

Physics

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Departmental information available at:

<http://casgroup.fiu.edu/physics/>

Bachelor of Science

Degree Program Hours: 120

The B.S. program in Physics prepares students for careers as professional physicists in industry, government, or graduate study in physics, engineering, or material science. It also prepares students for teaching careers. Students interested in teacher certification should contact the College of Education.

Lower Division Preparation

Common Prerequisite Courses and Equivalencies

<u>FIU Course(s)</u>	<u>Equivalent Course(s)</u>
CHM1045/CHM1045L	CHMX045C or CHMX040 & CHMX041 or CHMX045/X045L
CHM1046/CHM1046L	CHMX046C or CHMX046/046L
MAC2311	MACX311 or MACX281
MAC2312	MACX312 or MACX282
MAC2313	MACX313 or MACX283
PHY2048/2048L	PHYX048/X048L or PHYX048C
PHY2049/2049L	PHYX049/X049L or PHYX049C

Courses which form part of the statewide articulation between the State University System and the Community College System will fulfill the Lower Division Common Prerequisites.

For generic course substitutions/equivalencies for Common Program Prerequisites offered at community colleges, state colleges, or state universities, visit: <http://www.flvc.org>. See Common Prerequisite Manual.

Required Courses

Common Prerequisites: (30)

CHM 1045	General Chemistry I	3
CHM 1045L	General Chemistry Lab I	1
CHM 1046	General Chemistry II	3
CHM 1046L	General Chemistry Lab II	1
MAC 2311	Calculus I	4
MAC 2312	Calculus II	4
MAC 2313	Multivariable Calculus	4
PHY 2048	Physics with Calculus I	4
PHY 2048L	General Physics Lab I	1
PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics Lab II	1

To qualify for admission to the program, FIU undergraduates must have met all the lower division requirements, completed 60 semester hours, and must be otherwise acceptable into the program.

Additional Required Course: (4)

PHY 1033	First-Year Physics Seminar	1
MAP 2302	Differential Equations	3

Upper Division Program (60 total hours, 48 hours must be 3000 level or above)

Required Courses

PHY 3106	Modern Physics I	3
PHY 3106L	Modern Physics Lab I	1
PHY 3107	Modern Physics II	3
PHY 3107L	Modern Physics Lab II	1
PHZ 3113	Methods in Theoretical Physics	3
PHY 3513	Thermodynamics	3
PHY 4221	Intermediate Classical Mechanics I	3
PHY 4222	Intermediate Classical Mechanics II	3
PHY 4323	Intermediate Electromagnetism I	3
PHY 4324	Intermediate Electromagnetism II	3
PHY 4604	Quantum Mechanics I	3
PHY 4605	Quantum Mechanics II	3
PHY 4821L	Senior Physics Lab	3
PHY 4905, PHY 4906, PHY 4907	Independent Study	3
Approved electives in experimental or theoretical physics		6
Electives (Physics or Non-Physics)		16

Bachelor of Science with Honors in Physics

The Honors program in Physics provides outstanding students with the opportunity to do original research with a faculty sponsor. To graduate with Honors, the student must carry out a research project, write up the project as an Honors Thesis, and present the research results in a departmental seminar.

Admission to the Program

To be admitted to the track, a student must:

- Be admitted to the BS Physics program with a lower division GPA of at least 3.5 in science and math courses and an overall GPA of at least 3.2.
- Have completed at least 12 hours of physics courses.
- Have arranged to be sponsored by a faculty researcher.

- Submit a letter to the Physics Department requesting permission to pursue the honors course of study.

Graduation Requirements

1. Completion of all requirements for the BS Physics degree with a minimum GPA of 3.5 in science and math courses and overall GPA of 3.2.
2. Completion of honors research project in collaboration with a faculty advisor. The results of the research project must be written in the form of an honors thesis which is written in American Physical Society-style publication format. The faculty advisor and curriculum committee must judge the thesis as suitable in style and content.
3. Submission of two completed and approved copies of the Honors Thesis must be presented to the Physics department office; one copy is to be kept in the department and the second copy is to be housed in the University library.
4. The results of the research project must be presented orally to an audience of peers and faculty members in a departmental seminar.

Bachelor of Arts

Degree Program Hours: 120

This program prepares students interested in physics and planning to enter professional schools in business, education, journalism, law, and medicine, and for liberal arts students desiring a strong background in physical science but with career objectives in other areas. The flexible program offers the opportunity for parallel studies in another discipline and/or pre-professional preparation. Students may choose to follow the standard B.A. or choose a specific area of emphasis: the Biophysics Concentration, the Business Concentration, or the Entrepreneurship Concentration. Students wishing to pursue careers as professional physicists or graduate study in physics should seek the Bachelor of Science degree in physics.

Lower Division Preparation for all areas of Concentration

Common Prerequisite Courses and Equivalencies

<u>FIU Course(s)</u>	<u>Equivalent Course(s)</u>
CHM1045/CHM1045L	CHMX045C or CHMX040 & CHMX041 or CHMX045/X045L
CHM1046/CHM1046L	CHMX046C or CHMX046/046L
MAC2311	MACX311 or MACX281
MAC2312	MACX312 or MACX282
MAC2313	MACX313 or MACX283
PHY2048/2048L	PHYX048/X048L or PHYX048C
PHY2049/2049L	PHYX049/X049L or PHYX049C

Courses which form part of the statewide articulation between the State University System and the Community College System will fulfill the Lower Division Common Prerequisites.

