PHYSICS (PHYSICS)

PHYSICS 103 – GENERAL PHYSICS
4 credits.

Introduction to physics at the non-calculus level. Principles of mechanics, heat, and waves, with applications to a number of different fields. Not recommended for students in the physical sciences and engineering.
Requisites: MATH 112, 113, 114, 171, placement into MATH 211 or 221, or special student standing. Not open to students with credit for PHYSICS 201, 207, or 247.
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Summer 2025

PHYSICS 104 – GENERAL PHYSICS
4 credits.

Continuation of PHYSICS 103. Principles of electricity and magnetism, light, optics, and modern physics, with applications to a number of different fields. Not recommended for students in the physical sciences and engineering.
Requisites: PHYSICS 103, 201, 207, 247, E M A 201 or special student standing. Not open to students with credit for PHYSICS 202, 208, or 248.
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Summer 2025

PHYSICS 106 – PHYSICS OF SPORTS
3 credits.

A tenth of a second, a single inch, or a slightly different angle can make all the difference in a sporting event. Application of physical principles to competitive sport, leading to a better understanding of performances in such sports as track and field, cycling, archery, golf, football and basketball.
Requisites: Satisfied Quantitative Reasoning (QR) A requirement. Not open to students with credit for PHYSICS 103, 201, 207, or 247.
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Explain how sport performance is governed by universal physical principles.
Audience: Undergraduate

2. Solve problems relevant to sport performance proficiently regarding both quantitative and qualitive applications of these physical principles.
Audience: Undergraduate

3. Explain the significance of sport-related measurements and observations made in the presence of statistical and systematic uncertainties.
Audience: Undergraduate

4. Communicate effectively with scientific peers and the public regarding physical principles and measurements and observations relevant to sport performance.
Audience: Undergraduate

5. Be able to continue to educate themselves regarding the physical principles relevant to sport performance after completion of the course.
Audience: Undergraduate

PHYSICS 107 – THE IDEAS OF MODERN PHYSICS
3 credits.

The twentieth-century physical world picture and its origins. Selected topics in classical physics, relativity, and the quantum theory with emphasis on the meaning of basic concepts and their broader implications, rather than practical applications.
Requisites: Satisfied Quantitative Reasoning (QR) A requirement or special student standing
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 109 — PHYSICS IN THE ARTS
3 credits.

The nature of sound and sound perception; fundamentals of harmony, musical scales, and musical instruments. Studies of light including lenses, photography, color perception, and color mixing.
Requisites: Satisfied Quantitative Reasoning (QR) A requirement or special student standing. Not open to students with credit for PHYSICS 371.
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 115 — ENERGY AND CLIMATE
3 credits.

Introduction to energy, focusing on energy sources and their impacts on humans and the environment, particularly through climate change. Develop basic physics skills to form opinions on energy-related issues affecting the world as well as your own use of energy. Apply the physical principles of mechanics, heat, electricity, and atomic nuclei to various energy sources (fossil fuels, renewables, and nuclear) and their impacts.
Requisites: Satisfied Quantitative Reasoning (QR) A requirement. Not open to students with credit for PHYSICS 103, 201, 207, or 247.
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Qualitatively describe and quantitatively analyze the physics behind energy technologies and their impacts, including climate change
Audience: Undergraduate

2. Apply foundational physics concepts to solve quantitative problems regarding energy use in society
Audience: Undergraduate

3. Critically assess and discuss current issues in energy and climate, and how these issues are reported in the news
Audience: Undergraduate

PHYSICS 120 — SPECIAL TOPICS IN PHYSICS
1-3 credits.

Explores topics in Physics at the elementary undergraduate level.
Requisites: Satisfied Quantitative Reasoning (QR) A requirement
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Learning Outcomes: 1. Use physics concepts to explain the physical phenomena related to the topic of this course.
Audience: Undergraduate

2. Apply algebraic models of physics theories.
Audience: Undergraduate

3. Identify physical principles in the context of the student experience.
Audience: Undergraduate

PHYSICS 198 — DIRECTED STUDY
1-3 credits.

Introductory-level mentored research project in physics.
Requisites: Consent of instructor
Course Designation: Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Summer 2025

PHYSICS 199 — DIRECTED STUDY
1-3 credits.

Introductory-level mentored research project in physics.
Requisites: Consent of instructor
Course Designation: Level - Elementary
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2022

PHYSICS 201 — GENERAL PHYSICS
5 credits.

Calculus-based introduction to physics intended for engineering students. Mechanics: kinematics, statics, dynamics; energy and momentum.
Requisites: MATH 217 or 221. Not open to students with credit for PHYSICS 207 or 247.
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 202 – GENERAL PHYSICS
5 credits.

Calculus-based introduction to physics intended for engineering students. Electricity, magnetism, light, and sound.
Requisites: (PHYSICS 103, 201, 207, 247, or E M A 201) and (MATH 217 or 221). Not open to students with credit for PHYSICS 208 or 248.
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Summer 2025

PHYSICS 205 – MODERN PHYSICS FOR ENGINEERS
3 credits.

Introduction to atomic, solid state, and nuclear physics.
Requisites: PHYSICS 202, 208 or 248. Not open to students with credit for PHYSICS 241, 244, or 249.
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2021

PHYSICS 206 – SPECIAL TOPICS IN PHYSICS
1-5 credits.

Special topics in physics at the intermediate undergraduate level.
Requisites: (PHYSICS 103, 201, 207 or 247) and (MATH 217 or 221)
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2022

PHYSICS 207 – GENERAL PHYSICS
5 credits.

