		
Foreign language+	5	5
Electives and General Education	-	3
Total	15	15

+Can be waived with appropriate testing through MCLL.

Third Year		A		S
CSCI 205 (CS 242)	-	4		
Programming Languages w/C/C++				
CSCI 361 (CS 281)	3	-		
Computer Architecture				
M 311 (MATH 311)	3	-		
Ordinary Differential Equations/Systems				
M 325 (MATH 325)	-	3		
Discrete Mathematics				
PHSX 311 (PHYS 311)	2	-		
Oscillations and Waves				
PHSX 322 (PHYS 321)	3	-		
Electronics for Scientists				
PHSX 333 (PHYS 331)	3	-		
Computational Physics #				
PHSX 320 (PHYS 375)	-	3		
Classical Mechanics				
PHSX 330 (PHYS 330) Methods of Communicating Physics#	-	3		
Electives and General Education	3	2		
Total	15	15		

PHSX 333 (PHYS 331)
and PHSX 330 (PHYS
330) are offered every
other year and may be
taken in the third or fourth
year.

Fourth Year		A		S
CSCI 332 (CS 332)	3	-		
Design/Analysis of Algorithms				

CSCI 415 (CS 415E) Computers, Ethics, and Society*	-	3
PHSX 423-425 (PHYS 414-415) Electricity & Magnetism I, II *	3	3
PHSX 499 (PHYS 480) Senior Capstone Seminar	1	-
Electives and General Education	8	9
Total	15	15

* CSCI and PHSX courses marked with * are recommended. Other courses in physics and computer science can be substituted for them.

Physics with computational physics option majors with fewer than four years of college preparatory mathematics (students who begin M 171 (MATH 152) in the second semester) can use this suggested course of study for physics courses:

First Year	A	S
CSCI 135-136 (CS 131-132) Fundamentals of Computer Science I, II	3	3
WRIT 101 (ENEX 101) College Writing I*	-	3
M 151 (MATH 121) Precalculus	4	-
M 171 (MATH 152) Calculus I	-	4
PHSX 101 Freshman Physics Experience	1	-
Foreign Language+	5	5
Electives and General Education	2	-
Total	15	15

* Semester of enrollment depends on beginning letter of student's last name.

+ Can be waived with appropriate testing through MCLL.

Second Year	A	S
CSCI 232 (CS 241) Data Structure and Algorithms	4	-
CSCI 205 (CS 242) Programming Languages w/C/C++	-	4
M 225 (MATH 225) Introduction to Discrete Math	3	-
M 172 (MATH 153) Calculus II	4	-

M 273 (MATH 251)	-		4	
Multivariable Calculus				
PHSX 215N-216N, 217N-218N (PHYS 211N-212N, 213N-214N)	5		5	
Fundamentals of Physics with Calculus*				
Electives and General Education	-		2	
Total	16		15	
Third Year		A		S
CSCI 332 (CS 332)	3		-	
Design/Analysis of Algorithms				
M 311 (MATH 311)	3		-	
Ordinary Differential Equations/Systems				
M 325 (MATH 325)	-		3	
Discrete Mathematics				
PHSX 311 (PHYS 311)	2		-	
Oscillations and Waves				
PHSX 343 (PHYS 341)	3		-	
Fundamentals of Modern Physics				
PHSX 333 (PHYS 331)	3		-	
Computational Physics #				
PHSX 301 (PHYS 301)	-		3	
Introduction to Theoretical Physics				
PHSX 330 (PHYS 330) Methods of Communicating Physics#	-		3	
Electives and General Education	1		6	
Total	15		15	
# PHSX 333 (PHYS 331) and PHSX 330 (PHYS 330) are offered every other year and may be taken in the third or fourth year.				
Fourth Year		A		S
CSCI 415 (CS 415E)	-		3	
Computers, Ethics, and Society*				
PHSX 322 (PHYS 321)	3		-	
Electronics for Scientists				

PHSX 320 (PHYS 375)	-	3
Classical Mechanics		
PHSX 423-425 (PHYS 414-415)	3	3
Electricity & Magnetism I, II*		
PHSX 499 (PHYS 480)	1	-
Senior Capstone Seminar		
Electives and General Education	8	6
Total	15	15

* CSCI and PHSX courses marked with * are recommended. Other courses in physics and computer science can be substituted for them.

Requirements for a Minor in Astronomy

To earn a minor in astronomy the student must complete PHSX 205N-206N-207N-208N or 215N-216N-217N-218N (PHYS 111N-113N-112N-114N or 211N-212N-213N-214N); ASTR 131N- 132N (ASTR 134N-135N strongly recommended); and eight credits from ASTR 351, 353, 362, or 363-364. (Mathematics prerequisites for the astronomy minor are M171, 172, and 273 (MATH 152, 153, and 251)).