For generic course substitutions/equivalencies for Common Program Prerequisites offered at community

colleges, state colleges, or state universities, visit: <http://www.flvc.org>. See Common Prerequisite Manual.

Required Courses: (30)

Common Prerequisites

CHM 1045	General Chemistry I	3
CHM 1045L	General Chemistry Lab I	1
CHM 1046	General Chemistry II	3
CHM 1046L	General Chemistry Lab II	1
MAC 2311	Calculus I	4
MAC 2312	Calculus II	4
MAC 2313	Multivariable Calculus	4
PHY 2048	Physics with Calculus I	4
PHY 2048L	General Physics Lab I	1
PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics Lab II	1

Additional Required Course: (1)

PHY 1033	First-Year Physics Seminar	1
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Upper Division Program for the B.A. (60 total hours, 48 hours must be 3000 level or above)

PHY 3106	Modern Physics I	3
PHY 3106L	Modern Physics Lab I	1
PHY 3107	Modern Physics II	3
PHY 3107L	Modern Physics Lab II	1
PHY 3513	Thermodynamics	3
PHY 4134	Widely Applied Physics I	3
PHY 4135	Widely Applied Physics II	3
Approved Upper Division Physics Electives		15
Electives		28

Biophysics Concentration

This program prepares students interested in physics and planning to enter professional schools in medicine, biomedical engineering, and biomechanics as well as entry level biotechnology positions in industry and government. The flexible program offers the opportunity for parallel studies in another discipline. Students satisfying the degree requirements of this program will also have satisfied the course requirement for admission to medical schools. Interested students should consult the Premedical advisor at (305) 348-3084.

Lower Division Preparation

Common Prerequisite Courses and Equivalencies

<u>FIU Course(s)</u>	<u>Equivalent Course(s)</u>
CHM1045/CHM1045L	CHMX045C or CHMX040 & CHMX041 or CHMX045/X045L
CHM1046/CHM1046L	CHMX046C or CHMX046/046L
MAC2311	MACX311 or MACX281
MAC2312	MACX312 or MACX282
MAC2313	MACX313 or MACX283
PHY2048/2048L	PHYX048/X048L or PHYX048C
PHY2049/2049L	PHYX049/X049L or PHYX049C

Courses which form part of the statewide articulation between the State University System and the Community College System will fulfill the Lower Division Common Prerequisites.

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colleges, state colleges, or state universities, visit: <http://www.flvc.org>. See Common Prerequisite Manual.

Common Prerequisites as Detailed Under the B.A. Degree

Additional Lower Division Courses: (17)

BSC 1010	General Biology I	3
BSC 1010L	General Biology I Lab	1
BSC 1011	General Biology II	3
BSC 1011L	General Biology II Lab	1
CHM 2210	Organic Chemistry I	4
CHM 2210L	Organic Chemistry I Lab	1
CHM 2211	Organic Chemistry II	3
CHM 2211L	Organic Chemistry II Lab	1

Upper Division Program (60 total hours, 48 hours must be 3000 level or above)

PHY 3106	Modern Physics I	3
PHY 3106L	Modern Physics Lab I	1
PHY 3107	Modern Physics II	3
PHY 3107L	Modern Physics Lab II	1
PHY 3513	Thermodynamics	3
PHY 4134	Widely Applied Physics I	3
PHY 4135	Widely Applied Physics II	3
PHY 4221	Mechanics I	3
PHY 4821L	Senior Physics Lab	3
PHZ 4710	Introduction to Biophysics	3
Physics Electives		6
Electives in Biology and Chemistry		12
Electives		16

Pre-med students are strongly encouraged to take:

BCH 3033	General Biochemistry	4
BCH 3033L	General Biochemistry Lab	1
or		
CHM 4304	Biological Chemistry I	3
CHM 4304L	Biological Chemistry I Lab	1
PCB 3063	Genetics	3
PCB 3063	Genetics Lab	1
PCB 3702	Intermediate Human Physiology	3
PCB 3702L	Intermediate Human Physiology Lab	1

Business Concentration

This program prepares students interested in physics and planning to enter business and business management careers. Concentrates on the basics of business administration and on gaining a thorough understanding of electronics, lasers, computers and other tools of the physicist.

Lower Division Preparation

Common Prerequisite Courses and Equivalencies

<u>FIU Course(s)</u>	<u>Equivalent Course(s)</u>
CHM1045/CHM1045L	CHMX045C or CHMX040 & CHMX041 or CHMX045/X045L
CHM1046/CHM1046L	CHMX046C or CHMX046/046L
MAC2311	MACX311 or MACX281
MAC2312	MACX312 or MACX282
MAC2313	MACX313 or MACX283
PHY2048/2048L	PHYX048/X048L or PHYX048C
PHY2049/2049L	PHYX049/X049L or PHYX049C

Courses which form part of the statewide articulation between the State University System and the Community College System will fulfill the Lower Division Common Prerequisites.

For generic course substitutions/equivalencies for Common Program Prerequisites offered at community colleges, state colleges, or state universities, visit: <http://www.flvc.org>. See Common Prerequisite Manual.

