Physics

"Physics is the liberal arts education for a technological society."—Joseph Pimbley

Participation in research and proficiency in the main subject areas of physics are the twin goals of the physics program. The major program is designed to develop competency in quantum theory, electromagnetism and optics, thermodynamics and statistical mechanics, classical dynamics, and condensed-matter physics. Preparation in mathematical and computational methods is an integral part of the program.

Interested and qualified students may pursue several opportunities for advanced work, including graduate courses and participation with graduate students and faculty in research. The department encourages its students to "do physics" at the earliest opportunity by making arrangements to work with one of the research groups or by arranging an independent research tutorial. Research may be experimental or theoretical and may, but need not, result in a senior honors thesis. Most majors who intend to write a thesis begin research no later than the junior year and continue it through the summer into the senior year. Current research interests include quantum computing, single molecule biophysics, soft condensed-matter physics, charge transport in photovoltaic devices, fluid dynamics, laser plasmas, spectroscopy, collision studies involving excited atoms and molecules, and wave transport in complex media.

Many students also take advantage of Wesleyan’s computing facilities in their research or coursework. The University has a large computer cluster available to all who are doing research.

Each semester, opportunities exist to serve as a teaching apprentice, course assistant, or department assistant in one of the introductory or intermediate-level courses. Many physics majors have found that this is a stimulating way to learn more about the fundamentals of the discipline and how to teach them. The Cady Lounge in the department serves as a focus for the major by providing a place where students can study and discuss physics. There is also a study room where students in the introductory courses can come to get help and to work together. Students are encouraged to attend the weekly colloquium series and to participate in the weekly research seminars in atomic and molecular physics, chemical physics, condensed-matter physics, and theory. The Society of Physics Students is also a great resource for sharing ideas and questions with like-minded students.

Faculty

Reinhold Blümel
PHD, Technical University Munich
Charlotte Augusta Ayres Professor of Physics; Professor of Physics; Co-Coordinator, Informatics and Modeling

Fred M. Ellis
BS, University of Massachusetts Amherst; MAA, Wesleyan University; PHD, University of Massachusetts Amherst
Professor of Physics; Chair, Physics

Candice M Etson
BA, New York University; BFA, New York University; PHD, Harvard University
Assistant Professor of Physics; Assistant Professor, Chemistry; Assistant Professor, Integrative Sciences; Assistant Professor, Molecular Biology and Biochemistry

Lutz Hüwel

Tsampikos Kottos
BA, University of Crete; MS, University of Crete; PHD, University of Crete
Lauren B. Dachs Professor of Science and Society; Professor of Physics; Professor, Integrative Sciences; Professor, Mathematics

Thomas J. Morgan
BA, Montana State University; BS, Montana State University; MAA, Wesleyan University; MSC, University of California, Berkeley; PHD, University of California, Berkeley
Foss Professor of Physics; Professor of Physics

George Mathew Daily
MSC, Indian Institute of Technology; PHD, Pennsylvania State University
Assistant Professor of the Practice in Physics

Meng-ju Renee Sher
BA, Wesleyan University; MA, Harvard University; PHD, Harvard University
Assistant Professor of Physics; Assistant Professor, Environmental Studies; Assistant Professor, Integrative Sciences

Francis W. Starr
BS, Carnegie Mellon University; MS, Boston University; PHD, Boston University
Professor of Physics; Professor, Integrative Sciences; Professor, Molecular Biology and Biochemistry; Coordinator, Integrated Design, Engineering and Applied Science

Brian A. Stewart
BS, Stanford University; PHD, Massachusetts Institute of Technology
Professor of Physics; Professor, Environmental Studies; Professor, Integrative Sciences

Min-Feng Tu
BS, National Tsing Hua University; MS, California Institute Tech; PHD, California Institute Tech
Assistant Professor of the Practice in Physics

Greg A. Voth
BS, Wheaton College; MS, Cornell University; PHD, Cornell University
Professor of Physics; Professor, Integrative Sciences

Visiting Faculty

Alba Ramos
Temporary Employee, Physics; Temporary Employee, Physics; Visiting Scholar in Physics

Emeriti

Ralph F. Baierlein
BA, Harvard University; MAA, Wesleyan University; PHD, Princeton University
Charlotte Ayres Professor of Physics, Emeritus

Richard W. Lindquist
BS, Worcester Poly Institute; MA, Princeton University; MAA, Wesleyan University; PHD, Princeton University
Professor of Physics, Emeritus

