PHYSICS (PHYS)

PHYS102 Physics for Future Presidents
Physics of terrorism, energy, nukes, global warming, and space travel. This course offers the opportunity to students who previously have not studied physics to learn about the physics of timely topics that influence our lives. Students who are interested in having a working knowledge of physics to assist their decisions as citizens on the above topics are encouraged to enroll. Students who have already taken a high school physics course or other introductory physics courses may be too overqualified to enjoy this course.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Prereq: None

PHYS103 Science Information Literacy
Information literacy is the set of skills needed to find, retrieve, analyze, and use information. This course will focus on teaching these skills as especially applied to scientific information. Students will learn to determine the nature and extent of information needed, to acquire needed information effectively and efficiently, to evaluate information and its sources critically, and to use information effectively to accomplish a specific purpose. Students will also examine the economic, ethical, legal, and social issues surrounding the use of information and how information literacy is important to lifelong learning and keeping current to new developments in his/her field. Topics will include the structure of scientific information and scientific publishing, the research process, types of information retrieval systems, search strategies and syntax, use of bibliographic management software (e.g., EndNote), criteria for critical evaluation, open-access publication, plagiarism, and copyright.
Offering: Crosslisting
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Identical With: MB&B102, CHEM102, BIOL102, NS&B102, PSYC102, E&E102, ASTR102, MB&B102, CHEM102, BIOL102, NS&B102, PSYC102, E&E102, ASTR102
Prereq: None

PHYS104 Newton to Einstein: The Trail of Light
The course will follow the trail of light from Newton’s corpuscles to Einstein’s relativity. The major theoretical landmarks are the wave-particle duality and the special theory of relativity. Along the way, we will examine the properties of light and our perceptions of light, including topics on color, vision, and art. The emphasis will be on principles, not problem solving (although there will be weekly problems).
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Prereq: None

PHYS105 Science of Sustainability
What is sustainability? It most certainly is not switching light bulbs or “buying organic,” although perhaps those activities contribute to sustainability. The task for our course will be to undertake a scientific inquiry into the conditions for an enduring human presence on Earth. To do so, we must begin with physical principles, examining both what humans require and demand from the world and what the world is capable of providing. Our inquiry will broaden to include chemical and ecological principles, ultimately asking what the social sciences can do to illuminate the problem without violating the physical constraints nature imposes.

Students should bring a familiarity with quantitative and algebraic concepts and above all a desire to incorporate quantitative thinking into verbal discourse. Writing is also a core element of the course with weekly writing assignments in various formats.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: ENVVS235, ENVVS235, ENVVS235, ENVVS235, ENVVS235
Prereq: None

PHYS107 Life in the Cell from a Molecule’s Perspective
What does DNA look like when it is not condensed into chromosomes? How do partners in molecular processes find each other? If a molecular motor “walks,” how does it take a step?

We will explore these major topics in molecular biophysics by discussing primary scientific literature. An emphasis will be placed on revealing the ways in which our understanding of biological processes can be improved by understanding the underlying physics.

Students should have a broad high school science background, familiarity with quantitative and algebraic concepts, and a desire to incorporate quantitative thinking into verbal discourse. Writing is a core element of the course.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: MB&B117, MB&B117, MB&B117, MB&B117
Prereq: None

PHYS111 Introductory Physics I
This is the first of two noncalculus courses covering the fundamental principles of physics and is targeted specifically toward life-science majors and students planning to enter the health professions. Note that PHYS111 and PHYS112 may be taken in any order. By drawing on examples from everyday life, such as car crashes, basketball, and dance, as well as drawing from examples of interest to life scientists, the physics of mechanics, atoms, and nuclei will be covered in the first semester. The emphasis will be on developing a conceptual understanding of the physical processes as well as problem-solving skills. The lab PHYS121 is recommended.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: MB&B117, MB&B117, MB&B117, MB&B117
Prereq: None