Requirements for a Minor in Physics

- 1) To earn a minor in physics the student must complete PHSX 215N-216N-217N-218N (PHYS 211N-212N-213N-214N) (or PHSX 205N-206N-207N-208N (PHYS 111N-112N-113N-114N)); PHSX 301 (PHYS 301);
- 2) Eleven additional physics credits, at least eight of which must be upper division. (Mathematics prerequisites for the physics minor are M 171, 172, 273, and 311 (MATH 152, 153, 251, and 311)). Possible concentrations for the eleven additional physics credits include:

Classical Physics:

- PHSX 311 (PHYS 311) Oscillations and Waves 2 cr
- PHSX 327 (PHYS 325) Optics 3 cr
- PHSX 320 (PHYS 375) Classical Mechanics 3 cr
- PHSX 423 (PHYS 414) Electricity and Magnetism I 3 cr

Quantum Physics

- PHSX 311 (PHYS 311) Oscillations and Waves 2 cr
- PHSX 343 (PHYS 341) Fundamentals of Modern Physics 3 cr
- PHSX 461 (PHYS 461) Quantum Mechanics I 3 cr
- PHSX 462 (PHYS 462) Quantum Mechanics II 3 cr

Experimental Physics

- PHSX 322 (PHYS 321) Electronics for Scientists 3 cr
- PHSX 327 (PHYS 325) Optics 3 cr
- PHSX 343 (PHYS 341) Modern Physics 3 cr

- PHSX 444 (PHYS 444) Advanced Physics Lab 3 cr

Electrical and Computational Physics

- PHSX 322 (PHYS 321) Electronics for Scientists 3 cr
- PHSX 330 (PHYS 330) Communicating Physics 3 cr
- PHSX 333 (PHYS 331) Computational Physics 3 cr
- PHSX 423 (PHYS 414) Electricity and Magnetism I 3 cr

Engineering Physics

- PHSX 291 (PHYS 295) Engineering Mechanics - Statics 3 cr
- PHSX 311 (PHYS 311) Oscillations and Waves 2 cr
- PHSX 322 (PHYS 321) Electronics for Scientists 3 cr
- PHSX 446 (PHYS 446) Thermodynamics & Stat. Mechanics 3 cr

These concentrations are meant to be suggestive only. All meet the Minor in Physics requirements of eleven additional credits with at least eight of these being upper-division. For additional possibilities, a student can consult with a physics advisor.

Courses

U=for undergraduate credit only, UG=for undergraduate or graduate credit, G=for graduate credit. R after the credit indicates the course may be repeated for credit to the maximum indicated after the R. Credits beyond this maximum do not count toward a degree.

Astronomy (ASTR)

U 131N Elementary Astronomy I 3 cr. Offered autumn. Prereq., high school algebra and geometry. An introduction to historical and solar system astronomy.

U 132N Elementary Astronomy II 3 cr. Offered spring. Prereq., high school algebra and geometry. An introduction to stars, stellar evolution, galaxies, and the universe.

U 134N Elementary Astronomy Laboratory I 1 cr. Offered autumn. Prereq. or coreq., ASTR 131N Laboratory exercises in observational and solar system astronomy.

U 135N Elementary Astronomy Laboratory II 1 cr. Offered spring. Prereq. or coreq., ASTR 132N. Laboratory exercises in stellar and galactic astronomy.

U 142N The Evolving Universe: Theories and Observations in Modern Astronomy 4 cr. Offered spring. Prereq., M 151 (MATH 121) or equiv. Overview of recent developments in planetary system formation, stars, galaxies, and cosmology. Some astronomical observing required outside of normal class hours.

U 191 (ASTR 195) Special Topics Variable cr. (R-6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses or one-time offerings of current topics.

U 198 Internship Variable cr. (R-6) Offered intermittently. Prereq., consent of department. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained

from the faculty supervisor and the Internship Services office. A maximum of 6 credits of Internship (198, 298, 398, 498) may count toward graduation.

U 351 Planetary Science 3 cr. Offered autumn even-numbered years. Prereq., PHSX 215N-216N or 205N-206N (PHYS 211N-213N or 111N-113N) and M 162 or 171 (MATH 150 or 152). Same as GEO 317 (GEOS 309). Physical and geological characteristics of planets, satellites, asteroids, comets, and meteoroids, with an emphasis on comparative planetology.