Robert J. Rollefson
DEPARTMENTAL ADVISING EXPERTS

- Brian A. Stewart and Meng-Ju Renee Sher, Class of 2020
- Candice Etson and Reinhold Blumel, Class of 2021
- Undergraduate Physics Major (catalog.wesleyan.edu/departments/phys/ugrd-phys)
- Doctor of Philosophy in Physics (catalog.wesleyan.edu/departments/phys/grad-phys)
- Master of Arts in Physics (catalog.wesleyan.edu/departments/phys/grad-phys-ma)

PHYS105 Radical Sustainability

The year 2020 marks the 50th anniversary of the first Earth Day. Writings and legislation from that time sought to discuss and address the many growing environmental challenges the world faced. The idea of sustainability became current: to create conditions for the human presence to endure, along with the ecosystems in which it is embedded.

Despite some successes, the challenges remain and have grown since that time. The many problems we face are hard to deal with in isolation, and no amount of effort seems enough to keep up as the problems worsen. The climate crisis is a case in point. Maybe we haven’t worked hard enough, or maybe we’ve been going about sustainability the wrong way.

Radical Sustainability explores the intersection of these now critical challenges—extinction, climate change, and many others—as well as the physical and social constraints on action to address them. Our aim is to identify the pressure points for an effective response, within the geo-ecosystem and the human systems embedded within it. Radical Sustainability is radical both by being fundamental and by being activist, recognizing that sustained large-scale change is urgently necessary if we are to persist and thrive on an Earth that itself is changing.

In addition to studying physical science, which establishes the conditions for the life of all beings, a justice-aware sustainability requires us to think scientifically about society as well. The course will consist of lecture, discussion, visits from experts, field trips, and class actions to promote competent and effective engagement with the issues.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS
Identical With: MB&B117
Prereq: None

PHYS111 Introductory Physics I

This course, along with PHYS 112 in the spring semester, is an introduction to the fundamental principles of physics. Employing trigonometry, algebra, and basic calculus, the goal is to provide tools for the quantitative understanding of a wide variety of phenomena, with many examples taken from the life sciences. The lab PHYS 121 is recommended. Since algebra is an important prerequisite for PHYS 111, we strongly recommend that all students take a diagnostic test prior to the start of the course. It can be found at https://www.khanacademy.org/math/algebra/test/subject-challenge?modal=1

Taking this “Course Challenge” will take 30-45 minutes and leave you with a good idea of where your algebra skills might need review. Follow-up guided lessons can be chosen at this website.

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

PHYS112 Introductory Physics II

This is the second of two non-calculus courses covering fundamental principles of physics. The emphasis is on developing a conceptual understanding of the physical processes that govern our universe. Proficiency in elementary algebra, vector algebra, trigonometry, and arithmetic is required. The lab PHYS122 is recommended.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS
Prereq: PHYS111

PHYS113 General Physics I

This course is the first term of a general physics course with calculus, recommended for students interested in majoring in the sciences. With the focus on Newtonian dynamics, PHYS 113 seeks to develop both conceptual understanding and the ability to use this knowledge to obtain quantitative predictions of how the universe works. Through a collaborative and interactive classroom experience, students develop problem-solving skills and a mathematical description of mechanics. The associated lab, PHYS123, is highly recommended.

PHYS113 and PHYS116 are part of a sequence of courses that lead into the physics major. PHYS113 is a pre-requisite for PHYS116; therefore, students must take them in sequence.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: 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, employing contemporary instructional techniques. It will also teach elementary programming and data analysis skills essential to
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: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS
Prereq: None

PHYS162 It's About Time
This 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: the origin of time, its smoothness, time dilation, the relativity of simultaneity, and the direction of time's arrow.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: 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: Cr/U
Credits: 1.00
Gen Ed Area: NSM-CIS
Identical With: IDEA170, CIS170
Prereq: None

PHYS207 Introduction to Biophysics
This course will introduce students to major topics in biophysics with an emphasis on the statistical physics of biological systems at the microscopic or molecular level. Topics covered will include molecular motors, self-assembly, and single-molecule manipulation. Students will learn how physical arguments and reasoning can provide significant insight into the design and function of biological systems. While this course is geared toward students who have had a full year of calculus-based physics, relevant concepts in biology and chemistry will be introduced as needed. No detailed knowledge of biology or chemistry beyond the high-school level is required for this course.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: 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. Topics will include damped and forced harmonic motion, normal modes, the
wave equation, Fourier series and integrals, and complex analysis. Principles and techniques developed in this course are central to many subsequent courses, particularly Quantum Mechanics (PHYS214, PHYS315), 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
Prereq: 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: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS
Prereq: PHYS116

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 Nonlinear Dynamics and Chaos
The techniques of nonlinear dynamics and chaos have been proven useful for a variety of disciplines, ranging from astrophysics to population dynamics. This course provides an introduction with applications.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS
Prereq: PHYS113, PHYS116, AND PHYS213

PHYS219 Introduction to Contemporary Physics
This course examines the foundations of modern physics, including special relativity, the building blocks of matter, the fundamental interactions and gravity, and recent views of the universe such as entanglement, supersymmetry, strings, and dark matter and dark energy.

Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: NSM-PHYS
Prereq: (PHYS113 AND PHYS116)

PHYS221 Modeling and Data Analysis: 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.
Dynamics, and the Annual Review of Molecular Biophysics and Biomolecular Structure.

Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-CHEM
Identical With: MB&B507, MB&B307, CHEM507, CHEM307, PHYS517
Prereq: None

PHYS318 Molecular Biophysics Journal Club II

Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-CHEM
Identical With: MB&B507, MB&B307, CHEM507, PHYS518, CHEM308
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 cover electrodynamics to complete Maxwell’s equations and to derive the elementary properties of electromagnetic radiation.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS
Identical With: PHYS524
Prereq: PHYS116 AND PHYS124 AND PHYS213 AND MATH222

PHYS339 Molecular and Cellular Biophysics
This course is an integrated consideration of the biophysics and biophysical chemistry of biological systems from molecules to cells. The objective is to develop a critical sense of the quantitative data currently being obtained from microscopy to spectroscopy, considering both ensemble and single-molecule experiments, and to gain familiarity and facility with interpretation using mathematical and computational models. Biological systems are inherently complex, and some form of modeling is always involved in developing an explanation of how they work. However, these models typically involve only a few basic constructs (simple harmonic motion, ideal fluids, two-state Ising models, random walks, electrostatic interactions, classical dynamics, rate equations, QM energy levels, distribution functions, and network analysis) and only elementary aspects of linear algebra, calculus, differential equations, and statistics. This course deals with how these constructs are integrated in the framework of Boltzmann statistical mechanics to formulate mathematical models of biological phenomena, how these models are validated and refined, and how they are used to form explanations and make testable predictions. Model systems to be considered include the nucleosome, the ribosome, membrane dynamics and ion channels, molecular devices and motors, prototype signal transduction systems, and regulatory processes. This course is suitable for physics and chemistry students who wish to learn about biological applications and for molecular and cellular biology students to develop skills with quantitative physicochemical modes of inquiry applied to the life sciences.

Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-CHEM
Identical With: CHEM309, MB&B309, CHEM509, MB&B509, PHYS539

PHYS340 Computational Physics
This course introduces students to numerical techniques used in modern computational physics. Using the UNIX operating system and its support software as our programming environment, we will write code using the c programming language to implement the basic numerical techniques necessary for solving the majority of physics problems that do not have an analytical solution. Previous experience with UNIX/c is useful but not required.

Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-PHYS
Prereq: (MATH221 AND PHYS213) OR (MATH223 AND PHYS213)

PHYS342 Experimental Optics
This is 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
Identical With: PHYS542
Prereq: PHYS116 AND PHYS213

PHYS345 Electronics Lab
This laboratory course covers the fundamentals of analog and digital electronics: passive DC and AC circuits, linear transistor and integrated circuits, and digital integrated circuits.

Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS
Identical With: PHYS545
Prereq: PHYS116 AND PHYS213

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: OPT
Credits: 1.00
Gen Ed Area: NSM-PHYS
Identical With: PHYS558
Prereq: [PHYS315 or PHYS515] AND [PHYS324 or PHYS524]

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. The course 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
Identical With: MB&B395, CHEM395
Prereq: ([MB&B208 or BIOL208] AND CHEM141 AND CHEM142) OR ([MB&B208 or BIOL208] AND CHEM143 AND CHEM144)

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 thesis)
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor. Only enrolled in through the Honors Coordinator.
Offering: Host
Grading: A-F

PHYS408 Senior Tutorial (downgraded thesis)
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor. Only enrolled in through the Honors Coordinator.
Offering: Host
Grading: A-F

PHYS409 Senior Thesis Tutorial
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS410 Senior Thesis Tutorial
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS411 Group Tutorial, Undergraduate
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS412 Group Tutorial, Undergraduate
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS419 Student Forum
Student-run group tutorial, sponsored by a faculty member and approved by the chair of a department or program.
Offering: Host
Grading: Cr/U

PHYS420 Student Forum
Student-run group tutorial, sponsored by a faculty member and approved by the chair of a department or program.
Offering: Host
Grading: Cr/U