PHYS112 Introductory Physics II
This is the second in the series of two noncalculus courses covering fundamental principles of physics and is targeted specifically toward non-science majors. Note that PHYS111 and PHYS112 may be taken in any order. By drawing on examples from everyday life, such as tasers, defibrillators, household electrical power, and cameras, PHYS112 covers the physics of electricity and magnetism, waves, sound, light, and optics, as well as buoyancy and flight. The emphasis will be on developing a conceptual understanding of the physical processes as well as problem-solving skills. The associated lab PHYS122 is recommended.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: MS&B102, MS&B102, MS&B102, MS&B102, MS&B102, MS&B102
Prereq: PHYS111 OR PHYS111 OR PHYS111 and PHYS121

PHYS113 General Physics I
This course is the first term of a general physics course with calculus. The focus is on Newtonian dynamics and its ramifications for mechanics and heat. This course
seeks to develop both conceptual understanding and the ability to use this understanding to obtain precise, quantitative predictions of how the universe works. The associated lab PHYS123 is recommended.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Prereq: None

**PHYS115 Newtonian Mechanics**

This course in classical mechanics assumes a level of familiarity with general physics and comfort with vectors and calculus that is not assumed in PHYS113. This course will study classical mechanics at a level that is rigorous and mathematically sophisticated. The course will also use a hands on, exploratory approach to emphasize the key physical ideas. This course may be ideal for students who have previously taken a general physics course, but not at the level required as preparation for PHYS116, Electricity and Magnetism.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS, NSM-PHYS
Prereq: None

**PHYS116 General Physics II**

PHYS116, following PHYS113, focuses on the physics of charged particles that give rise to both electricity and magnetism. This course develops our understanding of the forces charged particles exert on each other and develops the concepts of electric and magnetic fields. Calculus is used extensively.

The associated lab, PHYS124, is recommended.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS, NSM-PHYS
Prereq: PHYS113 OR PHYS115 OR PHYS113

**PHYS121 Physics Laboratory I**

This laboratory course provides experience with phenomena discussed in PHYS111 lectures. Video cameras and computer analysis of captured video clips will be the primary tools for data acquisition and investigation. While this course is not required by the Physics Department, students planning to enter the health professions should be aware that a year of physics WITH LABORATORY is usually required for admission. Consult your major advisor if you are in doubt about similar requirements in your field. Each laboratory is limited to 16.

Offering: Host
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS
Prereq: None

**PHYS122 Physics Laboratory II**

This course provides laboratory experiences for students taking PHYS 112.

Offering: Host
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Prereq: None

**PHYS123 General Physics Laboratory I**

This laboratory course provides experience with phenomena discussed in PHYS113 lecture, integrating calculus with the experiments.

Offering: Host
Grading: Cr/U
Credits: 0.50

**PHYS124 General Physics Laboratory II**

This laboratory course is designed to be taken in conjunction with PHYS116. Students will get hands-on experience with physical systems that demonstrate the principles being studied in PHYS116. Hands-on experience helps in developing physical intuition, a deeper understanding of the course material and the world around us.

The emphasis in this course is on experimental technique and the proper identification, appreciation, and handling of experimental error.

Offering: Host
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS, NSM-PHYS
Prereq: PHYS113 OR PHYS123

**PHYS162 It’s About Time**

The course will explore ideas and tools that help us to conceptualize and quantify time. Measurement of time has been accomplished by careful observation of celestial objects, counting growth rings in trees, or determining the abundance of radioactive decay products and with devices as varied as the hour glass and the atomic clock. A thorough investigation of these and other methods and tools will illuminate old and new views of time and will allow us to venture into various fields of physics such as classical mechanics, the theory of relativity, atomic and nuclear physics, electricity, and optics. Along the way, we will discuss concepts including, but not limited to (and not in that order), the origin of time, its smoothness, time dilation, the relativity of simultaneity, and the direction of time’s arrow.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Prereq: None

**PHYS170 Introduction to Design and Engineering**

This course will provide a hands-on introduction to design and engineering. Students will engage in individual and team projects in a studio environment where we seek to develop a shared practice and understanding of the engineering design process. We will study biological organisms to find inspiration for design of hoppers, swimmers, and climbers. Students will build skills using computer aided design (CAD) software and using tools for fabrication and prototyping including laser cutting and 3D printing. We will also hone skills in identifying which scientific and engineering principles need to be understood to achieve design goals.

Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-CIS, NSM-CIS, NSM-CIS
Identical With: IDEA170, CIS170, CIS170, IDE1A170, CIS170, CIS170, IDE1A170, CIS170, CIS170
Prereq: None

**PHYS204 Introduction to Contemporary Physics**

This course examines the foundations of modern physics, including the building blocks of matter, the fundamental interactions and gravity, and recent views of the universe such as entanglement, super symmetry, wimps and dark physics.

Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: PHYS219, PHYS219, PHYS219, PHYS219, PHYS219, PHYS219
Prereq: (PHYS113 AND PHYS116) OR PHYS113 OR PHYS116
PHYS213 Waves and Oscillations

The properties of periodic motion recur in many areas of physics, including mechanics, quantum physics, and electricity and magnetism. We will explore the physical principles and fundamental mathematics related to periodic motions. Focus topics will include damped and forced harmonic motion, normal modes, the wave equation, Fourier series and integrals, and complex analysis. The principles and techniques developed in this course are central to many subsequent courses, particularly quantum mechanics (PHYS214, 315), classical dynamics (PHYS313), and electricity and magnetism (PHYS324). An important component of this course is to develop the ability to use mathematical software packages to graph expressions, solve equations, and obtain numerical solutions to differential equations.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Prereq: (PHYS113 AND PHYS116)

PHYS214 Quantum Mechanics I

This course provides an introduction to wave and matrix mechanics, including wave-particle duality, probability amplitudes and state vectors, eigenvalue problems, and the operator formulation of quantum mechanics.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS
Prereq: PHYS213

PHYS215 Special Relativity

This calculus-based half-credit, half-semester introduction to Einstein’s theory of special relativity promotes both a qualitative understanding of the subject and a quantitative problem-solving approach.

Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS
Prereq: None

PHYS217 Chaos

This calculus-based course provides an introduction to the physics of chaos. Chaos is everywhere, in economics, biology, political science, chemistry, and physics.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS
Prereq: None

PHYS219 Introduction to Contemporary Physics

This course examines the foundations of modern physics, including the building blocks of matter, the fundamental interactions and gravity, and recent views of the universe such as entanglement, super symmetry, wimps and dark physics.

Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS
Prereq: PHYS113, PHYS116, AND PHYS213

PHYS221 Introduction to Modeling: From Molecules to Markets

The development of models to describe physical or social phenomena has a long history in several disciplines, including physics, chemistry, economics, and sociology. With the emergence of ubiquitous computing resources, model building is becoming increasingly important across all disciplines. This course will examine how to apply modeling and computational thinking skills to a range of problems. Using examples drawn from physics, biology, economics, and social networks, we will discuss how to create models for complex systems that are both descriptive and predictive. The course will include significant computational work. No previous programming experience is required, but a willingness to learn simple programming methods is essential.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: PHYS214
Prereq: PHYS213, PHYS213
Credits: 0.50
Gen Ed Area: NSM-PHYS
Prereq: PHYS213

PHYS313 Classical Dynamics

This is a comprehensive course in classical mechanics at the intermediate level. It approaches Newtonian mechanics from a more advanced point of view and introduces Lagrangian and Hamiltonian dynamics. Attention is paid to approximation and numerical solutions.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS313
Prereq: PHYS313

PHYS314 Quantum Mechanics II

This course will begin with the development of the formalism of quantum mechanics in three dimensions to include spin and angular momentum. The quantum theory of identical particles will be developed and applied to multi-electron atoms. The remainder of the course will explore approximation methods for applying quantum mechanics to more complex systems.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS313
Prereq: PHYS313

PHYS316 Thermal and Statistical Physics

An introductory course in classical thermodynamics, statistical mechanics, and kinetic theory. Focus areas will include phase transitions, critical phenomena, and statistical properties of fermions and bosons.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS316
Prereq: PHYS316

PHYS317 Molecular Biophysics Journal Club I

This course includes presentation and active discussion of a series of current research articles in the field of molecular biophysics and biophysical chemistry from the BIOPHYSICAL JOURNAL, BIOPOLYMERS, CURRENT OPINION IN STRUCTURAL BIOLOGY, JOURNAL OF BIOMOLECULAR STRUCTURE AND DYNAMICS, and the ANNUAL REVIEW OF MOLECULAR BIOPHYSICS AND BIOMOLECULAR STRUCTURE.

Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-CHEM, NSM-CHEM, NSM-CHEM
Prereq: None
PHYS318 Molecular Biophysics Journal Club II
Offering: Crosslisting
Grading: C/F/U
Credits: 0.50
Gen Ed Area: NSM-CHEM, NSM-CHEM
Prereq: None
PHYS324 Electricity and Magnetism
This course covers the classical field theory of electricity and magnetism. The core of the course covers electrostatics and magnetostatics with emphasis on both physical insight and the partial differential equations that describe these fields. We then begin electrodynamics in order to complete Maxwell’s equations and to derive the elementary properties of electromagnetic radiation.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS524, PHYS524, PHYS524, PHYS524
Prereq: (PHYS116 AND PHYS124 AND MATH222)
PHYS325 Radiation and Optics
In this course, you will have the opportunity to apply your electrodynamic knowledge to explore electromagnetic waves and optics, radiation, and a bit of relativistic electrodynamics. You will get to relate these topics to a wide variety of recent physics research, such as: invisibility cloaks, metamaterials with negative index of refraction, stopping and storing light in atomic gases, polarization of the cosmic microwave background, and the optical properties of bird feathers and iridescent butterfly wings. The goal is for you to leave this course with a deeper understanding and appreciation for electrodynamics and its applications.
Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: PHYS525, PHYS525, PHYS525, PHYS525, PHYS525, PHYS525
Prereq: [PHYS324 or PHYS524]
PHYS339 Molecular Biophysics
This course is an introduction to the branch of inquiry in the life sciences concerned with understanding the structures, functional energetics, and mechanisms of biological systems at the molecular level. Topics covered will include Brownian motion and its implications; theories of macromolecular binding, specificity, and catalysis; ion channels; molecular motors; self-assembly processes and single-molecule manipulations; protein and nucleic acid structure; physics of biopolymers; rate processes; mechanical and adhesive properties of biomolecules; molecular manipulation techniques; cell membrane structure; membrane channels and pumps; and molecular motors.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-CHEM, NSM-CHEM, NSM-CHEM, NSM-CHEM, NSM-CHEM
Prereq: None
PHYS340 Computational Physics: Algorithms and Clusters
The aim of this course is to introduce students to both numerical techniques and the software used in modern computational physics. In the first part of the course, we will learn how to work with computers running the Linux operating system and the essential components of the C programming language. The majority of material in the course will focus on the most important numerical techniques that we will implement in weekly exercises. A functional knowledge of Linux/Unix is preferred but not required.
Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: (MATH221 AND PHYS213) OR (MATH223 AND PHYS213) OR (MATH222 AND PHYS213)
PHYS342 Experimental Optics
An experimental course in optics, including lenses, lens combinations, interference and diffraction, interferometry, and spectrometry.
Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: PHYS542, PHYS542, PHYS542, PHYS542, PHYS542, PHYS542, PHYS542
Prereq: (PHYS116 AND PHYS123) Prereq: (MATH221 AND PHYS213) OR (MATH223 AND PHYS213) OR (MATH222 AND PHYS213)
PHYS345 Electronics Lab
This laboratory course will cover the fundamentals of analog and digital electronics: passive DC and AC circuits, linear transistor and integrated circuits, and digital integrated circuits.
PHYS358 Condensed Matter
This course is an introduction to condensed-matter physics with emphasis on fundamental properties of solids. We will explore crystal structure, phonons, and electrons in solids as a basis for understanding the thermal, electronic, and magnetic properties of materials. In addition to lectures and problem sets, there will be several numerical experiments in which computer simulation and visualization tools will be used to explore microscopic properties of materials.
Offering: Host
Grading: Cr/U
Credits: 1.00
Gen Ed Area: NSM-PHY, NSM-PHY, NSM-PHY, NSM-PHY
Identical With: PHYS354, PHYS354, PHYS354, PHYS354, PHYS354, PHYS354, PHYS354, PHYS354
Prereq: [PHYS116 AND PHYS213] OR PHYS112 OR PHYS116 OR [PHYS324 or PHYS324]

