2009-2010 Course Catalog

The University Of Montana

Department of Physics and Astronomy

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 which 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 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: 211N-212N-213N-214N or 111N-113N-112N-114N (211N-212N-213N-214N strongly recommended), 301, 311, 321, 325, 341, 375, 414 (415 strongly recommended), 444, 461, and 480. Mathematics 171, 172, 273, 311 also must be taken.

Physics majors must satisfy successfully the general education requirements including the following requirement in Foreign Language/Symbolic Systems: Completion of a semester of a foreign language or demonstration of equivalent skill in a foreign language in testing administered by the Counseling Center and Department of Modern and Classical Languages and Literatures, and completion of at least one computer science language course: PHYS 331 (strongly recommended), or CS 101, 131, or 201. Recommended courses in other departments include Mathematics 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 131N, 132N, 134N, 135N, PHYS 211N- 212N-213N-214N, or 111N-113N-112N-114N (2 normally during the sophomore year), 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: 211N-212N or 213N-214N, 301, 311, 480 plus at least four courses from the following: 325, 341, 375, 414, 415, and 461. Required astronomy courses are: 131N, 132N, 134N, 135N, 353, 363, and 364 (351 and 362 recommended). At least one lab course must be taken from ASTR 362, PHYS 321, or PHYS 444. Mathematics 171, 172, 273, and 311 also must be taken. The Foreign Language/Symbolic Systems requirements must be met as set forth above under Bachelor of Arts with a major in Physics (one semester of a foreign language and one computer language course chosen from PHYS 331, CS 101, 131, or 201).

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 211N-212N-213N-214N, or 111N-113N-112N-114N, 301, 311, 331, 341, 375, 414, and 480 (PHYS 321, 444, and 415 are highly recommended); Computer Science 131-132, 241, 332, and seven credits of CS electives selected from courses numbered 200 and above (CS 242, 281, 415E, 471, and 477 recommended); Mathematics 171, 172, 273, 311 and 325 (M 307, 448 and STAT 341 recommended). Foreign language

requirements must be met as set forth above under Bachelor of Arts with a major in Physics.

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 111N-113N-112N-114N or 211N-212N and 213N-214N, 301, 325, 330, 341, 375, 414, 461, and 480. Also required are Astronomy 131N-132N; Mathematics 171, 172, 273, 311, STAT 216 or 341 (MATH 241 or 341) and ; Computer Science 101 or 131 or 201; Curriculum & Instruction 426; Chemistry 121N and 485; Biology 108N or 110N or 120N or 121N; Geology 101N-102N; and EVST 101 or Science 350 or Geology 301. Students also must gain admission to Teacher Education and Student Teaching and meet the requirements for certification as a secondary teacher (see the School 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 111N-113N-112N-114N or 211N-212N-213N-214N, 325, 330, 341 and 375. Also required are Astronomy 131N or 132N; Biology 108N or 110N or 120N or 121N; Chemistry 121N, 485; Mathematics 171, 172, 273, 311, STAT 216 or 341 (MATH 241 or 341); and Computer Science 101, 131, or 201. Students also must gain admission to Teacher Education and Student Teaching and meet the requirements for certification as a secondary teacher (see the School 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 MATH 121 by examination:

First Year	A	S
CS 101 or 131 Fundamentals of Computer Science	-	3
*WRIT 101 (ENEX 101) College Writing I	3	-
M 171-172 (MATH 152-153) Calculus I, II	4	4
PHYS 211N, 212N, 213N, 214N Fundamentals of Physics	5	5
Electives and General Education	3	3
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	-
PHYS 301 Mathematical Methods for Physical Scientists	-	3
PHYS 311 Oscillations and Waves	2	-
PHYS 325 Optics	-	3
PHYS 341 Fundamentals of Modern Physics	3	
Foreign Language*	5	
Electives and General Education	1	9
Total	15	15

*Can be waived with two years of foreign language in high school.