Common Prerequisites as Detailed Under the B.A. Degree

Additional Lower Division Courses: (9)

ECO 2013	Principles of Macroeconomics	3
ECO 2023	Principles of Microeconomics	3
ACG 2021	Accounting for Decisions	3

Upper Division Program (60 total hours, 48 hours must be 3000 level or above)

PHY 3106	Modern Physics I	3
PHY 3106L	Modern Physics Lab I	1
PHY 3107	Modern Physics II	3
PHY 3107L	Modern Physics Lab II	1
PHY 3513	Thermodynamics	3
PHY 4134	Widely Applied Physics I	3
PHY 4135	Widely Applied Physics II	3
PHY 4821L	Senior Physics Lab	3
Physics Electives		6
ACG 3301	Acc. for Planning and Control	3
CGS 3300	Introduction to Information Systems	3
FIN 3403	Financial Management	3
MAN 3025	Organization and Management	3
MAN 4602	International Business	3
MAR 3023	Marketing Management – GL	3
Business Electives		3
Electives		13

Entrepreneurship Concentration

This program provides students with a strong background in physics as well as the skill set for starting and growing new high-tech business ventures. The curriculum encourages “hands on” interdisciplinary research in the form of an independent study course and an entrepreneurial science internship. It also provides the flexibility to tailor coursework to science and technology entrepreneurial activities. Graduates of this program will be well equipped to create their own high-tech jobs within existing companies as well as their own startup ventures.

Lower Division Preparation

Common Prerequisite Courses and Equivalencies

<u>FIU Course(s)</u>	<u>Equivalent Course(s)</u>
CHM1045/CHM1045L	CHMX045C or CHMX040 & CHMX041 or CHMX045/X045L
CHM1046/CHM1046L	CHMX046C or CHMX046/046L
MAC2311	MACX311 or MACX281
MAC2312	MACX312 or MACX282
MAC2313	MACX313 or MACX283
PHY2048/2048L	PHYX048/X048L or PHYX048C
PHY2049/2049L	PHYX049/X049L or PHYX049C

Courses which form part of the statewide articulation between the State University System and the Community College System will fulfill the Lower Division Common Prerequisites.

For generic course substitutions/equivalencies for Common Program Prerequisites offered at community colleges, state colleges, or state universities, visit: <http://www.flvc.org>. See Common Prerequisite Manual.

Common Prerequisites as Detailed Under the B.A. Degree

Upper Division Program (60 total hours, 48 hours must be 3000 level or above)

PHY 3106	Modern Physics I	3
PHY 3106L	Modern Physics Lab I	1
PHY 3107	Modern Physics II	3
PHY 3107L	Modern Physics Lab II	1
PHY 3513	Thermodynamics	3
PHY 4221	Intermediate Classical Mechanics I	3
PHY 4323	Intermediate Electromagnetism I	3
PHY 4604	Quantum Mechanics I	3
PHY 4134	Widely Applied Physics I	3
PHY 4135	Widely Applied Physics II	3
PHY 4905	Independent Study	3
PHY 4821L	Senior Physics Lab	3
Physics Electives		6
ENT 4113	Entrepreneurship: New Business Development	3
ISC 4947	Entrepreneurial Science Internship	3
GEB 4110	Writing the Business Plan	3
	or	
GEB 4xxx	Technology Product and Service Development	3
Electives		13

Physics Education Track

This program prepares students interested in physics and science for teaching at the secondary level. Students are encouraged to participate in on-campus teaching experiences that parallel their coursework, available for freshman and sophomores. Interested students are encouraged to contact the department for additional details and information on teacher support programs.

Lower Division Preparation

Common Prerequisite Courses and Equivalencies

<u>FIU Course(s)</u>	<u>Equivalent Course(s)</u>
CHM1045/CHM1045L	CHMX045C or CHMX040 & CHMX041 or CHMX045/X045L
CHM1046/CHM1046L	CHMX046C or CHMX046/046L
MAC2311	MACX311 or MACX281
MAC2312	MACX312 or MACX282
MAC2313	MACX313 or MACX283
PHY2048/2048L	PHYX048/X048L or PHYX048C
PHY2049/2049L	PHYX049/X049L or PHYX049C

Courses which form part of the statewide articulation between the State University System and the Community College System will fulfill the Lower Division Common Prerequisites.

For generic course substitutions/equivalencies for Common Program Prerequisites offered at community colleges, state colleges, or state universities, visit: <http://www.flvc.org>. See Common Prerequisite Manual.

Common Prerequisites as Detailed Under the B.A. Degree

Additional Lower Division Courses: (8)

BSC 1010	General Biology I	3
BSC 1010L	General Biology I Lab	1
BSC 1011	General Biology II	3
BSC 1011L	General Biology II Lab	1

Upper Division Program (60 total hours, 48 hours must be 3000 level or above)

PHY 3012	Seminar in Physics Education	1
PHY 3106	Modern Physics I	3
PHY 3016L	Modern Physics Lab I	1
PHY 3107	Modern Physics II	3
PHY 3107L	Modern Physics Lab II	1
PHY 3513	Thermodynamics	3
PHY 4134	Widely Applied Physics I	3
PHY 4135	Widely Applied Physics II	3
PHY 4221	Intermediate Classical Mechanics I	3
PHY 4821L	Senior Physics Lab	3
PSC 4813	Modeling Instruction	3
SCE 4xxx	Nature of Math and Science	3
SCE 4xxx	Perspectives on Science Education	3
SCE 4330	Secondary Science Teaching Methods	3
SCE 4944	Student Teaching	6
SCE 4xxx	Senior Seminar in Science Education	2
RED 4325	Subject Area Reading	3
TSL 4324	ESOL Issues and Strategies for Content Teachers – GL	3
Electives		10

Minor in Physics

This program is designed for students who desire additional capabilities in physics beyond the basic sequence. This program is especially recommended for chemistry, mathematics, and engineering/technology majors.