PHYS377 Chemistry of Materials and Nanomaterials
This course will provide an introduction to materials chemistry, with a special emphasis on nanomaterials. Topics covered will include colloidal metal nanomaterials; semiconductors and quantum dots; carbon nanotubes, fullerenes, and graphene; metal-organic frameworks; self-assembly and metamaterials; electron and scanning probe microscopies; and lithography. The course will also discuss applications of these materials and techniques in areas such as plasmonics and sensing, catalysis, energy generation, and medicine.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-CHEM
Identical With: CHEM377
Prereq: CHEM251

PHYS395 Structural Biology Laboratory
One of the major catalysts of the revolution in biology that is now under way is our current ability to determine the physical properties and three-dimensional structures of biological molecules by x-ray diffraction, nuclear magnetic resonance (NMR) spectroscopy, and other spectroscopic methods. This course is designed to familiarize students with current research techniques in biochemistry and molecular biophysics. Students will perform spectroscopic investigations on a protein that they have isolated and characterized using typical biochemical techniques, such as electrophoresis, enzyme extraction, and column chromatography. It will provide hands-on experience with spectroscopic methods such as NMR, fluorescence, UV-Vis absorption, and Raman as well as bioinformatic computational methods. All of these methods will be applied to the study of biomolecular structure and energetics. This course provides a broad knowledge of laboratory techniques valuable for independent research at the undergraduate level and beyond.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MBB, NSM-MBB, NSM-MBB, NSM-MBB

PHYS400 Academic Skills
The objectives of this course are 1) build a supportive cohort that will help students sustain their goals when they enter graduate school, and 2) provide students with skills they will need to succeed in graduate school. Students will work on writing, presentation, and discussion skills. This will be done by reading some classic books on writing, critiquing the ability of different figures and graphs to convey information, reading and discussing scientific papers and giving research presentations.
Offering: Crosslisting
Grading: A-F
Credits: 0.25
Gen Ed Area: NSM-EES, NSM-EES, NSM-EES, NSM-EES
Identical With: E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400, E&ES400, NS&B400, PSYC400
Prereq: None

PHYS401 Individual Tutorial, Undergraduate
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS402 Individual Tutorial, Undergraduate
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS407 Senior Tutorial
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor.
Offering: Host
Grading: A-F

PHYS408 Senior Tutorial
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor.
Offering: Host
Grading: A-F

PHYS409 Senior Thesis Tutorial
Offering: Host
Grading: OPT

PHYS410 Senior Thesis Tutorial
Offering: Host
Grading: OPT

PHYS411 Group Tutorial, Undergraduate
Offering: Host
Grading: OPT

PHYS412 Group Tutorial, Undergraduate
Offering: Host
Grading: OPT

PHYS419 Student Forum
Offering: Host
Grading: Cr/U

PHYS420 Student Forum
Offering: Host
Grading: Cr/U

**PHYS421 Undergraduate Research, Science**
Topic to be arranged in consultation with the tutor. The subject may be theoretical or experimental, according to the needs of each individual.
Offering: Host
Grading: OPT

**PHYS422 Undergraduate Research, Science**
Offering: Host
Grading: OPT

**PHYS423 Advanced Research Seminar, Undergraduate**
Offering: Host
Grading: OPT

**PHYS424 Advanced Research Seminar, Undergraduate**
Offering: Host
Grading: OPT

**PHYS491 Teaching Apprentice Tutorial**
Apprenticeships are available in both introductory and intermediate-level courses.
Offering: Host
Grading: OPT