Third Year	A	S
M 311, 412 Ordinary Differential Equations/Systems, Partial Differential Equations	3	3
PHYS 321 Electronics for Scientists	3	-
PHYS 330 Communicating Physics	-	3
PHYS 375 Classical Mechanics	-	3
PHYS 414-415 Electromagnetism	3	3
PHYS 446 Thermodynamics and Statistical Mechanics *	(3)	-
Electives and General Education	(3)	3
* PHYS 446 is offered every other year and may be taken in the third or fourth year.		
Total	15	15

Fourth Year	A	S
PHYS 444 Advanced Physics Laboratory	-	3
PHYS 446 Thermodynamics and Statistical Mechanics*	(3)	-

PHYS 461 Quantum Mechanics I	3	-
PHYS 463 Selected Topics or 462 Quantum Mechanics II	-	3
PHYS 480 Senior Seminar	1	-
Electives and General Education	8	9
* PHYS 446 is offered every other year and may be taken in the third or fourth year.		
Total	15	15

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

First Year	A	S
ASTR 131N-132N Elementary Astronomy	3	3
CS 101 or 131Fundamentals 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+ or General Education	5	5
Total	15	15

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

+Can be waived with two years of foreign language in high school.

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

Third Year	A	S

M 311, 412 Ordinary Differential Equations/Systems, Partial Differential Equations	3		3
PHYS 311 Oscillations and Waves	2		-
PHYS 321 Electronics for Scientists	3		-
PHYS 325 Optics	-		3
PHYS 330 Communicating Physics	-		3
PHYS 341-Fundamentals of Modern Physics	3		-
PHYS 375 Classical Mechanics	-		3
PHYS 446 PHYS 446 Thermodynamics and Statistical Mechanics*	(3)		-
PHYS 301 Mathematical Methods for Physical Scientists	-		3
Electives and General Education	3		-
* PHYS 446 is offered every other year and may be taken in the third or fourth year.			
Total	15		15
Fourth Year		A	S
PHYS 414-415 Electromagnetism	3		3
PHYS 444 Advanced Physics Laboratory	-		3
PHYS 446 Thermodynamics and Statistical Mechanics *	(3)		-
PHYS 461-462 Quantum Mechanics I	3		-
PHYS 480 Senior Seminar	1		-
Electives and General Education	5		-
Total	15		16
* 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

First Year	A	S
ASTR 131N-132N Elementary Astronomy	3	3
ASTR 134N-135N Elementary Astronomy Laboratory	1	1
CS 101or 131 Introduction to Programming	-	3
WRIT 101 (ENEX 101) Composition*	3	-
M 151 (MATH 121) Precalculus	4	-
M 171 (MATH 152) Calculus I	-	4
Foreign language+ or General Education	5	5
Total	16	16

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

+Can be waived with two years of foreign language in high school.

Second Year	A	S
M 172, 273 (MATH 153, 251) Calculus II, Multivariable Calculus	4	4
PHYS 211N, 212N, 213N, 214N Fundamentals of Physics with Calculus*	5	5
General Education	6	6
Total	15	15

*Student who are ready for calculus in their first year could take PHYS 211N, 212N, 213N, 214N Fundamentals of Physics with Calculusin their first year instead of a foreign language.

Third Year	A	S
ASTR 351 Planetary Science or ASTR 362 Observational Astronomy*	2-3	-
ASTR 353 Galactic Astrophysics and Cosmology*	-	3
M 311 (MATH 311) Ordinary Differential Equations/ Systems	3	-

PHYS 301 Mathematical Methods for Physical Scientists	-		3	
PHYS 325 Optics	-		3	
PHYS 311 Oscillations and Waves	2		-	
PHYS 330 Communicating Physics	-		3	
PHYS 341 Fundamentals of Modern Physics	3		-	
General Education or electives	3-4		3	
Total	15		15	
Fourth Year		A		S
ASTR 363-364 Stellar Astronomy and Astrophysics*	3		3	
PHYS 375 Classical Mechanics or PHYS 461 Quantum Mechanics I or PHYS 414-415 Electromagnetism I, II	3		3	
PHYS 480 Senior Seminar	1		-	
General Education or electives	8		9	
	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

First Year		A		S
CS 131-132 Fundamentals of Computer Science	3		3	
WRIT 101 (ENEX 101) College Writing I*	3		-	
M 171, 172 (MATH 152-153) Calculus I, II	4		4	
PHYS 211N, 212N, 213N, 214N Fundamentals of Physics with Calculus	5		5	
General Education	-		3	
Total	15		15	

