

# PHYSICS (PH-UY)

## PH-UY 1 Pre-college Physics (0 Credits)

*Typically offered Summer term*

This course introduces the foundational concepts and laws of physics and their connection to the engineering disciplines. The subject matter helps students apply scientific methods to physical problems and prepares them for physics at the university level. Topics include vectors, kinematics, Newton's Laws, work and energy, momentum and collision theory, rotational motion, and angular momentum.

**Grading:** Ugrd Tandon Pass/Fail

**Repeatable for additional credit:** No

## PH-UY 323 Electricity and Magnetism (4 Credits)

The course covers properties of the electrostatic, magnetostatic and electromagnetic field in vacuum and in material media. Maxwell's equations with applications to elementary problems. | Prerequisites: PH-UY 2033 and MA-UY 2114.

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

## PH-UY 1002 Physics: The Genesis of Technology (2 Credits)

*Typically offered Fall*

This course introduces contemporary topics in physics, along with readings and discussions of topics with technological implications. | Prerequisite: Only first-year students are permitted to enroll in this introductory level course.

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

## PH-UY 1004 Introductory Physics I (4 Credits)

*Typically offered occasionally*

This course is the first of a two-semester integrated lecture and laboratory sequence in general physics for science and engineering students. One-dimensional motions. Vectors and two-dimensional motions. Newton's laws of motion. Conservation of energy and momentum. Rotational motions. Gravity. Statics and elasticity. Fluids. Oscillations. Heat and the laws of thermodynamics. | Prerequisite: MA-UY 1024 or an approved equivalent. Co-requisite: MA-UY 1124 or an approved equivalent, and EX-UY 1

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

**Prerequisites:** MA-UY 1024 or an approved equivalent.

## PH-UY 1004H HONORS PHYSICS I: PHYSICS TAUGHT SOCRATICALLY (4 Credits)

*Typically offered not typically offered*

The course involves students in debate while covering fundamental principles of natural law and their applications to contemporary areas of technology. Effectively, this course can be considered an Oxford model. Examples will not be limited to material in traditional textbooks. Rather, areas from conventional physics to biomedical physics will be discussed with both analytical and quantitative problems. The emphasis is on individual growth toward independent thinking. | Prerequisites: MA-UY 1024 or approved equivalent. Co-Requisites: MA-UY 1124 or approved equivalent, and EX-UY 1

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

## PH-UY 1013 MECHANICS (3 Credits)

*Typically offered Fall, Spring, and Summer terms*

This course is the first of a three-semester lecture sequence in general physics for science and engineering students. Motion of particles and systems of particles. One-dimensional motion. Vectors and two-dimensional motions. Forces and acceleration. Conservation of energy and momentum. Rotations. The free and driven harmonic oscillator. Gravitation. (This class meets four hours per week for lectures and recitation.) | Prerequisites: MA-UY 1024 or an approved equivalent.

Corequisites: MA-UY 1124 or approved equivalent, and EX-UY 1

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

## PH-UY 1013H HONORS MECHANICS (3 Credits)

*Typically offered not typically offered*

This course is the first of a three-semester lecture sequence in general physics for science and engineering students. Motion of particles and systems of particles. One-dimensional motion. Vectors and two-dimensional motions. Forces and acceleration. Conservation of energy and momentum. Rotations. The free and driven harmonic oscillator. Gravitation. (This class meets four hours per week for lectures and recitation.) | Prerequisites: MA-UY 1024/1054/1324 and Enrolled in Honors Program; Corequisites: MA-UY 1124/1154/1424, and EX-UY 1

Corequisites: MA-UY 1124/1154/1424, and EX-UY 1

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

## PH-UY 1213 MOTION AND SOUND (3 Credits)

*Typically offered Spring*

PH-UY 1213 Motion and Sound. (3:0:1:3) First of a two courses introductory sequence in general physics for majors other than science or engineering. (Not an acceptable substitute for PH-UY 1013) One-dimensional motions. Vectors and Two-Dimensional Motions. Newton's Laws of motion. Conservation Laws of Energy and Momentum. Collisions. Rotational motions. Gravity. Statics and Elasticity. Fluids. Oscillations. Mechanical Waves. Superposition and Standing Waves. Sound and Acoustics. | Co-requisite: EX-UY, Anti-requisite: PH-UY 1013