Calculus-based introduction to physics intended for students majoring in biological sciences. Mechanics: kinematics, statics, dynamics; energy and momentum. Heat and sound.
Requisites: MATH 217 or 221. Not open to students with credit for PHYSICS 201 or 247.
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 208 – GENERAL PHYSICS
5 credits.

Continuation of PHYSICS 207: calculus-based introduction to physics intended for students majoring in biological sciences. Electricity, magnetism, light, and modern physics.
Requisites: PHYSICS 201, 207, 247, E M A 201, or (PHYSICS 103 and MATH 217 or 221). Not open to students with credit for PHYSICS 202 or 248.
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS/E C E 235 – INTRODUCTION TO SOLID STATE ELECTRONICS
3 credits.

An introduction to the physical principles underlying solid-state electronic and photonic devices, including elements of quantum mechanics, crystal structure, semiconductor band theory, carrier statistics, and band diagrams. Offers examples of modern semiconductor structures. Prior experience with MATLAB [such as E C E 203] is strongly encouraged but not required.
Requisites: MATH 222 and (PHYSICS 202, 208, or 248), or member of Engineering Guest Students
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 241 – INTRODUCTION TO MODERN PHYSICS
3 credits.

Kinetic theory; relativity; experimental origin of quantum theory; atomic structure and spectral lines; topics in solid state, nuclear and particle physics.
Requisites: (PHYSICS 202, 208, or 248) and MATH 222. Not open to students with credit for PHYSICS 205, 244, or 249.
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Summer 2025

PHYSICS 247 – A MODERN INTRODUCTION TO PHYSICS
5 credits.

Calculus-based introduction to physics intended for Physics, AMEP, and Astronomy-Physics majors. Mechanics, waves, thermodynamics and statistical mechanics, topics in modern physics; with computation. A more mathematically rigorous and in-depth introduction to physics than the other introductory physics sequences.
Requisites: MATH 222 or concurrent enrollment
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 248 – A MODERN INTRODUCTION TO PHYSICS
5 credits.

Continuation of PHYSICS 247. Electromagnetism, circuits, optics, additional topics in modern physics; with computation.
Requisites: PHYSICS 247 and (MATH 234 or concurrent enrollment or MATH 376 or concurrent enrollment)
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 249 – A MODERN INTRODUCTION TO PHYSICS
4 credits.

Continuation of PHYSICS 248. Modern physics: introduction to quantum mechanics, topics from nuclear and particle physics, condensed matter physics, and atomic physics. Three lectures and one discussion per week.
Requisites: PHYSICS 248
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS/MED PHYS 265 – INTRODUCTION TO MEDICAL PHYSICS
2 credits.

A general interest survey that introduces the principles and applications of medical physics. Topics include biomechanics, energy usage and temperature regulation, pressure, sound and hearing, ultrasound, electricity in the body, optics and the eye, ionizing radiation in diagnosis and therapy, radiobiology, and nuclear medicine.
Requisites: PHYSICS 104, 202, 208, or 248
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply physics concepts, such as force, energy, and pressure, to the study of human physiology
Audience: Undergraduate

2. Describe the relevance of physics concepts to the etiology of major disease, such as heart failure, sudden cardiac death, obstructive lung disease, and nerve conduction disorders
Audience: Undergraduate

3. Explain the principles of medical imaging based on x-rays, gamma rays, sound, and other physical phenomena
Audience: Undergraduate

4. Understand the principles of radiobiology that underlie radiation sickness and radiation therapy
Audience: Undergraduate

PHYSICS 298 – DIRECTED STUDY
1-3 credits.

Intermediate-level mentored research project in physics.
Requisites: Consent of instructor
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2021

PHYSICS 299 – DIRECTED STUDY
1-3 credits.

Intermediate-level mentored research project in physics.
Requisites: Consent of instructor
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS 301 – PHYSICS TODAY
1 credit.

A series of weekly presentations and discussions of current research topics in physics, by scientists directly involved in those studies. Provides undergraduates with access to the topics and excitement of the research frontier in a manner not possible in normal subject courses.
Requisites: PHYSICS 202 or concurrent enrollment, PHYSICS 208 or concurrent enrollment, or PHYSICS 248 or concurrent enrollment
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS 307 – INTERMEDIATE LABORATORY-MECHANICS AND MODERN PHYSICS
2 credits.

Experiments in modern physics, with discussion of statistical uncertainties and error analysis. Propagation of error. Available labs include gamma-ray spectroscopy, X-ray physics and diffraction, blackbody radiation, and Cavendish measurement of the gravitational constant G.
Requisites: PHYSICS 202, 208, 248 or graduate/professional standing.
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Summer 2025
Learning Outcomes: 1. Learn how to keep a lab notebook, a laboratory skill essential to the study of physics.
Audience: Undergraduate

2. Perform quantitative measurements of physical phenomena, and understand the statistical significance of observations made in the presence of statistical and systematic uncertainties.
Audience: Undergraduate

3. Become proficient in using common research-grade laboratory equipment.
Audience: Undergraduate

4. Understand basic physical principles, as revealed in laboratory experiments.
Audience: Undergraduate

5. Gain an appreciation for, and an understanding of, scientific method.
Audience: Undergraduate

PHYSICS 311 – MECHANICS
3 credits.

Origin and development of classical mechanics; mathematical techniques, especially vector analysis; conservation laws and their relation to symmetry principles; brief introduction to orbit theory and rigid-body dynamics; accelerated coordinate systems; introduction to the generalized-coordinate formalisms of Lagrange and Hamilton.
Requisites: (PHYSICS 202, 208, or 248) and (MATH 234, 321, or 376), or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 321 – ELECTRIC CIRCUITS AND ELECTRONICS
4 credits.