PHY 2048	Physics with Calculus I	4
PHY 2048L	General Physics Lab I	1
PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics Lab II	1
PHY 3106	Modern Physics I	3
PHY 3106L	Modern Physics Lab I	1
PHY 3107	Modern Physics II	3
PHY 3107L	Modern Physics Lab II	1
Approved physics electives		3

Minor in Astronomy

This program is designed for students who desire additional capabilities in astronomy. The program offers enhanced preparation for graduate studies in astronomy and astrophysics. It is also aimed at students interested in careers in science education, science centers, museums, and planetaria.

PHY 2048	Physics with Calculus I	4
PHY 2048L	Physics with Calculus Lab I	1
PHY 2049	Physics with Calculus II	4
PHY 2049L	Physics with Calculus Lab II	1

PHY 3106	Modern Physics I	3
PHY 3106L	Modern Physics Lab I	1
AST 3213	Modern Astrophysics	3
AST 3722	Observational Astronomy	3
AST 3722L	Observational Astronomy Lab	1

Cooperative Education

Students seeking the baccalaureate degree in physics may also take part in the Cooperative Education Program conducted in conjunction with Career Planning & Placement. The student spends several semesters fully employed in an industrial or governmental physics laboratory. For further information consult the Department of Physics or Career Planning & Placement.

Course Descriptions

Definition of Prefixes

AST-Astronomy; ENU-Engineering: Nuclear; MET-Meteorology; PHY-Physics; PHZ-Physics; PSC-Physical Sciences

F-Fall semester offering; S-Spring semester offering; SS-Summer semester offering.

AST 2003 Solar System Astronomy (3). General principles of Astronomy with emphasis on the structure and evolution of the Solar System, the laws of planetary motion, and the physical aspects of the sun, planets, and interplanetary debris. (F,S,SS)

AST 2003L Solar System Astronomy Laboratory (1). Laboratory section of AST 2003. Outdoor observing of the moon, planets and indoor exercises including celestial positions and time, the moon's orbit, planetary motions, comparative planetology. Corequisite: AST 2003. (Lab fees assessed) (F,S,SS)

AST 2004 Stellar Astronomy (3). General principles of Astronomy with emphasis on the structure and evolution of stars, stellar systems, galaxies and the universe. Topics include stellar birth and death, neutron stars and black holes, galactic distances and the expansion of the universe. (F,S,SS)

AST 2004L Stellar Astronomy Laboratory (1). Laboratory section of AST 2004. Outdoor observing of stars, constellations, binary and variable stars, star clusters, nebulae and indoor exercises including radiative properties of the stars, spectra, stellar and galactic distances, Hubble's Law. Corequisite: AST 2004. (Lab fees assessed) (F,S,SS)

AST 2037 Intelligent Life in the Universe (3). Examines the possibility of extraterrestrial life in terms of the probability of the existence of planets in other solar systems, the conditions necessary for life, and means of communication. (F or S)

AST 3213 Modern Astrophysics (3). An introduction to the structure of stars and galaxies and the evolution of the universe as a whole. Topics will include atomic spectra, stellar classifications, galactic structure, and cosmology. Prerequisites: PHY 2048, 2049. (F or S)

AST 3722 Observational Astronomy (3). Observational astronomical techniques from radio to x-rays including CCD Imaging, Photometry, and Spectroscopy.

AST 3722L Observational Astronomy Laboratory (1). The lab component associated with Observational Astronomy. Covers acquisition, reduction and interpretation of astronomical data using telescopes and computers. Corequisite: AST 3722.

AST 5215 Stellar Astrophysics (3). Topics in Stellar Astrophysics, in greater detail and depth than similar topics in AST 3213. Emphasis on current stellar structure, evolution models and the underlying observational data. Prerequisites: PHY 3107, PHY 3513, PHY 4324, PHY 4222 or equivalent. (F or S)

AST 5405 Extragalactic Astrophysics (3). Topics in extragalactic astrophysics, in greater detail and depth than similar topics in AST 3213. Emphasis on galactic structure and evolution, quasars and cosmology. Prerequisites: PHY 3107, PHY 3513, PHY 4324, PHY 4222 or equivalent. (F or S)

AST 5507 Celestial Mechanics (3). Principles of classical Newtonian mechanics applied to the motions of planets, satellites, and interplanetary space probes. Prerequisites: PHY 4222 or equivalent. (F or S)

ENU 4101 Introduction to Nuclear Reactors (3). An elementary course in nuclear fission reactor theory and power plant operation. An overview of the relevant nuclear processes and their application to reactor design. Prerequisites: PHY 2048, PHY 2049.