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

## PH-UY 1214 PHYSICS OF MOTION AND SOUND (4 Credits)

*Typically offered not typically offered*

This course is the first of two in an introductory sequence in general physics for majors other than science or engineering. (This is not an acceptable substitute for majors where PH-UY 1004 is required.) One-dimensional motions. Vectors and Two-Dimensional Motions. Newton's Laws of motion. Conservation Laws of Energy and Momentum. Collisions. Rotational motions. Gravity. Statics and Elasticity. Fluids. Oscillations. Mechanical Waves. Superposition and Standing Waves. Sound and Acoustics. | Co-requisites: MA-UY 1114.

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

**Corequisites:** MA-UY 1114.

**PH-UY 1223 ELECTRICITY AND LIGHT (3 Credits)***Typically offered Fall*

Second of two introductory courses in general physics for non science or engineering majors. (Not an acceptable substitute for PH-UY 2023 or PH-UY 2033) Electric forces and fields. Electric potential and capacitance. Electric current. Magnetic forces and fields. Faradays law and inductance. Maxwell's Theory of Electromagnetism. Electromagnetic waves. Light and Color. Geometrical optics. Image Formation. Interference and diffraction. | Prerequisite(s): PH-UY 1213 or PH-UY 1013; Co-requisite: EX-UY 1.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 1213 or PH-UY 1013; Co-requisite: EX-UY 1.**PH-UY 1224 Physics of Electricity and Light (4 Credits)***Typically offered not typically offered*

This is the second of two introductory courses in general physics for non-science or engineering majors. (It is not an acceptable substitute for majors where PH-UY 2004 is required.) Electric forces and fields. Electric potential and capacitance. Electric current. Magnetic forces and fields. Faradays law and inductance. Maxwell's Theory of Electromagnetism. Electromagnetic waves. Light and Color. Geometrical optics. Image Formation. Interference and diffraction. | Prerequisites: PH-UY 1214, MA 1054.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 1214 with a Minimum Grade of D AND MA-UY 1054 with a Minimum Grade of D.**PH-UY 2002 Introduction to Quantum Science (2 Credits)***Typically offered Spring*

This course offers an introduction to the essential concepts of quantum mechanics. Topics covered include basic principles like superposition, measurement and entanglement, along with elementary mathematical models such as wave functions and probability amplitudes. While the course does involve mathematical descriptions, the emphasis is on developing an intuitive understanding of quantum principles. | Prerequisites: PH-UY 1013 and MA-UY 1124

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2004H ELECTRICITY AND MAGNETISM: FUNDAMENTALS AND TECHNOLOGICAL IMPLICATIONS (4 Credits)***Typically offered not typically offered*

This is the second of two introductory courses in general physics. Electric forces and fields. Electric potential and capacitance. Electric current. Magnetic forces and fields. Faraday's law and inductance. Maxwell's equations. Mechanical and electromagnetic waves. Geometrical optics. Interference and diffraction. | Prerequisites: PH-UY 1004, MA-UY 1122. The theory class meets five hours per week for lectures and recitation. The laboratory class meets for three hours on alternate weeks. Corequisite: EX-UY 1

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 1004 with a Minimum Grade of D AND MA-UY 1122 with a Minimum Grade of D AND Corequisite: EX-UY 1.**PH-UY 2012 Introduction to Quantum Programming (2 Credits)***Typically offered Fall*

This course offers an accessible introduction to quantum programming. Students will explore fundamental quantum algorithms and learn to implement them using popular quantum programming languages and frameworks, with a particular focus on Python-based tools. Topics will include qubits, quantum gates, quantum circuits, and essential quantum algorithms like Deutsch-Josza and Grover's algorithm. | Prerequisites: PH-UY 2002 and CS-UY 1114

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2021H HONORS INTRODUCTORY PHYSICS LAB I (0.5 Credits)***Typically offered not typically offered*