Direct current circuits, circuit theorems, alternating current circuits, transients, non-sinusoidal sources, Fourier analysis, characteristics of semiconductor devices, typical electronic circuits, feedback, non-linear circuits; digital and logic circuits.
Requisites: PHYSICS 202, 208, 248 or graduate/professional standing.
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 322 – ELECTROMAGNETIC FIELDS
3 credits.

Electrostatic fields, capacitance, multi-pole expansion, dielectric theory; magnetostatics; electromagnetic induction; magnetic properties of matter; Maxwell's equations and electromagnetic waves; relativity and electromagmetism. Experiments for this course are covered in PHYSICS 308.
Requisites: (PHYSICS 202, 208 or 248) and (MATH 234, 321 or 376), or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 323 – ELECTROMAGNETIC FIELDS
3 credits.

Special relativity, electromagnetic momentum, electromagnetic waves: propagation, interference, scattering, reflection and refraction at a dielectric interface, waves in a conductor. Wave packets and group velocity, dispersion. Waveguides and transmission lines. Retarded potentials. Radiation.
Requisites: PHYSICS 322 or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2022
Learning Outcomes: 1. Be able to use the principles of special relativity to transform electric and magnetic fields between reference frames.
Audience: Undergraduate

2. Be able to use the Maxwell stress tensor to calculate electromagnetic forces and momentum density.
Audience: Undergraduate

3. Be able to calculate the properties of electromagnetic waves reflecting from surfaces.
Audience: Undergraduate

4. Be able to calculate the characteristics of guided waves.
Audience: Undergraduate

5. Be able to use electromagnetic principles to calculate the propagation of electromagnetic waves in conductors.
Audience: Undergraduate

6. Be able to calculate radiation patterns from dynamic charges and currents.
Audience: Undergraduate

7. Be able to use the principles of retardation to calculate Liénard-Wiechert potentials, and from them calculate radiation fields
Audience: Undergraduate

PHYSICS 325 – OPTICS
4 credits.

Classical and modern optics, including imaging, polarization optics, optical telescopes, optical microscopes, interference and interferometers, optical fibers and fiber-optic communication, optical resonators, lasers, optical modulators, introduction to quantum and nonlinear optics. Concepts covered in lecture reinforced by weekly laboratory experiments.
Requisites: (PHYSICS 202, 208, or 248) and (PHYSICS 322 or concurrent enrollment), or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Be able design and analyze an imaging instrument involving two or more optical elements including mirrors and lenses.
Audience: Undergraduate

2. Be able to quantitatively analyze images obtained from an optical microscope using physics calculation software.
Audience: Undergraduate

3. Be able to design, construct, and evaluate an optical telescope.
Audience: Undergraduate

4. Be able to use the principles of Fourier optics and interference to design and analyze interferometric instruments, including a Michelson interferometer and a grating spectrometer, and use these instruments to characterize light sources
Audience: Undergraduate

5. Be able to apply the fundamental properties of electromagnetic waves to determine the behavior of fiber optic combinations
Audience: Undergraduate

6. Be able to calculate parameters of a functioning laser, and design, align, and operate a diode pumped solid-state laser.
Audience: Undergraduate

7. Be able to apply the principles of refraction modulation to calculate the behavior of acousto-optic and electro-optic modulators.
Audience: Undergraduate

PHYSICS 361 – MACHINE LEARNING IN PHYSICS
3 credits.

A detailed introduction to the use of machine learning techniques in physics. Topics will include basics of probability theory and statistics, basics of function fitting and parameter inference, basics of optimization, and machine learning techniques. A selection of physics topics that are particularly amenable to analysis using machine learning will be discussed. These might include processing collider data, classifying astronomical images, solving the Ising model, parameter estimation from physics data sets, learning physical probability distributions, finding string theory compactifications, and finding symbolic physical laws.
Requisites: MATH 234 and (PHYSICS 104, 202, 208, or 248), or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Understand the conceptual foundations of machine learning and its application to physics problems. Be able to describe accurately and quantitatively the benefits of machine learning over other methods.
Audience: Undergraduate

2. Master the techniques of supervised and unsupervised machine learning, and neural networks. Be able to apply this knowledge to identification and classification of physical events, and the analysis of data.

Audience: Undergraduate

3. Become familiar with the programming techniques and common tools used in machine learning. Learn how to construct a working program and to recognize and solve problems that may arise in a large piece of code.
Audience: Undergraduate

4. Grasp the big picture behind a project that involves machine learning. Be able to articulate the goals, and the project, and where it fits into the overall scientific context.
Audience: Undergraduate

5. Understand how novel machine learning developments from the last years can be used to solve physics problems that were previously intractable.
Audience: Undergraduate

PHYSICS 371 – ACOUSTICS FOR MUSICIANS
3 credits.

Intended for music students who wish to learn about physical basis of sound, sound perception, musical scales, musical instruments, and room acoustics.
Requisites: Satisfied Quantitative Reasoning (QR) A requirement
Course Designation: Gen Ed - Quantitative Reasoning Part B
Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Fall 2022

PHYSICS 406 – SPECIAL TOPICS IN PHYSICS
1-4 credits.

Special topics in physics at the advanced undergraduate level.
Requisites: PHYSICS 205, 241, 244, 249, or PHYSICS/E C E 235
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2024

PHYSICS 407 – ADVANCED LABORATORY
2-4 credits.