MET 2010 Meteorology and Atmospheric Physics (3). Physics of the Earth's atmosphere and weather including energy and heat transfer, radiation, temperature and pressure changes and the development of storms, atmospheric optical effects, and weather forecasting. Prerequisite: High school algebra. (F,S)

MET 2010L Meteorology and Atmospheric Physics Laboratory (1). Practical weather analysis including fronts, local severe weather, hurricanes, also elementary analyses and interpretation of weather maps, satellite imagery, radar data. Corequisite: MET 2010. (F,S)

PHY 1020 Understanding the Physical World (3). A course to introduce non-science majors to the basic principles of the physical world with emphasis on understanding common devices, biological and medical applications, natural phenomena and sports. Prerequisite: one year high school or college algebra. (F,S)

PHY 1020L Understanding the Physical World Laboratory (1). Laboratory section of Understanding the Physical World. (F,S)

PHY 1033 First-Year Physics Seminar (1). Introduces activities, members, research and facilities of the Physics Department, curriculum choices, and physics career options to freshman through group discussions and faculty seminars. Repeatable for credit.

PHY 1037 Quarks, Superstrings, and Black Holes (3). Introduction to physics in the modern era for nonscientists. Topics include quantum mechanics, relativity, fundamental forces, and unification theory.

PHY 1037L Quarks, Superstrings, and Black Holes Laboratory (1). Laboratory to accompany Quarks, Superstrings, and Black Holes.

PHY 2023 Survey of General Physics (3). Units, quantities, Newton's laws, work, momentum, fluids, heat, gas laws, waves, charge and current, electric fields, circuits, light, atomic and nuclear physics. Prerequisites: Algebra, trigonometry (high school). (F,S,SS)

PHY 2048 Physics with Calculus I (4). First in physics with calculus sequence. Covers kinematics, Newton's Laws, conservations laws, gravitation, fluids, sound, and thermodynamics. PHZ 2102 strongly recommended for problem solving skills. Calculus I (MAC 2311 or equivalent) should be taken prior to or concurrent with this course. Prerequisite or Corequisite: MAC 2311 or equivalent.

PHY 2048L General Physics Laboratory I (1). Laboratory sections of PHY 2048, PHY 2049, PHY 2053, PHY 2054. Prerequisites or Corequisites: PHY 2048, PHY 2049, PHY 2053, PHY 2054. (Lab fees assessed) (F,S,SS)

PHY 2049 Physics with Calculus II (4). Second in basic physics with calculus sequence. Covers electricity and magnetism, field theory, geometrical and wave optics. PHZ 2103 strongly recommended for problem solving skills. Calculus II (MAC 2312 or equivalent) should be taken prior to or concurrent with this course. Prerequisites: PHY 2048. Prerequisite or Corequisite: MAC 2312. (F,S,SS)

PHY 2049L General Physics Laboratory II (1). Laboratory sections of PHY 2048, PHY 2049, PHY 2053, PHY 2054. Prerequisites or Corequisites: PHY 2048, PHY 2049, PHY 2053, PHY 2054. (Lab fees assessed) (F,S,SS)

PHY 2053 Physics without Calculus I (4). First in physics without calculus sequence. Covers kinematics, Newtonian mechanics, properties of fluids, thermodynamics, and wave motion. PHY 2065 strongly recommended for problem solving skill. Trigonometry (MAC 1114 or equivalent) should be taken prior to or concurrently with this course.

PHY 2054 Physics without Calculus II (4). Second in basic physics without calculus sequence. Covers electricity and magnetism, geometrical and wave optics and the structure of matter. PHY 2166 strongly recommended for problem solving skills. Prerequisite: PHY 2053. (F,S,SS)

PHY 2065 Problem Solving in Physics without Calculus I (1). Supplemental course for Physics 2053 that teaches problem solving skills and reinforces concepts learned in the lecture. Corequisite: PHY 2053.

PHY 2166 Problem Solving in Physics without Calculus II (1). Supplemental course for Physics 2054 that teaches problem solving skills and reinforces concepts learned in the lecture. Corequisite: PHY 2054.

PHY 3012 Seminar in Physics Education (1). Physics education theory, pedagogy, and practice for those considering physics education careers. Covers conceptual development, collaborative learning, and assessment in multiple physics topics.

PHY 3106 Modern Physics I (3). Recent developments in physics are discussed. Subject matter includes: review of classical physics, special relativity, four-vectors, wave-particle duality, the hydrogen atom, many electron atoms, nuclear instrumentation, nuclear structure, nuclear reactions, elementary particles, introduction to quantum mechanics, and solid state physics. Prerequisites: PHY 2049 and MAC 2312. (F)

PHY 3106L Modern Physics Laboratory I (1). Laboratory courses to accompany Modern Physics I consisting of experiments in atomic and nuclear physics. Pre- or Corequisites: PHY 3106. (F)

PHY 3107 Modern Physics II (3). Recent developments in physics are discussed. Subject matter includes: review of classical physics, special relativity, four-vectors, wave-particle duality, the hydrogen atom, many electron atoms, nuclear instrumentation, nuclear structure, nuclear reactions, elementary particles, introduction to quantum mechanics, and solid state physics. Prerequisite: PHY 2049. (S)

PHY 3107L Modern Physics Laboratory II (1). Laboratory courses to accompany Modern Physics II consisting of experiments in atomic and nuclear physics. Pre- or Corequisites: PHY 3107. (S)

PHY 3272 Physics of Space Flight (3). Basic physics is used to describe the motions of space craft, with a discussion of various types of propulsion systems, including chemical methods, nuclear systems, electric and photon propulsion. Prerequisite: PHY 2049.

