PHYSICS (PH)

PH 104, *DESCRIPTIVE ASTRONOMY, 4 Credits

Historical and cultural context of discoveries concerning planets and stars and their motions. Topics include the solar system, the constellations, birth and death of stars, pulsars and black holes. An accompanying laboratory is used for demonstrations, experiments, and projects, as well as for outdoor observations. Lec/lab. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Equivalent to: PH 104H

PH 104H, *DESCRIPTIVE ASTRONOMY, 4 Credits

Historical and cultural context of discoveries concerning planets and stars and their motions. Topics include the solar system, the constellations, birth and death of stars, pulsars and black holes. An accompanying laboratory is used for demonstrations, experiments, and projects, as well as for outdoor observations. Lec/lab. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science; HNRS – Honors Course Designator
Equivalent to: PH 104

PH 106, *PERSPECTIVES IN PHYSICS, 4 Credits

A descriptive and non-mathematical study of the development of physical concepts and their historical and philosophical context. The emphasis is on the origin, meaning, significance, and limitations of these concepts and their role in the evolution of current understanding of the universe. Concepts to be covered include Copernican astronomy, Newtonian mechanics, energy, electricity and magnetism, relativity, and quantum theory. Intended primarily for non-science students. Lec/lab. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science

PH 107, *DESCRIPTIVE ASTRONOMY: STARS AND THE UNIVERSE, 4 Credits

Examines the structure and lifecycle of the Sun and other stars, and how stars evolve to form white dwarfs, neutron stars, and black holes. Explores galaxies and cosmology, as well as the roles of dark matter and dark energy. Reviews and integrates the basic physics concepts and mathematics required to understand how we have learned what we know about the Universe. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science

PH 111, *INQUIRING INTO PHYSICAL PHENOMENA, 4 Credits

Development of conceptual understandings through investigation of everyday phenomena. Emphasis is on questioning, predicting, exploring, observing, discussing, and writing in physical science contexts. Students document their initial thinking, record their evolving understandings, and write reflections upon how their thinking changed and what fostered their learning. Lec/lab. (Baccalaureate Core Course)
Attributes: CPPS – Core, Pers, Physical Science

PH 198, FIRST-YEAR ORIENTATION, 1 Credit

Introduction to the Physics Department including educational, research, and career opportunities. Recommended for all freshman and transfer physics majors, but open to all students interested in learning about opportunities in Physics.

PH 199, SPECIAL STUDIES, 1-16 Credits

One-credit sections are graded pass/no pass.
This course is repeatable for 99 credits.

PH 201, *GENERAL PHYSICS, 5 Credits

Introductory survey course covering a broad spectrum of classical and modern physics with applications. Topics include dynamics, vibrations and waves, electricity and magnetism, optics, and modern physics. Laboratory and recitation sections accompany the lectures. Mathematical preparation should include college algebra and trigonometry. Lec/lab/rec. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Equivalent to: PH 201H
Recommended: MTH 111 and MTH 112
Available via Ecampus

PH 202, *GENERAL PHYSICS, 5 Credits

Introductory survey course covering broad spectrum of classical and modern physics with applications. Topics include dynamics, vibrations and waves, electricity and magnetism, optics, and modern physics. Laboratory and recitation sections accompany the lectures. Mathematical preparation should include college algebra and trigonometry. Lec/lab/rec. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Equivalent to: PH 202H
Recommended: MTH 111 and MTH 112 and PH 201
Available via Ecampus

PH 203, *GENERAL PHYSICS, 5 Credits

Introductory survey course covering broad spectrum of classical and modern physics with applications. Topics include dynamics, vibrations and waves, electricity and magnetism, optics, and modern physics. Laboratory and recitation sections accompany the lectures. Mathematical preparation should include college algebra and trigonometry. Lec/lab/rec. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Equivalent to: PH 203H
Recommended: MTH 111 and MTH 112 and PH 202
Available via Ecampus

PH 205, *SOLAR SYSTEM ASTRONOMY, 4 Credits

History, laws, and tools of astronomy. Composition, motion, and origin of the sun, planets, moons, asteroids, and comets. An accompanying laboratory is used for demonstrations, experiments, and projects, as well as for outdoor observations. The courses in the astronomy sequence (PH 205, PH 206, PH 207) can be taken in any order. Lec/lab. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Available via Ecampus