U 353 Galactic Astrophysics and Cosmology 3 cr. Offered spring odd-numbered years. Prereq., ASTR 132N, PHSX 217N-218N (PHYS 212N-214N), M 273 (MATH 251). The nature of the Milky Way galaxy and other galaxies, galactic evolution, the large scale structure of the universe, active galaxies and quasars, and cosmology, including the early universe.

U 362 Observational Astronomy 3 cr. Offered autumn even-numbered years. Prereq., ASTR 132N or 142N, PHSX 217N-218N (PHYS 212N-214N). Laboratory study of the probabilistic behavior of light, data acquisition with telescopes, digital imaging and spectroscopy. Emphasis on fundamental statistical tools, scientific computer programming, and written and oral presentation of scientific results.

U 363 Stellar Astronomy and Astrophysics I 3 cr. Offered autumn odd-numbered years. Prereq., ASTR 132N, M 273 (MATH 251), and PHSX 217N-218N (PHYS 212N-214N); PHSX 343 (PHYS 341) recommended. Detailed application of physical laws to determine the nature of the stars; analysis of stellar spectra and atmospheres; solar astrophysics; structure of stars and their evolution.

U 365 (ASTR 364) Stellar Astronomy and Astrophysics II 3 cr. Offered spring even-numbered years. Prereq., ASTR 363. Continuation of ASTR 363.

U 391 (ASTR 395) Special Topics Variable cr. (R-6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

U 392 (ASTR 396) Independent Study Variable cr.

U 398 (PHYS 398) Internship Variable cr. (R-6) Offered intermittently. Prereq., consent of department. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office. A maximum of 6 credits of Internship (198, 298, 398, 498) may count toward graduation.

UG 499 (ASTR 480) Seminar/Workshop 1 cr. Offered autumn. Prereq., junior or senior standing in physics. Each student will present a seminar on research performed prior to or during their senior year.

Physics (PHSX)

U 101 (PHYS 180) Freshman Physics Experience 1 cr. Offered autumn. Prereq., freshman standing (fewer than 30-credits towards degree) or consent of instructor. This course is intended for all incoming students either majoring in physics or considering majoring in physics. This seminar course presents an overview of the undergraduate experience as a physics major. Seminars on recent developments in physics and astronomy and opportunities for undergraduate involvement in research and instruction are included.

U 205N (PHYS 111N) College Physics I 4 cr. Offered autumn and spring. Prereq., M 122 or 151 (MATH 112 or 121) or equivalent, and prereq. or coreq. PHSX 206N (PHYS 113N). Mechanics, sound, and heat. For non-physical science majors. This course satisfies the lecture portion of medical school requirements in general physics. Credit not allowed for both PHSX 205N-207N and 215N-217N (PHYS 111N-112N and 211N-212N).

U 206N (PHYS 113N) College Physics I Laboratory I 1 cr. Offered autumn and spring. Prereq. or coreq., PHSX 205N (PHYS 111N). Mechanics, sound, and heat. For non-physical science majors. This course satisfies the laboratory portion of medical school requirements in general physics. Credit not allowed for both PHSX 206N-208N and 216N-218N (PHYS 113N-114N and 213N-214N).

U 207N (PHYS 112N) College Physics II 4 cr. Offered autumn and spring. Prereq. PHSX 205N (PHYS 111N) and prereq. or coreq., PHSX 208N (PHYS 114N). Electricity, magnetism, light, and modern physics. For non-physical science majors. This course satisfies the lecture portion of medical school requirements in general physics. Credit not allowed for both PHSX 205N-207N and 215N-217N (PHYS 111N-112N and 211N-212N).

U 208N (PHYS 114N) College Physics Laboratory II 1 cr. Offered autumn and spring. Prereq., PHYS 206N (PHYS 113N), prereq. or coreq., PHSX 207 (PHYS 112N). Electricity, magnetism, light and modern physics. For non-physical science majors. This course satisfies the laboratory portion of medical school requirements in general physics. Credit not allowed for both PHSX 206N-208N and 216N-218N (PHYS 113N-114N and 213N-214N).

U 141N (PHYS 141) Einstein Relativity 3 cr. Offered spring. Prereq., working knowledge of high school physics and high school calculus, or consent of instr. Modern theoretical study of space, time, the principle of relativity, and its implications. Analysis of apparent paradoxes, and applications to particle physics.

U 191 (PHYS 195) Special Topics Variable cr. (R-6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

U 198 (PHYS 198) Internship Variable cr. (R-6) Offered intermittently. Prereq., consent of department. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office. A maximum of 6 credits of Internship (198, 298, 398, 498) may count toward graduation.