PHY 3424 Optics (3). General formulation of geometrical optics including matrix techniques, interference phenomena, and the theory of Fraunhofer and Fresnel diffraction are among the topics covered. Prerequisites: PHY 2048, PHY 2049.

PHY 3465 Physics of Music (3). Provides an understanding of the physics behind sound, sound reproduction and electronics that are necessary for musicians to understand to take full advantage of modern electronic and musical equipment.

PHY 3513 Thermodynamics (3). Fundamental principles of thermodynamics, the first, second, and third laws, free energy, entropy, the chemical potential, phase rule and its applications. Prerequisites: PHY 2049, MAC 2313. Corequisite: MAC 2313. (F)

PHY 3722 Electronics (3). Solid state theory and the theory of circuits, circuit operation and design in lecture and laboratory sessions. Prerequisites: PHY 2048, PHY 2049.

PHY 3949, PHY 4949 Cooperative Education in Physics (1-3). One semester of full-time supervised work in an outside laboratory taking part in the University Co-op Program. Limited to students admitted to the Co-op Program. A written report and supervisor evaluation will be required of each student. (F,S,SS)

PHY 4134 Widely Applied Physics I (3). Applications of Physics principles to a diverse set of phenomena. Topics include material science, computers and electronics, nuclear physics and energy, astrophysics, aeronautics and space flight, communication technology, and medical physics and imaging. Prerequisite: PHY 3107.

PHY 4135 Widely Applied Physics II (3). Second of a two-course sequence. Will investigate materials science, nanotechnology, computers and electronics, nuclear physics and energy, astrophysics, aeronautics and space flight, communications technology, meteorology, and medical physics and imaging. Course will focus on Chaos, Optical and Wireless Communications, High Temperature Superconductors. Prerequisite: PHY 3107.

PHY 4221 Intermediate Classical Mechanics I (3). Laws of motion, statics of particles and rigid bodies, motion of particles in one, two, and three dimensions, systems of particles, rigid bodies in a plane, central forces. Accelerated reference systems, rigid body in three dimensions, generalized coordinates, Lagrangian and Hamiltonian formulations of mechanics, vibrating systems, and normal coordinates. Prerequisites: MAC 2313, PHY 2048, PHY 2049. (F)

PHY 4222 Intermediate Classical Mechanics II (3). Laws of motion, statics of particles and rigid bodies, motion of particles in one, two, and three dimensions, systems of particles, rigid bodies in a plane, central forces. Accelerated reference systems, rigid body in three dimensions, generalized coordinates, Lagrangian and Hamiltonian formulations of mechanics, vibrating systems, and normal coordinates. Prerequisites: MAC 2313, PHY 2048, PHY 2049. (S)

PHY 4323 Intermediate Electromagnetism I (3). The theory of electromagnetic fields and waves is developed from basic principles. Vector calculus, Coulomb's law, Gauss's Law, electrostatic potential, dielectrics, solutions to Laplace's and Poisson's equations, magnetic induction, vector potential, magnetic materials, Maxwell's equations, and propagation of waves in space and various media are discussed. Prerequisites: PHY 2049, MAC 2313. Prerequisite or Corequisite: MAP 2302. (F)

PHY 4324 Intermediate Electromagnetism II (3). The theory of electromagnetic fields and waves is developed from basic principles. Vector calculus, Coulomb's law, Gauss's Law, electrostatic potential, dielectrics, solutions to Laplace's and Poisson's equations, magnetic induction, vector potential, magnetic materials, Maxwell's equations, and propagation of waves in space and various media are discussed. Prerequisites: MAC 2313, PHY 2048 and PHY 2049. (S)

PHY 4513 Statistical Thermodynamics (3). Review of the fundamental laws of thermodynamics applied to simple systems. Elementary kinetic theory of gases applied to diffusion, viscosity, thermal and electrical conductivity. Boltzmann, Fermi-Dirac and Bose-Einstein distribution functions applied in the Boltzmann limit to the calculation of thermodynamic variables. Prerequisites: MAC 2313, PHY 2048, PHY 2049.

PHY 4604 Quantum Mechanics I (3). A comprehensive introduction to quantum mechanics. Wave mechanics applied to standard one dimensional problems and the hydrogen atom. Prerequisites: PHY 3107 or permission of the instructor and MAP 2302, MAC 2313, and PHY 2049. (F)

PHY 4605 Quantum Mechanics II (3). General matrix formalism, angular momentum, symmetries, perturbation theory and variational methods, an introduction to relativistic theory and theory of fields. Prerequisite: PHY 4604. (S)

PHY 4752C Introduction to Scientific Instrumentation (3). The student learns to set up and operate such standard pieces of laboratory apparatus as bridges, amplifiers, oscilloscopes, frequency counters, flowmeters, and thermocouple circuits utilizing chart recorders. A background in general physics is required.