First part of introduction to the science of measurement. Students perform experiments chosen to illustrate basic physical principles and requiring a variety of measurement techniques and equipment. Results require progressively more detailed and sophisticated analysis. This course treats the same topics as PH-UY 2021 but because of the intended audience, in greater depth. | Prerequisites: Enrollment in Honors Program, PH-UY 1013 and MA-UY 1124 or an approved equivalent. Co-requisites: PH-UY 2023.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2023 ELECTRICITY, MAGNETISM, & FLUIDS (3 Credits)***Typically offered Fall, Spring, and Summer terms*

This is the second course of a three-semester lecture sequence in general physics for science and engineering students. Fluids at rest and in motion. An introduction to electric and magnetic forces and fields. Electric charge density. Electric fields from simple charge distributions. Electric potential. Capacitance. Magnetic forces. Magnetic field from a current loop. Inductance. Magnetism in matter. Current and resistance. (This class meets four hours per week for lectures and recitation.) | Prerequisites: PH-UY 1013 and MA-UY 1124 or an approved equivalent. Co-requisite: EX-UY 1

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2023G ELECTRICITY, MAGNETISM, & FLUIDS (3 Credits)***Typically offered Fall*

This is the second course of a three-semester lecture sequence in general physics for science and engineering students. Fluids at rest and in motion. An introduction to electric and magnetic forces and fields. Electric charge density. Electric fields from simple charge distributions. Electric potential. Capacitance. Magnetic forces. Magnetic field from a current loop. Inductance. Magnetism in matter. Current and resistance. (This class meets four hours per week for lectures and recitation.) | Prerequisites: PH-UY 1013 and MA-UY 1124 or an approved equivalent. Co-requisite: EX-UY 1

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No

**PH-UY 2023H HONORS ELECTRICITY, MAGNETISM, & FLUIDS (3 Credits)***Typically offered not typically offered*

Fluids at rest and in motion. An introduction to electric and magnetic forces and fields. Electric charge density. Electric fields from simple charge distributions. Electric potential. Capacitance. Magnetic forces. Magnetic field from a current loop. Inductance. Magnetism in matter. Current and resistance. This course treats the same topics as PH-UY 2023 but because of the intended audience, in greater depth. | Corequisite: EX-UY 1

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2031H HONORS INTRODUCTORY PHYSICS LAB II (0.5 Credits)***Typically offered not typically offered*

Continuation of introduction to the science of measurement. Students perform experiments chosen to illustrate basic physical principles and requiring a variety of measurement techniques and equipment. Results require progressively more detailed and sophisticated analysis. This course treats the same topics as PH-UY 2031 but because of the intended audience, in greater depth. | Prerequisites: Enrolled in Honors Program, PH-UY 2021 and PH-UY 2023. Corequisites: PH-UY 2033 and EX-UY 1.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No

**Prerequisites:** PH-UY 2021H with a Minimum Grade of D AND PH-UY 2023H with a Minimum Grade of D AND Corequisite: PH-UY 2033H AND Restriction: (Student Group = Honors Student OR Honor's BS MS Program).

**PH-UY 2033 WAVES, OPTICS, & THERMODYNAMICS (3 Credits)***Typically offered Fall, Spring, and Summer terms*

This is the third course of a three-semester lecture sequence in general physics for science and engineering students. Water, sound and electromagnetic waves. Reflection, scattering and absorption. Standing waves and spectra. Superposition, diffraction and beats. Geometrical optics. Introduction to thermodynamics; temperature, heat, and entropy. (This class meets four hours per week for lectures and recitation.) | Prerequisites: PH-UY 2121 and PH-UY 2023. Co-requisites: EX-UY 1.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2033G WAVES, OPTICS, & THERMODYNAMICS (3 Credits)**