PH 206, *STARS AND STELLAR EVOLUTION, 4 Credits

Properties of stars; star formation, evolution, and death; supernovae, pulsars, and black holes. An accompanying laboratory is used for demonstrations, experiments, and projects, as well as for outdoor observations. The courses in the astronomy sequence (PH 205, PH 206, PH 207) can be taken in any order. Lec/lab. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Available via Ecampus

PH 207, *GALAXIES, COSMOLOGY, LIFE IN THE UNIVERSE, 4 Credits

Nature and content of galaxies, properties of quasars, and the cosmic background radiation. Emphasis on the Big-Bang model and its features. An accompanying laboratory is used for demonstrations, experiments, and projects, as well as for outdoor observations. The courses in the astronomy sequence (PH 205, PH 206, PH 207) can be taken in any order. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Available via Ecampus

PH 211, *GENERAL PHYSICS WITH CALCULUS, 4 Credits

A comprehensive introductory survey course intended primarily for students in the sciences and engineering. Topics include mechanics, wave motion, thermal physics, electromagnetism, and optics. Elementary calculus is used. Laboratory work accompanies the lectures. Lec/lab/rec. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Equivalent to: PH 211H
Recommended: MTH 251 and concurrent enrollment in MTH 252 and a PH 221 recitation section

PH 211H, *GENERAL PHYSICS WITH CALCULUS, 4 Credits

A comprehensive introductory survey course intended primarily for students in the sciences and engineering. Topics include mechanics, wave motion, thermal physics, electromagnetism, and optics. Elementary calculus is used. Laboratory work accompanies the lectures. Lec/lab/rec. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science; HNRS – Honors Course Designator
Equivalent to: PH 211
Recommended: MTH 251 and concurrent enrollment in MTH 252 and a PH 221 recitation section

PH 212, *GENERAL PHYSICS WITH CALCULUS, 4 Credits

A comprehensive introductory survey course intended primarily for students in the sciences and engineering. Topics include mechanics, wave motion, thermal physics, electromagnetism, and optics. Elementary calculus is used. Laboratory work accompanies the lectures. Lec/lab. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Prerequisite: PH 211 with D- or better or PH 211H with D- or better
Equivalent to: PH 212H
Recommended: MTH 252 and concurrent enrollment in PH 222 and MTH 254

PH 212H, *GENERAL PHYSICS WITH CALCULUS, 4 Credits

A comprehensive introductory survey course intended primarily for students in the sciences and engineering. Topics include mechanics, wave motion, thermal physics, electromagnetism, and optics. Elementary calculus is used. Laboratory work accompanies the lectures. Lec/lab. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science; HNRS – Honors Course Designator
Prerequisite: PH 211 with D- or better or PH 211H with D- or better
Equivalent to: PH 212
Recommended: MTH 252 and concurrent enrollment in PH 222 and MTH 254

PH 213, *GENERAL PHYSICS WITH CALCULUS, 4 Credits

A comprehensive introductory survey course intended primarily for students in the sciences and engineering. Topics include mechanics, wave motion, thermal physics, electromagnetism, and optics. Elementary calculus is used. Laboratory work accompanies the lectures. Lec/lab/rec. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science
Equivalent to: PH 213H
Recommended: (MTH 254 or MTH 254H) and (PH 212 or PH 212H). Concurrent enrollment in a recitation section is strongly recommended

PH 213H, *GENERAL PHYSICS WITH CALCULUS, 4 Credits

A comprehensive introductory survey course intended primarily for students in the sciences and engineering. Topics include mechanics, wave motion, thermal physics, electromagnetism, and optics. Elementary calculus is used. Laboratory work accompanies the lectures. Lec/lab/rec. (Bacc Core Course)
Attributes: CPPS – Core, Pers, Physical Science; HNRS – Honors Course Designator
Equivalent to: PH 213
Recommended: (MTH 254 or MTH 254H) and (PH 212 or PH 212H). Concurrent enrollment in a recitation section is strongly recommended

PH 221, RECITATION FOR PHYSICS 211, 1 Credit

One-hour weekly session for the development of problem-solving skills in calculus-based general physics.
Prerequisite: PH 211 (may be taken concurrently) with D- or better or PH 211H (may be taken concurrently) with D- or better
Equivalent to: PH 221H