U 215N (PHYS 211N) Fundamentals of Physics with Calculus I 4 cr. Offered autumn. Prereq. or coreq., PHSX 216N (PHYS 213N) and M 171 (MATH 152) or equiv. This course satisfies the lecture portion of medical and technical school requirements in general physics. Mechanics, fluids, waves and sound. Credit not allowed for both PHSX 215N-216N-217N-218N and 205N-206N-207N-208N (PHYS 211N-214N and 111N-113N-112N-114N).

U 216N (PHYS 213N) Physics Laboratory I with Calculus 1 cr. Offered autumn. Coreq., PHSX 215N (PHYS 211N). This course satisfies the laboratory portion of medical and technical school requirements in general physics. Mechanics, fluids, waves, and sound. Credit not allowed for both PHSX 215N-216N-217N-218N and 205N-206N-207N-208N (PHYS 211N-214N and 111N-113N-112N-114N).

U 217N (PHYS 212N) Fundamentals of Physics with Calculus II 4 cr. Offered spring. Prereq., PHSX 215N (PHYS 211N), and prereq. or coreq. PHSX 218 (PHYS 214N), and prereq. or coreq., M 172 (MATH 153) or equivalent. This course satisfies the lecture portion of medical and technical school requirements in general physics. Heat, electricity, magnetism, and light. Credit not allowed for both PHSX 215N-216N-217N-218N and 205N-206N-207N-208N (PHYS 211N-214N and 111N-113N-112N-114N).

U 218N (PHYS 214N) Physics Laboratory II with Calculus 1 cr. Offered spring. Prereq., PHSX 215N (PHYS 211N), coreq., PHSX 217N (PHYS 212N). This course satisfies the laboratory portion of medical and technical school requirements in general physics. Heat, electricity, magnetism, and light. Credit not allowed for both PHSX 215N-216N-217N-218N and 205N-206N-207N-208N (PHYS 211N- 214N and 111N-113N-112N-114N).

U 251 (PHYS 251) Laboratory Arts 1 cr. (R-2) Offered intermittently. Prereq., PHSX 217N-218N (PHYS 212N-214N) and upper-division standing in physics. Elements of glass blowing, machine shop practice and electronic construction techniques.

U 291 (PHYS 295) Special Topics Variable cr. (R-6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

U 292 (PHYS 293) Independent Study

U 301 (PHYS 301) Introduction to Theoretical Physics 3 cr. Offered spring. Prereq., M 273 (MATH 251); coreq., PHSX 217N-218N (PHYS 212N-214N). Selected topics from applied linear algebra, ordinary and partial differential equations, vector analysis, complex variables, and Fourier series. Applications to classical mechanics, electromagnetism, and quantum mechanics.

U 311 (PHYS 311) Oscillations and Waves 2 cr. Offered fall. Prereq., PHSX 217N-218N or 207N-208N (PHYS 212N-214N or 112N-114N); Prereq. or coreq. M 273 (MATH 251). Detailed study of oscillations and waves at the intermediate level, to develop physical intuition and mathematical skills needed for analyzing a wide range of periodic phenomena encountered in physics.

U 320 (PHYS 375) Classical Mechanics 3 cr. Offered spring. Prereq., PHSX 301 (PHYS 301), M 311 (MATH 311). Topics in classical mechanics at the intermediate level, emphasizing Lagrangian and Hamiltonian dynamics.

U 322 (PHYS 321) Electronics for Scientists 3 cr. Offered autumn. Prereq., PHSX 217N-218N or PHSX 207N-208N (PHYS 212N-214N or PHYS 112N-114N). Laboratory exercises in the techniques of analog and digital electronics, including circuit design, construction, and measurement. Recommended for student who perform laboratory work in any experimental science.

U 327 (PHYS 325) Optics 3 cr. Offered spring. Prereq., PHSX 311 (PHYS 311). Intermediate level study of light and optics, including geometrical optics, wave optics, optical instruments, coherence, polarization, and special topics.

U 330 (PHYS 330) Communicating Physics 3 cr. Offered spring even-numbered years. Prereq., PHSX 217N-218N or PHSX 207N-208N (PHYS 212N-214N or PHYS 112N-114N). Oral and written communication skills in physics, to include teaching high school and college physics, presenting seminars, and writing technical and non-technical physics articles.

U 333 (PHYS 331) Computational Physics 3 cr. Offered autumn even-numbered years. Prereq., PHSX 217N-218N (PHYS 212N-214N); coreq., any upper-division PHXS course (301 or higher). Solution of advanced problems in physics using computational methods. Students will learn a variety of numerical methods, including FORTRAN programming techniques.