Advanced experiments in classical and modern physics. Possible experiments include beta decay, muon lifetime, nuclear magnetic resonance, Stern-Gerlach atomic beam, Mossbauer scattering, velocity of light, Zeeman effect, and Compton scattering. Techniques for the statistical analysis of experimental data and keeping a proper research lab notebook are emphasized. Two (four) credit students will typically perform four (eight) experiments.
Requisites: PHYSICS 307
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 415 – THERMAL PHYSICS
3 credits.

An introduction to thermodynamics and statistical mechanics from a physics perspective. Thermodynamics, phase equilibrium, kinetic theory of gases, classical and quantum statistical mechanics.
Requisites: (PHYSICS 205, 241, 249, or PHYSICS/E C E 235) and PHYSICS 311, or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. use aspects of probability and statistics to describe the basic thermodynamic properties of macroscopic systems, and interactions between systems
Audience: Undergraduate

2. use the principles of statistical analysis to explain equilibrium between systems, and thermodynamic reservoirs
Audience: Undergraduate

3. use macroscopic system parameters to calculate general properties of homogeneous systems using Maxwell relations
Audience: Undergraduate

4. explain and use the canonical distribution to calculate the properties of systems in contact with a heat reservoir
Audience: Undergraduate

5. use the partition function approach to calculate properties of systems.
Audience: Undergraduate

6. calculate the properties of systems undergoing phase transitions
Audience: Undergraduate

7. use quantum statistics to calculate the properties of non-interacting quantum systems
Audience: Undergraduate

PHYSICS 448 – ATOMIC AND QUANTUM PHYSICS
3 credits.

Review of atomic and other quantum phenomena and special relativity; introduction to quantum mechanics treating the more advanced topics of atomic physics and applications to molecular, solid state, nuclear, and elementary particle physics and quantum statistics.
Requisites: (PHYSICS 205, 241, 244, 249, or PHYSICS/E C E 235) and PHYSICS 311 and 322, or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 449 – ATOMIC AND QUANTUM PHYSICS
3 credits.

Continuation of PHYSICS 448. Review of atomic and other quantum phenomena and special relativity; introduction to quantum mechanics treating the more advanced topics of atomic physics and applications to molecular, solid state, nuclear, and elementary particle physics and quantum statistics.
Requisites: PHYSICS 448 or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 498 – DIRECTED STUDY
1-3 credits.

Advanced-level mentored research project in physics.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2024

PHYSICS 499 – DIRECTED STUDY
1-3 credits.

Advanced-level mentored research project in physics.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS/B M E/H ONCOL/MED PHYS 501 – RADIATION PHYSICS AND DOSIMETRY
3 credits.

Interactions and energy deposition by ionizing radiation in matter; concepts, quantities and units in radiological physics; principles and methods of radiation dosimetry.
Requisites: (PHYSICS 323, 449 and MATH 320) or graduate/professional standing or declared in Medical Physics VISP
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Use the physics of microscopic structures of nucleus, nuclear decay, electronic structure of atoms to calculate nuclear decay lifespan and solid state energy band structure
Audience: Both Grad & Undergrad

2. Calculate the radiation power spectrum for an accelerating charge particle under different physical conditions
Audience: Both Grad & Undergrad

3. Calculate cross-sections for the following interaction processes between photons and matter: Rayleigh scattering, photoelectric effect, Compton scattering, and pair production
Audience: Both Grad & Undergrad

4. Calculate the scattering cross-section of Coulomb scattering and energy transfer cross-section in collisions processes and radiative energy loss processes
Audience: Both Grad & Undergrad

5. Calculate radiation dose for both external photon beams, neutron beams, and charged particle beams
Audience: Both Grad & Undergrad

6. Identify open research topics in radiation imaging, radiation therapy, and radiation protection fields
Audience: Graduate

PHYSICS/E C E/N E 525 – INTRODUCTION TO PLASMAS
3 credits.

Basic description of plasmas: collective phenomena and sheaths, collisional processes, single particle motions, fluid models, equilibria, waves, electromagnetic properties, instabilities, and introduction to kinetic theory and nonlinear processes. Examples from fusion, astrophysical and materials processing processing plasmas.
Requisites: (E C E 320 or PHYSICS 322), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS/E C E/N E 527 – PLASMA CONFINEMENT AND HEATING
3 credits.

Principles of magnetic confinement and heating of plasmas for controlled thermonuclear fusion: magnetic field structures, single particle orbits, equilibrium, stability, collisions, transport, heating, modeling and diagnostics. Discussion of current leading confinement concepts: tokamaks, tandem mirrors, stellarators, reversed field pinches, etc.
Requisites: E C E/N E/PHYSICS 525, graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 531 – INTRODUCTION TO QUANTUM MECHANICS
3 credits.

Historical background and experimental basis of quantum mechanics; de Broglie waves, correspondence principle, uncertainty principle, Schrodinger equation, hydrogen atom, electron spin, Pauli principle; applications of wave mechanics.
Requisites: (PHYSICS 205, 241, 244, 249, or PHYSICS/E C E 235) and PHYSICS 311 and 322, or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Master the concept of the wavefunction
Audience: Both Grad & Undergrad

2. Perform statistical analysis using operator algebra
Audience: Graduate

3. Understand the energy levels of the hydrogen atom
Audience: Both Grad & Undergrad

4. Obtain the mathematical skills necessary to solve the 3-dimensional wave equation
Audience: Graduate

5. Acquire the skills necessary to apply various types of perturbation theory
Audience: Both Grad & Undergrad

6. Use the variational principle including taking advantage of symmetry
Audience: Graduate

7. Understand the necessary mathematical apparatus of scattering theory
Audience: Both Grad & Undergrad

8. Discuss and explain fully the logical foundations of quantum mechanics
Audience: Both Grad & Undergrad

PHYSICS 535 – INTRODUCTION TO PARTICLE PHYSICS
3 credits.