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

Second Year	A	S
CS 241 Data Structure	4	-
M 225 (MATH 225) Introduction to Discrete Math	3	-
M 273 (MATH 251) Multivariable Calculus	-	4
PHYS 301 Mathematical Methods for Physical Scientists	-	3
PHYS 311 Oscillations and Waves	2	-
PHYS 331 Introduction to Computational Physics #	(3)	-
PHYS 341 Fundamentals of Modern Physics	3	-
Foreign language+ or General Education	-	5
General Education or electives	-	0-3
Total	15	15

PHYS 331 is offered every other year and may be taken in the third or fourth year.

+Can be waived with two years of foreign language in high school.

Third Year	A	S
CS 242 Programming Languages	-	4
CS 281 Computer Architecture and Assembly Language Programming	3	-
M 311 (MATH 311) Ordinary Differential Equations/Systems	3	-
M 325 (MATH 325) Discrete Math II	-	3
PHYS 321 Electronics for Scientists*	3	-
PHYS 331 Introduction to Computational Physics #	(3)	-
PHYS 375 Classical Mechanics	-	3
General Education or electives	3-6	6

Total	15		16	
# PHYS 331 is offered every other year and may be taken in the third or fourth year.				
Fourth Year		A		S
CS 332 Algorithms	3		-	
CS 415E Computers, Ethics, and Society*	-		3	
PHYS 414-415 Electromagnetism*	3		3	
PHYS 480 Senior Seminar	1		-	
General Education or electives	8		9	
Total	15		15	

* CS and PHYS 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 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

To earn a minor in physics the student must complete PHYS 111N-113N-112N-114N or 211N-212N-213N-214N; 301, 311, and 375; and six credits from PHYS 325, 341, 414, 415, 446, 461 or 462. (Mathematics prerequisites for the physics minor are M 171, 172, 273, and 311 (MATH 152, 153, 251, and 311)).

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 142 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 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.

UG 351 Planetary Science 3 cr. Offered autumn even-numbered years. Prereq., 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.

UG 353 Galactic Astrophysics and Cosmology 3 cr. Offered spring odd-numbered years. Prereq., ASTR 132N, 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.

UG 362 Observational Astronomy 2 cr. Offered autumn even-numbered years. Prereq., ASTR 132N, PHYS 212N-214N. Telescopes and instrumentation for the determination of the positions, brightness, colors and other properties of stars; particular attention to photoelectric photometry. Includes observational and computational problems.

UG 363 Stellar Astronomy and Astrophysics I 3 cr. Offered autumn odd-numbered years. Prereq., ASTR 132N, M 273 (MATH 251), and PHYS 212N-214N; 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.

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

U 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 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.

Physics (PHYS)

U 111N Fundamentals of Physics I 4 cr. Offered autumn and spring. prereq., M 122 or 151 (MATH 112 or 121) or equivalent, and prereq. or coreq. 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 PHYS 111N-112N and 211N-212N.

U 112N Fundamentals of Physics II 4 cr. Offered autumn and spring. prereq. PHYS 111N and prereq. or coreq., 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 PHYS 111N-112N and 211N-212N.

U 113N Fundamentals of Physics Laboratory I 1 cr. Offered autumn and spring. Prereq. or coreq., PHYS 111. 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 PHYS 113N-114N and 213N-214N.

U 114N Fundamentals of Physics Laboratory II 1 cr. Offered autumn and spring. Prereq., PHYS 113N, prereq, or coreq., 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 PHYS 113N-114N and 213N-214N.

U 141N Relativity: From Galileo to Einstein and Beyond 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 175 Introduction to Engineering 3 cr. Offered autumn. Prereq. or coreq., M 151 (MATH 121) or equivalent. An introduction to engineering calculations, problem solving, and design. Students are taught to solve and present engineering problems on computers using spreadsheet and graphic software (AutoCAD). In addition, there will be discussions on engineering failures and engineering ethics. NOTE: This course may NOT be counted toward the Physics major.