PH 221H, RECITATION FOR PHYSICS 211, 1 Credit

One-hour weekly session for the development of problem-solving skills in calculus-based general physics.
Attributes: HNRS – Honors Course Designator
Prerequisite: PH 211 (may be taken concurrently) with D- or better or PH 211H (may be taken concurrently) with D- or better
Equivalent to: PH 221

PH 222, RECITATION FOR PHYSICS 212, 1 Credit

One-hour weekly session for the development of problem-solving skills in calculus-based general physics. Graded P/N.
Prerequisite: PH 212 (may be taken concurrently) with D- or better or PH 212H (may be taken concurrently) with D- or better
Equivalent to: PH 222H

PH 222H, RECITATION FOR PHYSICS 212, 1 Credit

One-hour weekly session for the development of problem-solving skills in calculus-based general physics. Lec/rec. Graded P/N.
Attributes: HNRS – Honors Course Designator
Prerequisite: PH 212 (may be taken concurrently) with D- or better or PH 212H (may be taken concurrently) with D- or better
Equivalent to: PH 222
Recommended: Concurrent enrollment in PH 212 or PH 212H

PH 223, RECITATION FOR PHYSICS 213, 1 Credit

One-hour weekly session for the development of problem-solving skills in calculus-based general physics. Lec/rec. Graded P/N.
Prerequisite: PH 213 (may be taken concurrently) with D- or better or PH 213H (may be taken concurrently) with D- or better
Equivalent to: PH 223H

PH 223H, RECITATION FOR PHYSICS 213, 1 Credit

One-hour weekly session for the development of problem-solving skills in calculus-based general physics. Lec/rec. Graded P/N.
Attributes: HNRS – Honors Course Designator
Prerequisite: PH 213 (may be taken concurrently) with D- or better or PH 213H (may be taken concurrently) with D- or better
Equivalent to: PH 223
Recommended: Concurrent enrollment in PH 213

PH 265, SCIENTIFIC COMPUTING, 3 Credits

Basic computational tools and techniques for courses in science and engineering. Project approach to problem solving using symbolic and compiled languages with visualization. Basic computer literacy assumed.
Equivalent to: CS 265
Recommended: Concurrent enrollment in MTH 251

PH 299, SPECIAL TOPICS, 1-16 Credits

This course is repeatable for 16 credits.

PH 313, *ENERGY ALTERNATIVES, 3 Credits

Exploration of the challenges and opportunities posed by dwindling resources; physical and technological basis of our current energy alternatives; new or controversial technologies such as nuclear or solar power; overview of resource availability, patterns of energy consumption, and current governmental policies. (Bacc Core Course)
Attributes: CSST – Core, Synthesis, Science/Technology/Society
Equivalent to: PH 313H
Recommended: Upper-division standing and 12 credits of introductory science.
Available via Ecampus

PH 313H, *ENERGY ALTERNATIVES, 3 Credits

Exploration of the challenges and opportunities posed by dwindling resources; physical and technological basis of our current energy alternatives; new or controversial technologies such as nuclear or solar power; overview of resource availability, patterns of energy consumption, and current governmental policies. (Bacc Core Course)
Attributes: CSST – Core, Synthesis, Science/Technology/Society; HNRS – Honors Course Designator
Equivalent to: PH 313
Recommended: Upper-division standing and 12 credits of introductory science

PH 315, PHYSICS OF CONTEMPORARY CHALLENGES, 3 Credits

An introduction to thermal and quantum physics in the context of contemporary challenges faced by our society, such as power generation, energy efficiency, and global warming.
Recommended: PH 211

PH 317, ^EXPERIMENTAL PHYSICS, 3 Credits

Conducting experiments, understanding equipment, modeling physical phenomena, analyzing and presenting data, sources of variation and uncertainty. (Writing Intensive Course)
Attributes: CWIC – Core, Skills, WIC
Prerequisite: PH 213 with C- or better and PH 315 [C-] and PH 335 [C-]
Equivalent to: PH 317X

PH 331, *SOUND, HEARING, AND MUSIC, 3 Credits

Basic course in the physics, technology, and societal implications of sound. Intended for students in nontechnical majors. Topics include wave motion, hearing and the perception of sound, noise pollution, music and musical instruments, architectural acoustics, and sound recording and reproduction. (Bacc Core Course)
Attributes: CSST – Core, Synthesis, Science/Technology/Society
Recommended: Upper-division standing and one year of university science