Review of quantum physics; introduction to particles, antiparticles and fundamental interactions; detectors and accelerators; symmetries and conservation laws; electroweak and color interactions of quarks and leptons; unification theories.
Requisites: PHYSICS 448 or concurrent enrollment, PHYSICS 531 or concurrent enrollment, or graduate/professional or special student standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 545 – INTRODUCTION TO ATOMIC STRUCTURE
3 credits.

Nuclear atom; hydrogen atom; Bohr-Sommerfeld model, wave model, electron spin, description of quantum electron spin, description of quantum electrodynamic effects; external fields; many-electron atoms; central field, Pauli principle, multiplets, periodic table, x-ray spectra, vector coupling, systematics of ground states; nuclear effects in atomic spectra; interaction with coherent radiation, optical forces, laser cooling and trapping.
Requisites: PHYSICS 448 or concurrent enrollment, PHYSICS 531 or concurrent enrollment, or graduate/professional or special student standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Master the concept of the Bohr Atom
Audience: Both Grad & Undergrad

2. Fully understand the orbitals of the hydrogen atom, including how to calculate their explicit forms
Audience: Both Grad & Undergrad

3. Prove and apply the Wigner-Eckart Theorem
Audience: Graduate

4. Become familiar with the phenomenology of multi-electron atoms
Audience: Both Grad & Undergrad

5. Calculate lifetimes and linewidths from first principles
Audience: Graduate

6. Determine quantum states and their properties in the presence of external fields
Audience: Both Grad & Undergrad

7. Categorize and explain the different types of atom traps
Audience: Both Grad & Undergrad

8. Perform density-matrix calculations to quantitatively measure entanglement and decoherence
Audience: Graduate

PHYSICS 551 – SOLID STATE PHYSICS
3 credits.

Mechanical, thermal, electric, and magnetic properties of solids; band theory; semiconductors; crystal imperfections.
Requisites: PHYSICS 205, 241, 244, 249, 448, 531, PHYSICS/E C E 235, or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Utilize ideas of atomic bonding to understand crystal lattice structures and reciprocal space
Audience: Both Grad & Undergrad

2. Use the reciprocal lattice to determine complex x-ray diffraction patterns
Audience: Graduate

3. Become familiar with the calculation of simple phonon dispersion relations and use them to determine lattice thermal properties
Audience: Both Grad & Undergrad

4. Master the electronic properties of metals in the quantum free-electron model and distinguish insulators, metals, and semiconductors
Audience: Both Grad & Undergrad

5. Obtain the ability to calculate general band structures in the nearly-free electronic and tight-binding approximations
Audience: Graduate

6. Analyze and calculate properties of bulk semiconductors and semiconductor junctions
Audience: Both Grad & Undergrad

7. Describe quantitatively ordered systems such as ferroelectrics, ferromagnets and superconductors
Audience: Both Grad & Undergrad

8. Understand the physics of superconducting junctions
Audience: Graduate

PHYSICS 603 – WORKSHOP IN COLLEGE PHYSICS TEACHING
1-2 credits.

Discussion, practice, and occasional lectures on various aspects of the teaching of physics. Course planning; course materials; lecture, demonstration, and discussion techniques; laboratory; problem solving; examinations, grading, and evaluation. Problems arising in the teaching of physics; levels of difficulty, differences in talents and backgrounds; methods of presentation of various specific topics.
Requisites: PHYSICS 311 and 322
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Fall 2021

PHYSICS/B M E/MED PHYS/PHMCOL-M/RADIOL 619 – MICROSCOPY OF LIFE
3 credits.

Survey of state of the art microscopic, cellular and molecular imaging techniques, beginning with subcellular microscopy and finishing with whole animal imaging.
Requisites: PHYSICS 104, 202, 208, or 248 or PHYSICS/MED PHYS 265
Course Designation: Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 623 – ELECTRONIC AIDS TO MEASUREMENT
4 credits.

Fundamentals of electronics, electronic elements, basic circuits; combinations of these into measuring instruments.
Requisites: (PHYSICS 202, 208, or 248) and (MATH 234 or 376), or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 625 – APPLIED OPTICS
4 credits.

Optical methods in research and technology. Reflection, refraction, absorption, scattering. Imaging. Sources and sensors. Schlieren methods. Interferometry. Instrumental spectroscopy. Fourier optics, image processing, holography. Laser technology, Gaussian beams, nonlinear optics.
Requisites: PHYSICS 322 or graduate/professional standing
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 681 – SENIOR HONORS THESIS
3 credits.

Mentored individual research and study for students completing Physics Honors in the Major.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Honors - Honors Only Courses (H)
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS 682 – SENIOR HONORS THESIS
3 credits.

Mentored individual research and study for students completing Physics Honors in the Major.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Honors - Honors Only Courses (H)
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS/MED PHYS 688 – RADIATION PRODUCTION AND DETECTION
4 credits.