**PHYS492 Teaching Apprentice Tutorial**
Apprenticeships are available in both introductory and intermediate-level courses.
Offering: Host
Grading: OPT

**PHYS500 Graduate Pedagogy**
The elements of good teaching will be discussed and demonstrated through lectures, practice teaching sessions, and discussions of problems encountered in the actual teaching environment. The staff consists of faculty and experienced graduate students. An integral part of the course is a required one-day workshop BEFORE the first day of formal classes.
Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: None
Identical With: E&ES500, CHEM500, BIOL500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500, ASTR500, PSYC500, ASTR500, PSYC500, E&ES500, CHEM500, BIOL500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500, ASTR500, PSYC500, ASTR500, PSYC500, E&ES500, CHEM500, BIOL500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500, ASTR500, PSYC500, ASTR500, PSYC500, E&ES500, CHEM500, BIOL500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500, ASTR500, PSYC500, ASTR500, PSYC500
Prereq: None

**PHYS501 Individual Tutorial, Graduate**
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

**PHYS502 Individual Tutorial, Graduate**
Topic to be arranged in consultation with the tutor.
PHYS512 Group Tutorial, Graduate
Offering: Host
Grading: OPT

PHYS513 Classical Dynamics
This is a comprehensive course in classical mechanics at the intermediate level. It approaches Newtonian mechanics from a more advanced point of view and introduces Lagrangian and Hamiltonian dynamics. Attention is paid to approximation and numerical solutions.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-BIO
Identical With: PHYS313, PHYS313, PHYS313, PHYS313, PHYS313, PHYS313, PHYS313, PHYS313, PHYS313, PHYS313, PHYS313,  
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Prereq: (PHYS213 AND MATH221 AND MATH222 AND MATH122)

PHYS515 Quantum Mechanics II
This course will begin with the development of the formalism of quantum mechanics in three dimensions to include spin and angular momentum. The quantum theory of identical particles will be developed and applied to multi-electron atoms. The remainder of the course will explore approximation methods for applying quantum mechanics to more complex systems.
Offering: Crosslisting
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS315, PHYS315, PHYS315, PHYS315
Prereq: (PHYS214 AND MATH223) OR (PHYS214 AND MATH221) OR (PHYS214 AND MATH221)

PHYS516 Thermal and Statistical Physics
An introductory course in classical thermodynamics, statistical mechanics, and kinetic theory. Focus areas will include phase transitions, critical phenomena, and statistical properties of fermions and bosons.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS316, PHYS316, PHYS316, PHYS316
Prereq: PHYS214

PHYS517 Molecular Biophysics Journal Club I
This course includes presentation and active discussion of a series of current research articles in the field of molecular biophysics and biophysical chemistry from the BIOPHYSICAL JOURNAL, JOURNAL OF BIOPOLYMERS, CURRENT OPINION IN STRUCTURAL BIOLOGY, JOURNAL OF BIOMOLECULAR STRUCTURE AND DYNAMICS, and the ANNUAL REVIEW OF MOLECULAR BIOPHYSICS AND BIOMOLECULAR STRUCTURE.
Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-CHEM, NSM-CHEM
Prereq: None

PHYS518 Molecular Biophysics Journal Club II
Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-CHEM, NSM-CHEM
Identical With: CHEM308, MB&B308, CHEM508, MB&B508, PHYS318, CHEM308, MB&B308, CHEM508, MB&B508, PHYS318, CHEM308, MB&B308, CHEM508, MB&B508
Prereq: None

PHYS521 Physics Colloquium I
Presentations by outside experts and discussion of material at the forefront of the discipline, emphasizing emerging, novel physics topics.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Prereq: None

PHYS522 Physics Colloquium II
Presentations by outside experts and discussion of material at the forefront of the discipline, emphasizing emerging, novel physics topics.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Prereq: [(PHYS315 or PHYS515] AND ([PHYS313 or PHYS513)]