PH 332, *LIGHT, VISION, AND COLOR, 3 Credits

Basic physics of light, optical instruments (lenses, telescopes, microscopes), the eye and visual perception, colors, photography, environmental lighting, lasers and holography. For nontechnical majors. (Bacc Core Course)
Attributes: CSST – Core, Synthesis, Science/Technology/Society
Recommended: Upper-division standing and one year of university science

PH 335, TECHNIQUES OF THEORETICAL MECHANICS, 3 Credits

Newtonian, Lagrangian, and Hamiltonian classical mechanics. Special relativity with relativistic mechanics.
Recommended: PH 212 and MTH 254

PH 365, COMPUTATIONAL PHYSICS LAB, 1 Credit

A project-driven laboratory experience in computational physics. Includes the use of basic mathematical and numerical techniques in computer calculations leading to solutions for typical physical problems. Topics to be covered will coordinate with the Paradigms in Physics course sequence.
Prerequisite: PH 213 with C- or better
Equivalent to: PH 365X
Recommended: Concurrent enrollment in Paradigms

PH 366, COMPUTATIONAL PHYSICS LAB, 1 Credit

A project-driven laboratory experience in computational physics. Includes the use of basic mathematical and numerical techniques in computer calculations leading to solutions for typical physical problems. Topics to be covered will coordinate with the Paradigms in Physics course sequence.
Prerequisite: PH 213 with C- or better
Recommended: Concurrent enrollment in Paradigms

PH 367, COMPUTATIONAL PHYSICS LAB, 1 Credit

A project-driven laboratory experience in computational physics. Includes the use of basic mathematical and numerical techniques in computer calculations leading to solutions for typical physical problems. Topics to be covered will coordinate with the Paradigms in Physics course sequence.
Prerequisite: PH 213 with C- or better
Recommended: Concurrent enrollment in Paradigms

PH 399, SPECIAL TOPICS, 1-16 Credits

Equivalent to: PH 399H
This course is repeatable for 16 credits.

PH 399H, SPECIAL TOPICS, 1-16 Credits

Attributes: HNRS – Honors Course Designator
Equivalent to: PH 399
This course is repeatable for 16 credits.

PH 401, RESEARCH, 1-16 Credits

A research project under the supervision of a faculty member, whose approval must be arranged by the student in advance of registration.
This course is repeatable for 16 credits.

PH 403, ^THESIS, 1-16 Credits

A research project leading to a thesis under the supervision of a faculty member, whose approval must be arranged by the student in advance of registration. (Writing Intensive Course)
Attributes: CWIC – Core, Skills, WIC
This course is repeatable for 16 credits.

PH 405, READING AND CONFERENCE, 1-16 Credits

An independent study project under the supervision of a faculty member, whose approval must be arranged by the student in advance of registration.
This course is repeatable for 16 credits.

PH 407, SEMINAR, 1-16 Credits

Departmental seminars or colloquium. Graded P/N.
Equivalent to: PH 407H
This course is repeatable for 16 credits.

PH 407H, SEMINAR, 1-16 Credits

Departmental seminars or colloquium.
Attributes: HNRS – Honors Course Designator
Equivalent to: PH 407
This course is repeatable for 16 credits.

PH 409, PHYSICS TEACHING PRACTICUM, 1-6 Credits

Physics practicum experience for students assisting in Physics courses. Includes training in course content and development of instructional materials. Admission is by application. See the department office in Weniger 301 for details.
This course is repeatable for 6 credits.

PH 410, INTERNSHIP, 1-16 Credits

This course is repeatable for 16 credits.

PH 411, ELECTRONICS, 3 Credits

Covers how to build and analyze basic circuits. Topics include passive dc and ac circuits including filters, complex impedance, Fourier analysis, operational amplifiers, semiconductor diodes, and transistors.
Recommended: PH 213

PH 415, COMPUTER INTERFACING AND INSTRUMENTATION, 3 Credits

Applications of computers as scientific instruments, with emphasis on hardware and instrumentation, online data acquisition, and computer control of experiments.