Physics of ionizing radiation production and detection in medical science; ionization chambers, solid-state detectors, charged and neutral particles for external beam radiotherapy, radionuclides activated with accelerators for diagnostic and therapeutic applications, radiochemistry, and X-ray tube physics.
Requisites: PHYSICS/B M E/H ONCOL/MED PHYS 501
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Achieve competence in experimental measurement methods of radiation dose
Audience: Both Grad & Undergrad

2. Develop a functional understanding of the principles and operation of the major types of ionizing radiation detectors used in modern medical physics including ion chambers, scintillators, semiconductors, chemical detectors, and calorimeters.
Audience: Both Grad & Undergrad

3. Apply fundamental atomic and nuclear physics and chemistry to radiation production using charged and neutral particles with accelerators and reactors, especially in the context of radionuclide production for diagnostic and therapeutic medical applications.
Audience: Both Grad & Undergrad

4. Develop an understanding of the principles and operation of medical electron linear accelerators for radiation therapy.
Audience: Both Grad & Undergrad

5. Apply physics and engineering concepts to understand the basic hardware configuration of an x-ray tube, the production of electrons by thermionic emission, the acceleration of electrons to a target material, and the physical interactions in the target resulting in x-rays.
Audience: Both Grad & Undergrad

6. Apply what has been learned to their current research project.
Audience: Graduate

PHYSICS 691 – SENIOR THESIS
2-3 credits.

Mentored individual research and study for students completing a thesis.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2024

PHYSICS 692 – SENIOR THESIS
2-3 credits.

Mentored individual research and study for students completing a thesis.
Requisites: Consent of instructor
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS 701 – GRADUATE INTRODUCTORY SEMINARS
1 credit.

Designed to give new students an introduction to the broad range of modern research going on at UW Physics, and to help students find research opportunities in the department. Each week, faculty from each major research area will present their research in a seminar setting. The research areas will include selected topics both in theory and experiment from biophysics; atomic, molecular, and optical physics; plasma; condensed matter; quantum information and computation; high energy and nuclear physics; particle physics, astrophysics, and cosmology.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Gains a broad awareness of the status of contemporary research in physics
Audience: Graduate

2. Learns to engage and communicate with other research professionals
Audience: Graduate

3. Learn how to work with the scientific literature
Audience: Graduate

4. Learn professional standards for the responsible conduct of research
Audience: Graduate

5. Learn responsibilities of authors and co-authors and acceptable authorship practices
Audience: Graduate

PHYSICS 707 – QUANTUM COMPUTING LABORATORY
4 credits.

Provides an intensive introduction to the experimental techniques of quantum computing. Students will do 8 experiments chosen from: Bell violation with entangled photons, Stern-Gerlach, Pulsed NMR, Optical pumping of Rb, Nanofabrication, Fiber optics communication, Diode pumped YAG laser, and Acousto-optic modulator.
Requisites: PHYSICS 709 and (PHYSICS 531 or 731)
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Summer 2025
Learning Outcomes: 1. Master fundamental techniques in experimental physics of quantum computing. This includes, but is not limited to: calibration and operation of devices to measure electromagnetic signals, particle detection, lasers and other optical equipment.
Audience: Graduate

2. Be able to analyze experimental data. This involves physical interpretation and judgment of data quality. Understand error analysis and how to extract signals from noisy data.
Audience: Graduate

3. Become familiar with all the requirements involved in the presentation of scientific data at an international level. Be able to achieve logical structure, clarity of expression and convincing narrative from introduction to conclusion.
Audience: Graduate

4. Acquire the skill of keeping a good lab notebook. This will include concision and accuracy of description and clear writing, particularly for mathematical arguments.
Audience: Graduate

PHYSICS 709 – INTRODUCTION TO QUANTUM COMPUTING
3 credits.

A detailed introduction to quantum computation and quantum information processing. Basic topics of quantum mechanics that are most relevant to quantum computing, particularly measurement theory. Specialized topics such as entanglement, other measures of quantum correlation and the Bell inequalities. Classical and quantum information theory, classical and quantum complexity theory. Qubits, quantum gates, quantum circuits. Teleportation, quantum dense coding, quantum cryptography. Quantum algorithms: Deustch, Simon, Shor, Grover, and adiabatic algorithms. Basic quantum error correction: 5-qubit, Steane and Shor codes. Completion of one undergraduate course in quantum mechanics recommended, such as PHYSICS 448 or 531.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Understand the conceptual foundations of quantum computing and its relation to classical computing. Be able to describe accurately and quantitatively the differences in their capacities.
Audience: Graduate

2. Master the formalism of many-qubit quantum mechanics, including Pauli matrices, commutation relations and repeated unitary transformations. Be able to apply this knowledge to quantum gates, quantum circuits and quantum algorithms.
Audience: Graduate

3. Become familiar with the differences between quantum correlations and classical correlations at a conceptual level. Use this knowledge to be able to analyze experiments on Bell inequalities.
Audience: Graduate

4. Understand the motivation for quantum error correction. Be able to follow and verify error-correction protocols.
Audience: Graduate

PHYSICS 711 – THEORETICAL PHYSICS-DYNAMICS
3 credits.

Lagrange's equations, Principle of Least Action, orbits and scattering, kinematics of rotation, rigid body dynamics, small oscillations, special relativistic dynamics, Hamiltonian formulation, canonical transformations, Hamilton-Jacobi theory, canonical perturbation theory, chaos, continuum mechanics, introduction to general relativity.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 715 – STATISTICAL MECHANICS
3 credits.

Statistical foundations, Liouville's theorem, ensembles, classical and quantum distribution functions, entropy and temperature, connection with thermodynamics, partition functions, quantum gases, non-ideal gases, phase transitions and critical phenomena, non-equilibrium problems, Boltzmann equation and the H-theorem, transport properties, connections with quantum field theory, applications of statistical mechanics to selected problems.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 716 – STATISTICAL MECHANICS II
3 credits.

Symmetries and symmetry breaking, phase transitions, mean field theory, critical exponents, scaling hypothesis, renormalization group, diagrammatic expansion, epsilon-expansion, exact solution of the 2d Ising model. Boltzman kinetic equation, H-theorem, Fokker-Planck and Langevin equations, Born-Markov master equation, Lindblad superoperators, classical and quantum noise, theory of amplifiers.
Requisites: PHYSICS 715 and 731
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2017

PHYSICS 717 – RELATIVITY
3 credits.