U 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 211N Fundamentals of Physics with Calculus I 4 cr. Offered autumn. Prereq. or coreq., 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 PHYS 211N-212N and 111N-113N-112N-114N.

U 212N Fundamentals of Physics with Calculus II 4 cr. Offered spring. Prereq., PHYS 211N, 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 PHYS 211N-212N and 111N-113N-112N-114N.

U 213N Physics Laboratory I with Calculus 1 cr. Offered autumn. Coreq., 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 PHYS 213N-214N and 111N-113N-112N-114N.

U 214N Physics Laboratory II with Calculus 1 cr. Offered spring. Prereq., PHYS 211N, coreq., 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 PHYS 213N- 214N and 111N-113N-112N-114N.

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

U 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.

UG 301 Mathematical Methods for Physical Scientists 3 cr. Offered spring. Prereq., M 273 (MATH 251); coreq., 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 Oscillations and Waves 2 cr. Offered fall. Prereq., 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 321 Electronics for Scientists 3 cr. Offered autumn. Prereq., PHYS 212N-214N or PHYS 113N-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 325 Optics 3 cr. Offered spring. Prereq., PHYS 311. Intermediate level study of light and optics, including geometrical optics, wave optics, optical instruments, coherence, polarization, and special topics.

UG 330 Methods of Communicating Physics 3 cr. Offered spring even-numbered years. Prereq., 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 331 Introduction to Computational Physics 3 cr. Offered autumn even-numbered years. Prereq., PHYS 212N-214N; coreq., any upper-division PHYS 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.

UG 341 Fundamentals of 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 375 Classical Mechanics 3 cr. Offered spring. Prereq., PHYS 301, M 311. Topics in classical mechanics at the intermediate level, emphasizing Lagrangian and Hamiltonian dynamics.

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

UG 414 Electromagnetism I 3 cr. Offered autumn. Prereq, PHYS 301. Electricity and magnetism at the intermediate level.

UG 415 Electromagnetism II 3 cr. Offered spring. Prereq., PHYS 414. Continuation of PHYS 414. Electricity and magnetism at the intermediate level.

U 444 Advanced Physics Laboratory 3 cr. Offered spring. Prereq., PHYS 341 or equiv., PHYS 325 or equiv.; 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 Thermodynamics and Statistical Mechanics 3 cr. Offered autumn odd-numbered years. Prereq., PHYS 341; coreq., M 311. Topics in thermodynamics and statistical mechanics.

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

UG 462 Quantum Mechanics II 3 cr. Offered spring. Prereq., 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 463 Selected Topics in Modern Physics 3 cr. (R-6) Offered intermittently. Prereq., 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 480 Senior 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.

U 493 Omnibus Variable cr. (R-9) Offered intermittently. University omnibus option for independent work. See index.

UG 495 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 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 Research 1-6 cr. (R-9) Offered intermittently. Prereq., consent of instr. Research in selected physics topics.

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

Faculty

Professors

- James P. Jacobs, Ph.D., University of Washington, 1991
- Eijiro Uchimoto, Ph.D., University of Wisconsin, 1988
- Andrew S. Ware, Ph.D., University of California, San Diego, 1992 (Chair)

Associate Professor

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

Assistant Professors

- Nate McCrady, Ph.D., University of California - Berkeley, 2005
- Michael L. Schneider, Ph.D., University of Wisconsin, 2003

Research Assistant Professor/Adjunct Assistant Professor

- Maureen A. McGraw, Ph.D., University of California, Berkeley, 1996

Adjunct Associate Professors

- David E. Andrews, Ph.D., Cornell University 1972
- Bradford L. Halfpap, Ph.D., Arizona State University, 1987

Adjunct Assistant Professor

- Jack Dostal, Ph.D., Montana State University, 2008
- John Williams, Ph.D., University of Washington, 2002

Lecturer/Research Assistant Professor

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

Adjunct Lecturer

- Julie Schneider, M.S., The University of Colorado, 2007

Emeritus Professors

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

- Mark J. Jakobson, Ph.D., University of California, Berkeley, 1951
- Randolph H. Jeppesen, Ph.D., New Mexico State University, 1980