PH 422, PARADIGMS IN PHYSICS: STATIC FIELDS, 3 Credits

Theory of static electric, magnetic, and gravitational potentials and fields using the techniques of vector calculus in three dimensions.
Equivalent to: PH 322
Recommended: PH 213 and MTH 255

PH 423, PARADIGMS IN PHYSICS: ENERGY AND ENTROPY, 3 Credits

Thermodynamics and canonical statistical mechanics.
Equivalent to: PH 323
Recommended: PH 213

PH 424, PARADIGMS IN PHYSICS: OSCILLATIONS AND WAVES, 3 Credits

Dynamics of mechanical and electrical oscillation using Fourier series and integrals; time and frequency representations for driven damped oscillators, resonance; one-dimensional waves in classical mechanics and electromagnetism; normal modes.
Recommended: PH 213 and PH 411 and MTH 256

PH 425, PARADIGMS IN PHYSICS: QUANTUM FUNDAMENTALS, 3 Credits

Introduction to quantum mechanics through Stern-Gerlach spin measurements. Probability, eigenvalues, operators, measurement, state reduction, Dirac notation, matrix mechanics, time evolution. Quantum behavior of a one-dimensional well.
Recommended: PH 213 and concurrent enrollment in MTH 341

PH 426, PARADIGMS IN PHYSICS: CENTRAL FORCES, 3 Credits

Gravitational and electrostatic forces; angular momentum and spherical harmonics, separation of variables in classical and quantum mechanics, hydrogen atom.
Recommended: PH 213 and PH 422 and PH 425 and concurrent enrollment in PH 335

PH 427, PARADIGMS IN PHYSICS: PERIODIC SYSTEMS, 3 Credits

Quantum waves in position and momentum space; Bloch waves in one-dimensional periodic systems, and the reciprocal lattice; coupled harmonic oscillators; phonons.
Recommended: PH 424 and PH 425 and concurrent enrollment in PH 315

PH 431, CAPSTONES IN PHYSICS: ELECTROMAGNETISM, 3 Credits

Static electric and magnetic fields in matter, electrodynamics, Maxwell equations, electromagnetic waves, wave guides, dipole radiation.
Recommended: (PH 424 or 524) and (PH 426 or PH 526)

PH 441, CAPSTONES IN PHYSICS: THERMAL AND STATISTICAL PHYSICS, 3 Credits

Entropy and quantum mechanics; canonical Gibbs probability; ideal gas; thermal radiation; Einstein and Debye lattices; grand canonical Gibbs probability; ideal Fermi and Bose gases; chemical reactions and phase transformations.
Recommended: (PH 423 or PH 523) and (PH 451 or PH 551)

PH 451, CAPSTONES IN PHYSICS: QUANTUM MECHANICS, 3 Credits

Wave mechanics, Schroedinger equation, operators, harmonic oscillator, identical particles, atomic fine structure, approximation methods and applications.
Recommended: (PH 424 or PH 524) and (PH 425 or PH 525) and (PH 426 or PH 526)

PH 455, ASTROPHYSICS, 3 Credits

Physics of stars and the cosmos.
Recommended: PH 213; PH 315 or equivalent junior-level background in modern physics and thermodynamics.

PH 464, SCIENTIFIC COMPUTING II, 3 Credits

Mathematical, numerical, and conceptual elements forming foundations of scientific computing: computer hardware, algorithms, precision, efficiency, verification, numerical analysis, algorithm scaling, profiling, and tuning. Lec/lab.
Equivalent to: PH 365

PH 465, COMPUTATIONAL PHYSICS, 3 Credits

The use of basic mathematical and numerical techniques in computer calculations leading to solutions for typical physical problems. Topics to be covered include models and applications ranging from classical mechanics and electromagnetism to modern solid state and particle physics.
Recommended: PH 464 or PH 564

PH 481, PHYSICAL OPTICS, 4 Credits

Wave propagation, polarization, interference, diffraction, and selected topics in modern optics.
Recommended: PH 431 or PH 531

PH 482, OPTICAL ELECTRONIC SYSTEMS, 4 Credits

Photodetectors, laser theory, and laser systems. Lec/lab. CROSSLISTED as ECE 482/PH 482 and ECE 582/PH 582.
Equivalent to: ECE 482
Recommended: ECE 391 or (PH 481 or PH 581)

PH 483, GUIDED WAVE OPTICS, 4 Credits

Optical fibers, fiber mode structure and polarization effects, fiber interferometry, fiber sensors, optical communication systems. Lec/lab. CROSSLISTED as ECE 483/PH 483 and ECE 583/PH 583.
Equivalent to: ECE 483
Recommended: Completion or concurrent enrollment in ECE 391 or PH 481

PH 495, INTRODUCTION TO PARTICLE AND NUCLEAR PHYSICS, 3 Credits

Elementary particles and forces, nuclear structure and reactions.
Recommended: PH 451 or PH 551

PH 499, SPECIAL TOPICS, 1-16 Credits

Topics vary from year to year. May be repeated for credit. Not offered every year.
This course is repeatable for 16 credits.