Special and general theories of relativity, relativistic electrodynamics, cosmology, unified field theories.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 721 – THEORETICAL PHYSICS-ELECTRODYNAMICS
3 credits.

Electrostatics, magnetostatics, Green functions, boundary value problems, macroscopic media, Maxwell's equations, the stress tensor and conservation laws, electromagnetic waves, wave propagation, dispersion, waveguides, radiation, multipole expansions, diffraction and scattering, special relativity, covariance of Maxwell's equations, Lienard-Wiechert potentials, radiation by accelerated charges. Knowledge of electrodynamics (such as PHYSICS 322) strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS/E C E/N E 724 – WAVES AND INSTABILITIES IN PLASMAS
3 credits.

Waves in a cold plasma, wave-plasma interactions, waves in a hot plasma, Landau damping, cyclotron damping, magneto-hydrodynamic equilibria and instabilities, microinstabilities, introduction to nonlinear processes, and experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS/E C E/N E 725 – PLASMA KINETIC THEORY AND RADIATION PROCESSES
3 credits.

Coulomb Collisions, Boltzmann equation, Fokker-Planck methods, dynamical friction, neoclassical diffusion, collision operators radiation processes and experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024

PHYSICS/E C E/N E 726 – PLASMA MAGNETOHYDRODYNAMICS
3 credits.

MHD equations and validity in hot plasmas; magnetic structure and magnetic flux coordinates; equilibrium in various configurations; stability formulation, energy principle, classification of instabilities; ideal and resistive instability in various configurations, evolution of nonlinear tearing modes; force-free equilibria, helicity, MHD dynamo; experimental applications. Basic knowledge of plasmas [such as PHYSICS/E C E/N E 525] and advanced electromagnetics [such as PHYSICS 721 or E C E 740] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 731 – QUANTUM MECHANICS
3 credits.

Schrodinger equation, operator theory, matrix mechanics, transformation theory, Heisenberg representation, orbital angular momentum, bound-state problems, scattering theory, stationary perturbation theory, degenerate systems, time-dependent perturbation theory, Born approximation, other approximation methods. Knowledge of quantum mechanics and atomic physics (such as PHYSICS 449 or 531) strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 732 – QUANTUM MECHANICS
3 credits.

Interaction of electromagnetic radiation with matter, quantization of the electromagnetic field, spontaneous transitions, identical particles and spin, addition of angular momenta, tensor operators, complex atoms, Hartree approximation, molecules, Dirac equation, relativistic effects in atoms.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 735 – PARTICLE PHYSICS
3 credits.

Structure of elementary particles, quarks and gluons, introduction to calculational techniques of particle interactions (Feynman diagrams), constituent models of electroweak and strong interactions and associated phenomenological techniques. Knowledge of introductory particle physics and quantum mechanics (such as PHYSICS 535) strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 736 – EXPERIMENTAL METHODS IN NUCLEAR-, PARTICLE-, AND ASTROPHYSICS
3 credits.

Interaction of particles with matter; detector techniques at colliding beam machines, in nuclear and particle physics, astrophysics, and cosmology; experimental strategies in detector design; principles of simulation and Monte Carlo methods, error analysis and statistical techniques in data analysis. Knowledge of introductory particle physics (such as PHYSICS 535) strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2024

PHYSICS/E C E 746 – QUANTUM ELECTRONICS
3 credits.

Elementary aspects of Lagrange theory of fields and field quantization; Bose, Fermi and Pauli operators; interaction of fields; quantum theory of damping and fluctuations; applications to lasers, nonlinear optics, and quantum optics. Knowledge of lasers [such as PHYSICS 546] and graduate-level electromagnetics [such as E C E 740 or PHYSICS 721] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS/E C E 748 – LINEAR WAVES
3 credits.

General considerations of linear wave phenomena; one dimensional waves; two and three dimensional waves; wave equations with constant coefficients; inhomogenous media; random media. Lagrangian and Hamiltonian formulations; asymptotic methods. Knowledge of electromagnetics [such as E C E 320 or PHYSICS 321], mechanics [such as M E 340], or vibrations [such as M E 440] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS/E C E/N E 749 – COHERENT GENERATION AND PARTICLE BEAMS
3 credits.

Fundamental theory and recent advances in coherent radiation charged particle beam sources (microwave to X-ray wavelengths) including free electron lasers, wiggler/wave-particle dynamics, Cerenkov masers, gyrotrons, coherent gain and efficiency, spontaneous emission, beam sources and quality, related accelerator concepts experimental results and applications.
Requisites: E C E 740
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 751 – ADVANCED SOLID STATE PHYSICS
3 credits.

Lattice dynamics; band theory; Fermi surfaces; electrodynamics of metals; optical properties; transport properties. Knowledge of introductory solid state physics (such as PHYSICS 551) strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 763 – QUBIT TUNE-UP AND PROGRAMMING
3 credits.