PHYS524 Electricity and Magnetism
This course covers the classical field theory of electricity and magnetism. The core of the course covers electrostatics and magnetostatics with emphasis on both physical insight and the partial differential equations that describe these fields. We then begin electrodynamics in order to complete Maxwell’s equations and to derive the elementary properties of electromagnetic radiation.
Offering: Crosslisting
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS324, PHYS324, PHYS324, PHYS324
Prereq: (PHYS3116 AND PHYS124 AND MATH222)

PHYS525 Radiation and Optics
In this course, you will have the opportunity to apply your electrodynamics knowledge to explore electromagnetic waves and optics, radiation, and a bit of relativistic electrodynamics. You will get to relate these topics to a wide variety of recent physics research, such as: invisibility cloaks, metamaterials with negative index of refraction, stopping and storing light in atomic gases, polarization of the cosmic microwave background, and the optical properties of bird feathers and iridescent butterfly wings. The goal is for you to leave this course with a deeper understanding and appreciation for electrodynamics and its applications.
Offering: Crosslisting
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS
Identical With: PHYS325, PHYS325, PHYS325, PHYS325, PHYS325, PHYS325, PHYS325, PHYS325, 

Prereq: [PHYS324 or PHYS524]
PHYS539 Molecular Biophysics

This course is an introduction to the branch of inquiry in the life sciences concerned with understanding the structures, functional energetics, and mechanisms of biological systems at the molecular level. Topics covered will include Brownian motion and its implications; theories of macromolecular binding, specificity, and catalysis; ion channels; molecular motors; self-assembly processes and single-molecule manipulations; protein and nucleic acid structure; physics of biopolymers; rate processes; mechanical and adhesive properties of biomolecules; molecular manipulation techniques; cell membrane structure; membrane channels and pumps; and molecular motors.

Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-CHEM, NSM-CHEM, NSM-CHEM, NSM-CHEM, NSM-CHEM
Prereq: (CHEM251 AND CHEM252)

PHYS542 Experimental Optics

An experimental course in optics, including lenses, lens combinations, interference and diffraction, interferometry, and spectrometry.

Offering: Crosslisting
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: PHYS342, PHYS342, PHYS342, PHYS342, PHYS342, PHYS342
Prereq: (PHYS116 AND PHYS213)

PHYS543 Analytical Mechanics

Advanced classical mechanics and mathematical physics, description of multidimensional motion, vibrations, perturbation theory, and chaos.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: None
Identical With: PHYS563, PHYS563
Prereq: (PHYS213 AND PHYS217 AND [PHYS313 or PHYS513] AND [PHYS316 or PHYS516])

PHYS545 Electronics Lab

This laboratory course will cover the fundamentals of analog and digital electronics: passive DC and AC circuits, linear transistor and integrated circuits, and digital integrated circuits.

Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: PHYS345, PHYS345, PHYS345, PHYS345, PHYS345, PHYS345, PHYS345
Prereq: [PHYS116 AND PHYS213] OR PHYS112 OR PHYS116 OR [PHYS324 or PHYS524]

PHYS549 Advanced Research Seminar, Graduate

Offering: Host
Grading: OPT

PHYS550 Advanced Research Seminar, Graduate

Offering: Host
Grading: OPT

PHYS558 Condensed Matter

This course is an introduction to condensed-matter physics with emphasis on fundamental properties of solids. We will explore crystal structure, phonons, and electrons in solids as a basis for understanding the thermal, electronic, and magnetic properties of materials. In addition to lectures and problem sets, there will be several numerical experiments in which computer simulation and visualization tools will be used to explore microscopic properties of materials.