PH 501, RESEARCH, 1-16 Credits

Graded P/N.
This course is repeatable for 16 credits.

PH 503, THESIS, 1-16 Credits

This course is repeatable for 999 credits.

PH 505, READING AND CONFERENCE, 1-16 Credits

This course is repeatable for 16 credits.

PH 507, SEMINAR, 1-16 Credits

Section 1: Departmental Colloquium. Section 3: Nuclear and Particle Physics. Section 5: Atomic, Molecular, and Optical Physics. Section 7: Solid State Physics. Section 9: Computational Physics. One-credit options are graded P/N.
This course is repeatable for 16 credits.

PH 510, INTERNSHIP, 1-16 Credits

This course is repeatable for 16 credits.

PH 511, ELECTRONICS, 3 Credits

Covers how to build and analyze basic circuits. Topics include passive dc and ac circuits including filters, complex impedance, Fourier analysis, operational amplifiers, semiconductor diodes, and transistors.
Recommended: PH 213

PH 515, COMPUTER INTERFACING AND INSTRUMENTATION, 3 Credits

Applications of computers as scientific instruments, with emphasis on hardware and instrumentation, online data acquisition, and computer control of experiments.

PH 531, CAPSTONES IN PHYSICS: ELECTROMAGNETISM, 3 Credits

Static electric and magnetic fields in matter, electrodynamics, Maxwell equations, electromagnetic waves, wave guides, dipole radiation.
Recommended: (PH 424 or PH 524) and (PH 426 or PH 526)

PH 541, CAPSTONES IN PHYSICS: THERMAL AND STATISTICAL PHYSICS, 3 Credits

Entropy and quantum mechanics; canonical Gibbs probability; ideal gas; thermal radiation; Einstein and Debye lattices; grand canonical Gibbs probability; ideal Fermi and Bose gases; chemical reactions and phase transformations.
Recommended: (PH 423 or PH 523) and (PH 451 or PH 551)

PH 551, CAPSTONES IN PHYSICS: QUANTUM MECHANICS, 3 Credits

Wave mechanics, Schroedinger equation, operators, harmonic oscillator, identical particles, atomic fine structure, approximation methods and applications.
Recommended: (PH 424 or PH 524) and (PH 425 or PH 525) and (PH 426 or PH 526)

PH 555, ASTROPHYSICS, 3 Credits

Physics of stars and the cosmos.
Recommended: PH 213; PH 315 or equivalent junior-level background in modern physics and thermodynamics.

PH 562, MATHEMATICAL PHYSICS, 3 Credits

Fundamental mathematical techniques needed for graduate students in physics. Topics include vector spaces and operators; fourier series, integrals, and transforms; partial differential equations; special functions, distributions, and delta functions; Green's functions; complex analysis.

PH 564, SCIENTIFIC COMPUTING II, 3 Credits

Mathematical, numerical, and conceptual elements forming foundations of scientific computing: computer hardware, algorithms, precision, efficiency, verification, numerical analysis, algorithm scaling, profiling, and tuning. Lec/lab.
Equivalent to: PH 365

PH 575, INTRODUCTION TO SOLID STATE PHYSICS, 3 Credits

Introduction to condensed matter physics for majors in physics, chemistry, and engineering. Topics include band structure, free electron behavior, optical properties, magnetism, and lattice excitations.
Recommended: (PH 451 or PH 551) and concurrent enrollment in PH 427 or PH 527

PH 581, PHYSICAL OPTICS, 4 Credits

Wave propagation, polarization, interference, diffraction, and selected topics in modern optics.
Recommended: PH 431 or PH 531

PH 582, OPTICAL ELECTRONIC SYSTEMS, 4 Credits

Photodetectors, laser theory, and laser systems. Lec/lab. CROSSLISTED as ECE 482/PH 482 and ECE 582/PH 582.
Equivalent to: ECE 582
Recommended: PH 481 or PH 581