Explore the development of quantum computers using specific hardware platforms, such as superconducting qubits. Walk through the entire process from a fabricated device to a functional quantum computer, focusing on qubit tune-up and the DiVincenzo criteria. Implement state preparation and measurement, single and two-qubit gates, and apply quantum characterization, verification, and validation (QCVV) techniques to diagnose and mitigate errors. Utilize quantum computer simulators and real quantum devices when available, leveraging current experimental data analysis methods to understand how to build scalable and reliable quantum systems. Knowledge of quantum mechanics [such as PHYSICS 531] required.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Learning Outcomes: 1. Describe the physics underlying a specific qubit hardware.
Audience: Graduate

2. Describe and implement qubit state preparation and measurement (SPAM).
Audience: Graduate

3. Characterize and implement single and two-qubit gates.
Audience: Graduate

4. Define and implement quantum characterization, verification, and validation (QCVV) techniques to diagnose errors in quantum hardware.
Audience: Graduate

5. Utilize data analysis techniques necessary for developing quantum computers.
Audience: Graduate

PHYSICS 765 – QUANTUM ALGORITHMS AND ERROR CORRECTION
3 credits.

Dive into the quantum computing stack by starting with real-world applications and progressing through the essential components needed for fault-tolerant quantum computers. Learn about key areas such as quantum algorithms, and advanced quantum error correction. Explore algorithms for scientific applications, including quantum phase estimation and the HHL algorithm, and examine the derivation, trade-offs, and implementation of sophisticated error correction techniques. Learn to analyze and estimate the full-stack quantum resources required for novel quantum algorithms by utilizing classical computational tools, in order to develop and evaluate scalable, high-utility quantum computing solutions.
Requisites: PHYSICS 709
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Learning Outcomes: 1. Summarize how to estimate quantum resources, starting from a high-utility application, through quantum algorithms, error correcting codes, and physical qubit parameters.
Audience: Graduate

2. Discuss quantum algorithms for scientific applications, including quantum phase estimation, time-stepping schemes (Trotterization, qubitization), initial state preparation, and the HHL algorithm.
Audience: Graduate

3. Describe advanced quantum error correction codes, their derivation, trade-offs between different codes, physical overheads, decoders, and threshold calculations.
Audience: Graduate

4. Use and develop classical computational tools to study various aspects of quantum computers.
Audience: Graduate

PHYSICS 772 – HIGH ENERGY ASTROPHYSICS
3 credits.

Interactions among the particles, fields, and radiation of interstellar and intergalactic space. Gamma-ray, x-ray, and cosmic ray production, propagation, and detection. Knowledge of electrodynamics (such as PHYSICS 322) strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 779 – ADVANCED QUANTUM COMPUTING
3 credits.

Explores applications of quantum theory to both the hardware and the software that underpin modern quantum information technology. Advanced quantum circuit theory: Clifford group and Gottesman-Knill theorem, Mathematica code. Decoherence: density matrices, probability distributions, T1 and T2. Advanced error correction: master equation, Kraus operators, fault tolerance, quantum tomography. Hardware: Trapped ions, Paul traps, sideband cooling, CZ and MS gates, neutral atoms, superconductors, quantum dots.
Requisites: PHYSICS 531 or 731
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Understand how to construct and analyze a quantum circuit. Be able to simulate using Mathematica.
Audience: Graduate

2. Master the formalism of decoherence of quantum computers. Be able to apply this knowledge for different noise models.
Audience: Graduate

3. Advance knowledge of error correction beyond simple 5- and 7-qubit codes. Understand connection to classical error correction methods.
Audience: Graduate

4. Be able to explain and compare all the major technologies in use today for quantum information processing. Grasp the physics behind each, including speed and resistance to decoherence.
Audience: Graduate

PHYSICS 799 – INDEPENDENT STUDY
1-3 credits.

Graduate-level mentored research project in physics.
Requisites: Consent of instructor
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Summer 2025

PHYSICS 801 – SPECIAL TOPICS IN THEORETICAL PHYSICS
1-3 credits.

Selected topics in theoretical physics.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Summer 2025

PHYSICS 805 – SPECIAL TOPICS IN PHYSICS
1-3 credits.

Special topics in physics at the graduate level.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS 831 – ADVANCED QUANTUM MECHANICS
3 credits.

Quantum theory of free and interacting fields, formal scattering theory, dispersion theory.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024

PHYSICS 832 – ADVANCED QUANTUM MECHANICS
3 credits.

Continuation of PHYSICS 831. Quantum theory of free and interacting fields, formal scattering theory, dispersion theory.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

PHYSICS 835 – COLLIDER PHYSICS PHENOMENOLOGY
2-3 credits.

Standard model. Application to e+e-, proton-antiproton, pp, and ep colliders. Jets. Weak boson, heavy-quark, and Higgs boson production and decay. Quarkonia. Neutral B meson mixing. Grand unification. Supersymmetry.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2021

PHYSICS/E C E 848 – NONLINEAR WAVES
3 credits.

General considerations of nonlinear wave phenomena; nonlinear hyperbolic waves; nonlinear dispersion; nonlinear geometrical optics; Whitham's variational theory; nonlinear and parametric instabilities; solitary waves; inverse scattering method. Knowledge of electromagnetics [such as E C E 320 or PHYSICS 321] or mechanics [such as M E 340] encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019

PHYSICS 900 – COLLOQUIUM
0-1 credits.

Lectures by staff and visitors.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS/ASTRON 910 – SEMINAR IN ASTROPHYSICS
0-1 credits.

Current topics in astrophysics.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS/E C E/N E 922 – SEMINAR IN PLASMA PHYSICS
0-1 credits.

Current topics in plasma physics.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025

PHYSICS 990 – RESEARCH
1-12 credits.

Research supervised by individual faculty members.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Summer 2025
Learning Outcomes: 1. Evaluates or synthesizes information pertaining to questions or challenges in physics.
Audience: Graduate

2. Engages appropriately and communicates clearly with other research professionals in physics.
Audience: Graduate

3. Formulates and plans original research.
Audience: Graduate

4. Creates research, scholarship, or performance that makes a substantive contribution to the field of physics.
Audience: Graduate