PHY 4821L Senior Physics Lab (3). Advanced laboratory topics are treated. Modern physics laboratory equipment is used and the student is introduced to current laboratory practice. Prerequisites: PHY 2049, PHY 3107L, MAC 2313. (S)

PHY 4905, PHY 4906, PHY 4907 Independent Study (3). The student works under the supervision of a faculty member on subject matter of mutual interest. Instructor's permission is required.

PHY 4936, PHY 4937, PHY 4938 Special Topics (VAR). A study of topics of special physics interest.

PHY 5115 Mathematical Physics I (3). Methods of solution for problems in mathematical physics: Variational principles, complex variables, partial differential equations, integral equations, and transforms. Prerequisites: MAC 2313, MAP 2302. (F)

PHY 5116 Mathematical Physics II (3). Additional solution methods in mathematical physics: Perturbation methods, Laplace's and Poisson's Equations, waves, special functions, vector fields, vector waves. Prerequisite: PHY 5115. (S)

PHY 5141 Intermediate Modern Physics I (3). Prepares advanced undergraduate and beginning graduate students to start research in atomic, molecular, or optical physics. Topics may be adapted to students' research interests. Prerequisite: Permission of the instructor.

PHY 5142 Intermediate Modern Physics II (3). Continuation of advanced undergraduate and beginning graduate student research preparation in atomic, molecular, optical or nuclear physics. Topics may be adapted to students' research interests. Prerequisite: PHY 5141.

PHY 5156C Physics Modeling II (4). Expanding the modeling guided-inquiry approach in Physics Modeling I to topics beyond mechanics such as electricity, magnetism, light, or modern physics. May be repeated for credit. Prerequisites: PHZ 5155C and permission of the instructor.

PHY 5235 Nonlinear Dynamics and Chaos (3). Introduction to the universal behavior of classical systems described by nonlinear equations. Prerequisites: PHY 4222, MAA 4211. (F or S)

PHY 5240 Advanced Classical Mechanics (3). Advanced formulations of the equations of motion and their applications: the central field problem, rigid body dynamics, oscillations and continuous systems. Prerequisite: PHY 4222. (F)

PHY 5346 Advanced Electromagnetic Theory I (3). Advanced treatment of classical electromagnetism: Electrostatics, Green's function, Laplace's equation, multipole expansion, magnetostatics, Maxwell's equations, waves. Prerequisite: PHY 4324. (F)

PHY 5347 Advanced Electromagnetic Theory II (3). Additional topics in classical electromagnetism: Wave guides, radiating and diffracting systems, Kirchoff's integral for diffraction, covariant formulation of field equations. Prerequisite: PHY 5346. (S)

PHY 5446 Laser Physics (3). Principles of lasers and laser applications, including atom-field interactions, stimulated emission and dipole oscillators, optical resonators and electromagnetic modes, semi-classical laser theory, and specific laser systems. Prerequisite: PHY 4605. (F or S)

PHY 5466 The Physics of Music (3). Provides music technology majors a physical understanding of sound, sound generation and reproduction. Concentrates mainly on physical principles and less on calculation. Prerequisite: Permission of the instructor.

PHY 5667 Nonperturbative Quantum Field Theory (3). Euclidean QFT, renormalization group, local gauge symmetry, lattice regularization, Wilson action, fermion fields, expansion schemes, numerical algorithms, hadron properties, recent developments. Prerequisite: PHY 4605.

PHY 5930 Seminar in Physics (1-3). A series of specialized lectures/seminars on selected topics in Physics/Astro-Physics. Prerequisite: Permission of the department.

PHY 5936 Special Topics Research (1-10). Participation in an original investigation in theoretical or experimental physics/astro-physics under direct faculty supervision. Prerequisite: Permission of the instructor.

PHY 5937, PHY 5938 Seminar in Special Topics (3). Seminar work under the supervision of a faculty member on subject material of mutual interest.

PHY 5940 Physics Graduate Teaching Workshop (1). The teaching of physics laboratories. Includes practice of lab experiments, use and adjustment of lab equipment and explanation of departmental grading policy. Supplemented by outside lectures on university policies. (F)

PHZ 2102 Problem Solving in Physics I (1). Supplemental course for Physics 2048 that teaches problem solving skills and reinforces concepts learned in the lecture. Corequisite: PHY 2048.

PHZ 2103 Problem Solving in Physics II (1). Supplemental course for Physics 2049 that teaches problem solving skills and reinforces concepts learned in the lecture. Corequisite: PHY 2049.

PHZ 3113 Methods in Theoretical Physics (3). Methods in theoretical physics and theoretical applications in physics. Includes analytic and numerical methods for differential equations, integral equations and transformations and other applications of real analysis. Prerequisite: MAC 2313.

PHZ 3422 Nanoscience and Nanotechnology (3). Introduction to the emerging nanoscience and nanotechnology, physical/chemical understanding of nanomaterials and nanostructures, basic skills and techniques for nanofabrication and characterization. Prerequisite: PHY 2049.

PHZ 4390 Nuclear and Particle Physics (3). Basics of Nuclear and Particle Physics, Nuclear forces, quark-gluon structure of hadrons, deep-inelastic scattering, qcd, nuclear and particle astrophysics, formation of quark-gluon plasma. Prerequisite: PHY 4604.

PHZ 4404 Introduction to Solid State Physics (3). Covers crystal structure, thermal properties, and survey of recent development in condensed matter physics. For upper division physics or engineering majors. Prerequisite: PHY 2049.