PHYS421 Undergraduate Research, Science
Individual research projects for undergraduate students supervised by faculty members.
Offering: Host
Grading: OPT

PHYS422 Undergraduate Research, Science
Individual research projects for undergraduate students supervised by faculty members.
Offering: Host
Grading: OPT

PHYS423 Advanced Research Seminar, Undergraduate
Advanced research tutorial; project to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS424 Advanced Research Seminar, Undergraduate
Advanced research tutorial; project to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS491 Teaching Apprentice Tutorial
The teaching apprentice program offers undergraduate students the opportunity to assist in teaching a faculty member's course for academic credit.
Offering: Host
Grading: OPT

PHYS492 Teaching Apprentice Tutorial
The teaching apprentice program offers undergraduate students the opportunity to assist in teaching a faculty member's course for academic credit.
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.

Training in pedagogy in the first semester of attendance is required for all incoming Wesleyan MA and PhD students who have not already fulfilled this requirement at Wesleyan. BA/MA students are not required to get training in pedagogy but may choose to do so.

Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: None
Identical With: E&ESS500, CHEM500, BIOL500, ASTR500, MB&B500, MUSC500, PSYC500, MATH500
Prereq: None

PHYS501 Individual Tutorial, Graduate
Topic to be arranged in consultation with the tutor.
Offering: Host
Phys 509 Atomic and Molecular Physics Seminar I
Presentations and discussions of material at the forefront of the discipline, emphasizing current research at Wesleyan.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Prereq: PHYS214

Phys 510 Theoretical Physics Seminar II
Presentations and discussions of material at the forefront of the discipline, emphasizing current research at Wesleyan.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Prereq: PHYS214

PHYS516 Thermal and Statistical Physics
Thermodynamics and statistical mechanics are pillars of physics. Thermodynamics provides a framework through which we can understand the rules for the conversion of energy and matter from one form to another. As we will learn, every transfer of energy results in the conversion of some energy into an unusable form. Using the tools of thermodynamics, we can establish limits for the amount of useful work that can be extracted from any process. These limits have important implications for the quest to achieve sustainability in our use of energy and materials. As we learn about thermodynamics, we will spend some time exploring this real-world application of the material covered.

Likewise, statistical mechanics provides us with a set of tools for understanding how the behavior of individual atoms and molecules impacts the properties and behavior of materials that can be observed in our daily lives. Our approach to this material differs from many previous physics courses and requires a mixture of statistical and counting skills, coupled with physical intuition for the nature of matter. In addition to explaining phase transitions, critical phenomena, and the statistical nature of fermions and bosons, the tools of statistical mechanics are essential for understanding phenomena like evaporative cooling and the greenhouse effect. We will explore the conditions that lead to these phenomena and discuss the role they may play in a comprehensive approach to sustainability.

Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS
Identical With: PHYS315
Prereq: PHYS214 AND MATH223 OR PHYS214 AND MATH221

PHYS517 Advanced Quantum Mechanics
This course will expand the formalism of quantum mechanics to include spin and angular momentum in three dimensions. 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: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS
Identical With: PHYS316
Prereq: PHYS214 AND MATH223 OR PHYS214 AND MATH221

PHYS518 Advanced Statistical Physics
Thermodynamics and statistical mechanics are pillars of physics. Thermodynamics provides a framework through which we can understand the rules for the conversion of energy and matter from one form to another. As we will learn, every transfer of energy results in the conversion of some energy into an unusable form. Using the tools of thermodynamics, we can establish limits for the amount of useful work that can be extracted from any process. These limits have important implications for the quest to achieve sustainability in our use of energy and materials. As we learn about thermodynamics, we will spend some time exploring this real-world application of the material covered.

Likewise, statistical mechanics provides us with a set of tools for understanding how the behavior of individual atoms and molecules impacts the properties and behavior of materials that can be observed in our daily lives. Our approach to this material differs from many previous physics courses and requires a mixture of statistical and counting skills, coupled with physical intuition for the nature of matter. In addition to explaining phase transitions, critical phenomena, and the statistical nature of fermions and bosons, the tools of statistical mechanics are essential for understanding phenomena like evaporative cooling and the greenhouse effect. We will explore the conditions that lead to these phenomena and discuss the role they may play in a comprehensive approach to sustainability.

Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-PHYS
Identical With: 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 journals including but not limited to the Biophysical Journal, Biopolymers, Current Opinion in Structural Biology, Journal of Biomolecular Structure and Dynamics, and the Annual Review of Molecular Biophysics and Biомolecular Structure.
Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-CHEM
Identical With: MB&B507, MB&B307, CHEM507, CHEM307, PHYS517
Prereq: None

PHYS518 Molecular Biophysics Journal Club II
Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: NSM-CHEM
Identical With: MB&B508, MB&B308, CHEM508, PHYS318, CHEM308
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 cover electrodynamics 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
Identical With: PHYS524
Prereq: PHYS5116 AND PHYS124 AND PHYS213 AND MATH222

PHYS539 Molecular and Cellular Biophysics
This course is an integrated consideration of the biophysics and biophysical chemistry of biological systems from molecules to cells. The objective is to develop a critical sense of the quantitative data currently being obtained from microscopy to spectroscopy, considering both ensemble and single-molecule experiments, and to gain familiarity and facility with interpretation using mathematical and computational models. Biological systems are inherently complex, and some form of modeling is always involved in developing an explanation of how they work. However, these models typically involve only a few basic constructs (simple harmonic motion, ideal fluids, two-state Ising models, random walks, electrostatic interactions, classical dynamics, rate equations, QM energy levels, distribution functions, and network analysis) and only elementary aspects of linear algebra, calculus, differential equations, and statistics. This course deals with how these constructs are integrated in the framework of Boltzmann statistical mechanics to formulate mathematical models of biological phenomena, how these models are validated and refined, and how they are used to form explanations and make testable predictions. Model systems to be considered include the nucleosome, the ribosome, membrane dynamics and ion channels, molecular devices and motors, prototype signal transduction systems, and regulatory processes. This course is suitable for physics and chemistry students who wish to learn about biological applications and for molecular and cellular biology students to develop skills with quantitative physicochemical modes of inquiry applied to the life sciences.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-CHEM
Identical With: CHEM309, MB&B309, CHEM509, MB&B509, PHYS339
Prereq: (CHEM251 AND CHEM252)

PHYS542 Experimental Optics
This is 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
Identical With: PHYS342
Prereq: (PHYS116 AND PHYS213)

PHYS545 Electronics Lab
This laboratory course covers 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
Identical With: PHYS345
Prereq: (PHYS116 AND PHYS213)

PHYS549 Advanced Research Seminar, Graduate
Advanced research tutorial; project to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

PHYS550 Advanced Research Seminar, Graduate
Advanced research tutorial; project to be arranged in consultation with the tutor.
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
Identical With: PHYS358
Prereq: [PHYS315 or PHYS515] AND [PHYS324 or PHYS524]

PHYS563 Analytical Mechanics
Advanced classical mechanics: multidimensional motion, rigid bodies and rotational dynamics, chaotic dynamics, and applications.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: None
Prereq: (PHYS213 AND PHYS217 AND PHYS313) OR (PHYS213 AND PHYS217 AND PHYS513)

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 students an overview of the powerful array of mathematical tools available for the solution of physical problems. Starting with the presentation of tools of complex analysis, 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
Prereq: MATH222 AND MATH223 AND PHYS313 AND PHYS315 AND PHYS324

PHYS566 Electrodynamics
This course covers boundary value problems, Green’s functions, multipoles, 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]

PHYS569 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: PHYS315

PHYS572 Advanced Topics in Atomic and Molecular Physics
In this round of Advanced Topics (PHYS 572), fundamentals and applications of low temperature plasmas will be considered. We will investigate theoretical and experimental aspects related to the production and diagnostic of such plasmas. Discussion of a several usages of plasmas—for example, in chemical analysis, material processing, environmental monitoring, or medical applications—will conclude the semester.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: PHYS515

PHYS573 Advanced Topics in Condensed Matter
The course will cover 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: [PHYS358 or PHYS558] AND [PHYS315 or PHYS515]

PHYS574 Advanced Topics in Condensed Matter: Fluid Mechanics
This course will be an introduction to fluid mechanics, with emphasis on current research problems within the department. Topics will include Navier-Stokes equations, boundary layers, instabilities and turbulence.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: None

PHYS575 Advanced Topics in Theoretical Physics
This graduate course presents advanced topics in theory of relevance for current research in the department. The specific material varies each time the course is taught.
Offering: Host
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Prereq: PHYS213 AND PHYS214 AND PHYS324

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
This course is taken by graduate students teaching PHYS121 or PHYS123.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Prereq: None

PHYS578 Lab Pedagogy
This course is taken by graduate students teaching PHYS122.
PHYS587 Seminar in Chemical Physics
Weekly seminars presented jointly with the Department of Physics 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: OPT
Credits: 0.50
Gen Ed Area: None
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: Crosslisting
Grading: Cr/U
Credits: 0.25
Gen Ed Area: None
Identical With: CHEM547
Prereq: None