PH 583, GUIDED WAVE OPTICS, 4 Credits

Optical fibers, fiber mode structure and polarization effects, fiber interferometry, fiber sensors, optical communication systems. Lec/lab. CROSSLISTED as ECE 483/PH 483 and ECE 583/PH 583.
Equivalent to: ECE 583
Recommended: Completion or concurrent enrollment in ECE 391 or PH 481/581

PH 585, ATOMIC, MOLECULAR, AND OPTICAL PHYSICS, 3 Credits

Atomic and molecular structure, interaction with electromagnetic fields, atomic and molecular spectra, spectroscopic techniques, laser theory, nonlinear optics.
Recommended: (PH 431 or PH 531) or (PH 451 or PH 551)

PH 591, BIOLOGICAL PHYSICS, 3 Credits

Basic physics principles applied to the kinetics and dynamics of molecular and cellular processes. Ion channels, two-state systems, dynamics of molecular motors, cell signalling, and multicellular phenomena.
Recommended: PH 320, PH 421, PH 422 and PH 423 or junior-level background in classical mechanics, electromagnetism, and thermodynamics

PH 595, INTRODUCTION TO PARTICLE AND NUCLEAR PHYSICS, 3 Credits

Elementary particles and forces, nuclear structure and reactions.
Recommended: PH 451 or PH 551

PH 599, SPECIAL TOPICS, 1-16 Credits

(See PH 499 for description.)
This course is repeatable for 16 credits.

PH 601, RESEARCH, 1-16 Credits

This course is repeatable for 16 credits.

PH 603, THESIS, 1-16 Credits

This course is repeatable for 999 credits.

PH 605, READING AND CONFERENCE, 1-16 Credits

This course is repeatable for 16 credits.

PH 607, SEMINAR, 1-16 Credits

Section 1: Departmental Colloquium. Section 3: Nuclear and Particle Physics. Section 5: Atomic, Molecular, and Optical Physics. Section 7: Solid State Physics. Section 9: Computational Physics. One-credit options are graded P/N.
This course is repeatable for 16 credits.

PH 609, PRACTICUM IN TEACHING, 1-6 Credits

This course is repeatable for 6 credits.

PH 621, DYNAMICS OF SINGLE- AND MULTI-PARTICLE SYSTEMS, 3 Credits

Introduction to theory of non-linear systems. Chaos in Hamiltonian and dissipative systems. Lyapunov exponents, fractal geometries.
Recommended: PH 435 or PH 535

PH 631, ELECTROMAGNETIC THEORY, 3 Credits

Electrostatics; multipole expansion; magnetostatics; radiation fields; dynamics of relativistic particles and electromagnetic fields.
Recommended: PH 431 or PH 531

PH 632, ELECTROMAGNETIC THEORY, 3 Credits

Electrostatics; multipole expansion; magnetostatics; radiation fields; dynamics of relativistic particles and electromagnetic fields.
Recommended: PH 631 and (PH 431 or PH 531)

PH 633, ELECTROMAGNETIC THEORY, 3 Credits

Electrostatics; multipole expansion; magnetostatics; radiation fields; dynamics of relativistic particles and electromagnetic fields.
Recommended: PH 632 and (PH 431 or PH 531)

PH 641, STATISTICAL THERMOPHYSICS, 3 Credits

Macroscopic thermodynamics and kinetic theory. Classical and quantal statistical ensembles; partition functions. Applications to atoms and molecules, clustering, solids, radiation.
Recommended: PH 435 or PH 535

PH 642, STATISTICAL THERMOPHYSICS, 3 Credits

Macroscopic thermodynamics and kinetic theory. Classical and quantal statistical ensembles; partition functions. Applications to atoms and molecules, clustering, solids, radiation.
Recommended: PH 641

PH 651, QUANTUM MECHANICS, 3 Credits

Basic principles of nonrelativistic quantum theory and applications. Schroedinger theory, quantum theory of angular momentum, matrix mechanics, perturbation theory, identical particles, scattering.
Recommended: (PH 435 or PH 535) and (PH 451 or PH 551)