U 343 (PHYS 341) Modern Physics 3 cr. Offered autumn. Prereq., one year of college physics; coreq., M 273 (MATH 251). Includes historical background for development of modern physics and an introduction to quantum mechanics, atomic and nuclear physics. Credit not allowed for graduate degree in physics.

U 391 (PHYS 395) Special Topics Variable cr. (R-9) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

U 392 (PHYS 396) Honors Physics Variable cr. (R-6) Offered intermittently. Prereq., consent of instr. Independent research in topics of current interest in physics.

UG 423 (PHYS 414) Electricity & Magnetism I 3 cr. Offered autumn. Prereq, PHSx 301 (PHYS 301). Electricity and magnetism at the intermediate level.

UG 425 (PHYS 415) Electricity & Magnetism II 3 cr. Offered spring. Prereq., PHSX 423 (PHYS 414). Continuation of PHSX 423 (PHYS 414). Electricity and magnetism at the intermediate level.

U 444 (PHYS 444) Advanced Physics Laboratory 3 cr. Offered spring. Prereq., PHSX 343 (PHYS 341) or equiv., PHSX 327 (PHYS 325) or equiv.; PHSX 322 (PHYS 321) suggested but not required. Advanced experiments in classical and modern physics, including optics, spectroscopy, laser science, atomic, nuclear, and particle physics, Data analysis techniques for experimental scientists. Recommended for students entering graduate school in any experimental science.

UG 446 (PHYS 446) Thermodynamics and Statistical Mechanics 3 cr. Offered autumn odd-numbered years. Prereq., PHSX 343 (PHYS 341); coreq., M 311 (MATH 311). Topics in thermodynamics and statistical mechanics.

UG 461 (PHYS 461) Quantum Mechanics I 3 cr. Offered autumn. Prereq., PHSX 311 (PHYS 311), PHSX 343 (PHYS 341); prereq. or coreq., M 311 (MATH 311). Introduction to quantum mechanics. Topics include Schroedinger equation, piecewise constant potential, harmonic oscillator, hydrogen atom, angular momentum theory, electron spin.

UG 462 (PHYS 462) Quantum Mechanics II 3 cr. Offered spring. Prereq., PHSX 461 (PHYS 461) or consent of instr. Advanced topics in quantum mechanics including linear vector spaces and Dirac notation, quantum dynamics, time-dependent perturbation theory, and scattering theory.

UG 491 (PHYS 463/495) Special Topics 3 cr. (R-6) Offered intermittently. Prereq., PHSX 461 (PHYS 461) or consent of instr. Studies of a topic in advanced modern physics including nuclear physics, solid state physics, and quantum optics. The topic chosen will vary according to instructor.

UG 499 (PHYS 480) Senior Capstone Seminar 1 cr. Offered autumn. Prereq., junior or senior standing in physics. Each student will present a seminar on research performed prior to or during their senior year.

G 595 (PHYS 595) Special Topics Variable cr. (R-9) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

G 597 (PHYS 597) Research 1-6 cr. (R-9) Offered intermittently. Prereq., consent of instr. Research in selected physics topics.

G 598 (PHYS 598) Internship Variable cr. (R-9) Offered intermittently. Prereq., consent of department. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office.

G 599 (PHYS 599) Thesis Variable cr. (R-9) Offered intermittently. Thesis preparation and execution.

Faculty

Professors

Eiji Uchimoto, Ph.D., University of Wisconsin, 1988

Andrew S. Ware, Ph.D., University of California, San Diego, 1992 (Chair)

Associate Professors

Daniel B. Reisenfeld, Ph.D., Harvard University, 1998

Michael L. Schneider, Ph.D., University of Wisconsin, 2003

Assistant Professor

Nate McCrady, Ph.D., University of California - Berkeley, 2005

Adjunct Associate Professors

David E. Andrews, Ph.D., Cornell University 1972

Bradford L. Halfpap, Ph.D., Arizona State University, 1987

Adjunct Assistant Professors

Alexander P. Bulmahn, Ph.D., University of Iowa, 2010

Benjamin N. Grossman, Ph.D., Oklahoma State University, 2010

Lecturer/Research Assistant Professor

Diane S. Friend, M.S., The University of Montana, 2000

Research Assistant Professor

Paul H. Janzen, Ph.D., Harvard University, 2002

Emeritus Professors

Richard J. Hayden, Ph.D., University of Chicago, 1948

James P. Jacobs, Ph.D., University of Washington, 1991

Mark J. Jakobson, Ph.D., University of California, Berkeley, 1951

Randolph H. Jeppesen, Ph.D., New Mexico State University, 1980