Offering: Crosslisting
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS, NSM-PHYS, NSM-PHYS, NSM-PHYS
Identical With: PHYS358, PHYS358, PHYS358, PHYS358, PHYS358, PHYS358, PHYS358
Prereq: [PHYS315 or PHYS515] AND [PHYS324 or PHYS524]

PHYS563 Analytical Mechanics

Advanced classical mechanics and mathematical physics, description of multidimensional motion, vibrations, perturbation theory, and chaos.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: None
Identical With: PHYS433, PHYS543
Prereq: (PHYS213 AND PHYS217 AND [PHYS313 or PHYS513] AND [PHYS316 or PHYS516])

PHYS565 Mathematical Physics

Historically, physics and mathematics are closely related. Physics uses powerful tools developed by mathematicians, while physicists, investigating the actually existing universe, provide mathematicians with new concepts and ideas to explore. This way, many mathematical techniques, and even entire areas of mathematics, developed from the need to solve certain real-life problems posed by physical reality. The purpose of this course is to give you an overview of the powerful array of mathematical tools available for the solution of physical problems. Starting with special functions, we will apply them to the solution of ordinary and partial differential equations. We will encounter Fourier and Laplace transforms and will study the Green’s function method for the solution of bound and scattering problems. We will also look into the elements of Group theory and apply it to angular momentum in quantum many-body systems.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: None
PHYS566 Electrodynamics
Boundary value problems, Green’s functions, multipole fields in dielectric and magnetic media, electromagnetic radiation, and wave guides.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: None
Prereq: None

PHYS567 Statistical Mechanics
This course will develop important concepts in statistical physics by examining several applications in detail. The areas covered will include the classical and quantum gases, critical behavior and phase transitions, and elementary transport phenomena.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: None
Prereq: [PHYS316 or PHYS516]

PHYS568 Quantum Mechanics
This course will develop advanced aspects of theory and application of quantum mechanics.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: None
Prereq: [PHYS315 or PHYS515]

PHYS571 Advanced Topics in Atomic and Molecular Physics
This course will introduce classical and quantum collision theory, with special consideration of atomic and molecular collisions.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: PHYS515

PHYS572 Advanced Topics in Atomic and Molecular Physics
The course will treat advanced topics in structure, spectroscopy, and dynamics of atoms and molecules.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: None

PHYS573 Advanced Topics in Condensed Matter
The course will treat advanced topics in condensed-matter physics, with emphasis on current research problems within the department.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: [PHYS535 or PHYS558 and PHYS315 or PHYS515]

PHYS574 Advanced Topics in Atomic, Molecular, and Optical Physics
The course will treat advanced topics in condensed-matter physics, with emphasis on current research problems within the department.
Offering: Host
Grading: Cr/U
Credits: 0.50
Gen Ed Area: None
Prereq: None

PHYS575 Advanced Topics in Theoretical Physics
This introduction to quantum computing formulates physical models that provide the basis for understanding how our world works at its most fundamental level.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: PHYS213 AND PHYS214 AND PHYS324 OR (PHYS214 AND [PHYS315 or PHYS515])

PHYS576 Advanced Topics in Theory
This graduate course will present advanced topics in theory of relevance for current research in the department.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: NSM-PHYS
Prereq: None

PHYS577 Lab Pedagogy
Course taken by graduate students teaching PHYS121
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Prereq: None

PHYS578 Lab Pedagogy
Course taken by graduate students teaching PHYS122
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: None

PHYS587 Seminar in Chemical Physics
Weekly seminars presented jointly with the Physics Department under the auspices of the Chemical Physics Program. These informal seminars will be presented by students, faculty, and outside visitors on current research and other topics of interest.
Offering: Crosslisting
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Identical With: CHEM547, CHEM547, CHEM547, CHEM547
Prereq: None

PHYS588 Seminar in Chemical Physics
Weekly seminars presented jointly with the Chemistry Department under the auspices of the Chemical Physics Program. These informal seminars will be presented by students, faculty, and outside visitors on current research and other topics of interest.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Identical With: CHEM548
Prereq: None

PHYS589 Advanced Research, BA/MA
Intensive investigation of special research problems leading to a BA/MA thesis.
Offering: Host
Grading: A-F

PHYS590 Advanced Research, BA/MA
Intensive investigation of special research problems leading to a BA/MA thesis.
Offering: Host
Grading: OPT

**PHYS591 Advanced Research, Graduate**
Investigation of special problems leading to a dissertation.
Offering: Host
Grading: OPT

**PHYS592 Advanced Research, Graduate**
Investigation of special problems leading to a dissertation.
Offering: Host
Grading: OPT