PH 652, QUANTUM MECHANICS, 3 Credits

Basic principles of nonrelativistic quantum theory and applications. Schroedinger theory, quantum theory of angular momentum, matrix mechanics, perturbation theory, identical particles, scattering.
Recommended: (PH 435 or PH 535) and (PH 451 or PH 551) and PH 651

PH 653, QUANTUM MECHANICS, 3 Credits

Basic principles of nonrelativistic quantum theory and applications. Schroedinger theory, quantum theory of angular momentum, matrix mechanics, perturbation theory, identical particles, scattering.
Recommended: (PH 435 or PH 535) and (PH 451 or PH 551) and PH 652

PH 654, ADVANCED QUANTUM THEORY, 3 Credits

Scattering theory, second quantization and many body theory, relativistic quantum mechanics, quantization of fields, quantum electrodynamics, and elementary particles.
Recommended: PH 653

PH 655X, ADVANCED QUANTUM THEORY, 3 Credits

Covers scattering theory, second quantization and many body theory, relativistic quantum mechanics, quantization of fields, quantum electrodynamics, and elementary particles.
Prerequisite: PH 654 with C- or better

PH 671, SOLID STATE PHYSICS, ELECTRON TRANSPORT, 3 Credits

Fundamentals of solid state physics, Boltzmann transport, phonon and defect scattering, quantum transport, transport in magnetic field, localization, Mott-insulator transition, electron tunneling, superconductivity. Not offered every year.
Recommended: Basic knowledge of electromagnetism and quantum mechanics

PH 672, SOLID STATE PHYSICS, THEORY, 3 Credits

The many-body problem, density functional theory, excited states properties, BCS theory of superconductivity. Not offered every year.
Prerequisite: PH 575 with D- or better and PH 654 [D-]
Recommended: Basic knowledge of electromagnetism and quantum mechanics

PH 673, SOLID STATE PHYSICS, NANOSCIENCE AND NANOTECHNOLOGY, 3 Credits

Introduction to nanoscience and nanotechnology; semiconductor quantum wells, wires, and dots; bulk metals vs nanoparticles; molecular ensembles vs single molecules; fabrication of nanoparticles and nanostructured materials; scanning probe microscopy; advanced optical imaging and manipulation. Not offered every year.
Recommended: Basic knowledge of electromagnetism and quantum mechanics

PH 674, SOLID STATE PHYSICS, MAGNETISM, 2 Credits

Magnetism of atoms; interaction between magnetic atoms, magnetic ordering in crystalline solids; excitations in magnetic solids; temperature dependent phenomena in magnetic solids; magnetism of metals, alloys, insulators and semiconductors; topics of considerable interest in contemporary research.
Recommended: Basic knowledge of electromagnetism and quantum mechanics.

PH 681, ATOMIC, MOLECULAR AND OPTICAL PHYSICS, MODERN OPTICS, 3 Credits

Maxwell's equations in matter; refraction, phase and group indices; material and geometry dispersion; effective-medium regime. Not offered every year.
Recommended: Basic knowledge of electromagnetism and quantum mechanics

PH 682, ATOMIC, MOLECULAR, OPTICAL PHYSICS, SEMICONDUCTOR OPTICS, 3 Credits

Linear response theory; polarization effects; interband excitations and emissions; low dimensional systems; excitons; phonons; semiconductor lasers; photovoltaics. Not offered every year.
Recommended: Basic knowledge of electromagnetism and quantum mechanics

PH 683, ATOMIC, MOLECULAR AND OPTICAL PHYSICS, NONLINEAR OPTICS, 3 Credits

Coherent nonlinear electromagnetic phenomena; harmonic generation and parametric mixing; quantum mechanical description of multi-photon interactions; incoherent multi-photon interactions; coherent nonlinear optical phenomena and spectroscopies. Not offered every year.
Recommended: Basic knowledge of electromagnetism and quantum mechanics

PH 684, ATOMIC, MOLECULAR AND OPTICAL PHYSICS, ULTRAFAST OPTICS, 2 Credits

Introduction of ultrafast optical science; short pulse propagation in linear media; pulse stretching and compressing; Q-switching and mode-locking; characterization of femtosecond lasers; coherent optical effects. Offered in alternate years.
Recommended: Basic knowledge of electromagnetism and quantum mechanics.

PH 699, SPECIAL TOPICS: BIOLOGICAL PHYSICS, 3 Credits

Topics vary from year to year. Not offered every year.
This course is repeatable for 9 credits.