PHZ 4710 Introduction to Biophysics (3). Physical investigation of biological molecules with special reference to structure and function of protein, biomembranes and visual receptors. Prerequisites: PHY 3107 or CHM 3411.

PHZ 5130 Theoretical Treatment of Experimental Data (3). Statistical analysis of physical processes and statistical tests, with particular emphasis on instrumentation-related problems. Mathematical modeling and computer simulation. Prerequisites: Undergraduate statistics course or equivalent, or permission of the instructor.

PHZ 5155C Physics Modeling I (4). An inquiry physics-teaching approach incorporating physics education research. Emphasis on basics models in mechanics, scientific discourse, and student learning assessment. May be repeated for credit. Prerequisite: Permission of the instructor.

PHZ 5156 Computational Physics I (3). Physical systems by means of computer simulation. Monte Carlo, molecular dynamics, percolation, random systems, chaos, criticality, gauge fields. Prerequisites: PHY 5115 and PHY 5116.

PHZ 5157C Computational Physics II (3). Advanced computer simulation methods of physical systems. Application in chaos, nonlinear and random systems, criticality, field theory and practices. Prerequisite: PHZ 5156. Corequisites: PHY 5115 and PHY 5116.

PHZ 5234 Atomic and Molecular Collision Phenomena (3). Investigation of atomic and molecular collision phenomena: Kinetic theory, elastic scattering, inelastic scattering, excitation and ionization, heavy particle collisions. Prerequisites: PHY 4605 and PHY 4222. (F or S)

PHZ 5304 Advanced Nuclear Physics (3). Fundamental properties of nuclei, nuclear forces, nuclear models, radioactivity, weak processes and nuclear reactions. Prerequisite: PHY 4604. Corequisite: PHY 4605. (F or S)

PHZ 5340 Particle Interactions and Detection (3). Subatomic particle detectors and the utilization of physics in practical instrumentation applications in medical physics. The course will include laboratory exercises using various detectors. Prerequisites: PHY 3107 or permission of the instructor.

PHZ 5370 Nanoscience (3). Overview of the nanoscience with emphasis on physical properties, such as electrical, magnetic and optical properties, of nanomaterials. Prerequisites: PHY 3106, PHY 3107.

PHZ 5405 Solid State Physics (3). Crystalline form of solids, lattice dynamics, metals, insulators, semiconductors, crystalline surfaces, and amorphous materials. Prerequisites: PHY 3107 or CHM 3411. (F or S)

PHZ 5505 Low Energy Plasma Physics (3). The investigation of the kinetics of rarefied gases and thermal plasmas: Phase space, random currents, orbit theory, plasma sheaths, radiation, the pinch effect. Prerequisites: PHY 3513, PHY 4324, and PHY 4222.

PHZ 5506 Plasma Physics (3). An introduction to plasma fundamentals, the Boltzmann equation, the hydro-dynamic equations, orbit theory, the interaction of electromagnetic waves with plasmas, the pinch effect and instabilities. Prerequisite: PHY 2049.

PHZ 5606 Special Relativity (3). A detailed study of special relativity: Lorentz transformations, relativistic electrodynamics. Prerequisite: PHY 3107.

PHZ 5607 General Relativity (3). General relativity using differential geometry and tensor analysis. Topics include Einstein's field equations and their solutions, applications and observational tests. Black Holes and cosmology are also discussed. Prerequisites: PHY 4222 and PHY 4605.

PHZ 5705 Biomedical Physics (3). Physics principles applied to biology and medicine; transport through cell membranes, biochemical signaling, thermodynamics, neurons, biomechanics, biofluid flow, bioelectrical signals. Prerequisite: PHY 3107.

PHZ 5730 Biophysical Effects of Radiation (3). Biological effects resulting from interactions of radiation and matter for scientifically, technically, and medically oriented students. Prerequisite: PHY 3107.

PHZ 5732 Clinical and Medical Dosimetry (3). Practical patient dosimetry problems in radiation oncology. Irregular field calculations, two- and three-dimensional treatment planning, isodose distribution, dose rate brachytherapy planning. Prerequisite: PHY 3107.

PHZ 5734 Nuclear Medicine Physics (3). The nuclear physics principles of diagnostic and therapeutic applications of radionuclides, radiation beams, with lab activities in facility design, instrumentation essentials, quality assurance. Prerequisite: PHY 3107.

PHZ 5736 Therapeutic Radiological Physics (3). Production, application, and measurement of electromagnetic radiation and particle beams in therapeutic practice. Conceptual, instrumental, and methodological aspects of therapeutic radiology. Prerequisite: PHY 3107.

PHZ 5945 Clinical Experience in Medical Physics (3). Arranged through the Physics Department at local institutions e.g. hospitals, treatment centers, etc., this course places students in clinical medical physics facilities. Prerequisite: PHY 3107.

PSC 4813 Modeling Instruction (3). Inquiry physics instruction approach incorporating physics education research. Includes basic models in mechanics, scientific discourse, and assessment. Includes use of technology in content delivery. Prerequisite: PHY 3012.

PSC 4814 Advanced Modeling Instruction (3). Extends modeling guided inquiry approach to topics including electricity and magnetism, light, and/or modern physics. Includes use of technology in content delivery. May be repeated for credit. Prerequisite: PSC 4813.