This is the third course of a three-semester lecture sequence in general physics for science and engineering students. Water, sound and electromagnetic waves. Reflection, scattering and absorption. Standing waves and spectra. Superposition, diffraction and beats. Geometrical optics. Introduction to thermodynamics; temperature, heat, and entropy. (This class meets four hours per week for lectures and recitation.) | Prerequisites: PH-UY 2121 and PH-UY 2023. Co-requisites: EX-UY 1.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2033H HONORS WAVES, OPTICS, & THERMODYNAMICS (3 Credits)***Typically offered not typically offered*

Water, sound, and electromagnetic waves. Reflection, scattering, and absorption. Standing waves and spectra. Superposition, diffraction and beats. Geometrical optics. Introduction to thermodynamics; temperature, heat, and entropy. This course treats the same topics as PH-UY 2033 but because of the intended audience, in greater depth. | Corequisite: EX-UY 1

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2104 Analytical Mechanics (4 Credits)***Typically offered Fall*

The course covers statics by virtual work and potential energy methods. Stability of equilibrium. Particle dynamics, harmonic oscillator and planetary motion. Rigid body dynamics in two and three dimensions. Lagrangian mechanics. Dynamics of oscillating systems. | Prerequisite: PH-UY 2023; Co-requisite: MA-UY 2034

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 2023; Co-requisite: MA-UY 2034.**PH-UY 2121 General Physics Laboratory I (1 Credit)***Typically offered Fall, Spring, and Summer terms*

PH-UY 2121 General Physics Laboratory I (0.5:1:0:1). An introductory level experimental course. Fundamental laboratory experiments in classical mechanics and electrostatics. Stresses basic experimental techniques, error analysis, and written presentation of experiment results. Experiments require progressively more detailed and sophisticated analysis. This laboratory class meets for three hours on alternate weeks. | Prerequisites: PH-UY 1013 and MA-UY 1124 or equivalent. Co-requisite: PH-UY 2023.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2121G General Physics Laboratory I (1 Credit)***Typically offered Fall*

PH-UY 2121 General Physics Laboratory I (0.5:1:0:1). An introductory level experimental course. Fundamental laboratory experiments in classical mechanics and electrostatics. Stresses basic experimental techniques, error analysis, and written presentation of experiment results. Experiments require progressively more detailed and sophisticated analysis. This laboratory class meets for three hours on alternate weeks. | Prerequisites: PH-UY 1013 and MA-UY 1124 or equivalent. Co-requisite: PH-UY 2023.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2131 General Physics Laboratory II (1 Credit)***Typically offered Fall, Spring, and Summer terms*

PH 2131 General Physics Laboratory II (0.5:1:0:1). The second part of the introductory physics laboratory program. Fundamental laboratory experiments in E&M, waves, optics, and thermodynamics. Stresses experimental models and design, error and data analysis. This laboratory class meets for three hours on alternate weeks. | Prerequisites: PH-UY 2121 and PH-UY 2023. Corequisite: PH-UY 2033

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Corequisites:** PH-UY 2033.**PH-UY 2131G General Physics Laboratory II (1 Credit)**

PH 2131 General Physics Laboratory II (0.5:1:0:1). The second part of the introductory physics laboratory program. Fundamental laboratory experiments in E&M, waves, optics, and thermodynamics. Stresses experimental models and design, error and data analysis. This laboratory class meets for three hours on alternate weeks. | Prerequisites: PH-UY 2121 and PH-UY 2023. Corequisite: PH-UY 2033

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No

**PH-UY 2344 INTRODUCTION TO MODERN AND SOLID STATE PHYSICS (4 Credits)***Typically offered Spring*

Special theory of relativity, Michelson Morley experiment. Planck's quantum hypothesis, photoelectric effect, Compton effect, Rutherford scattering, Bohr's atom, DeBroglie wavelength, electron diffraction, wave function, uncertainty principle, Schrodinger equation. Application to: square well potential, one electron atom. Atomic nucleus, fission and fusion. Energy bands in a periodic lattice, Kronig Penney model, valence, conduction bands, impurity states, electron mobility. Semiconductor properties. Introduction to superconductivity; electron pairs, energy gap, Josephson effect. | Prerequisites: PH-UY 2023; Co-requisite: PH-UY 2033 and MA-UY 2034.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2813 Astronomy and Astrophysics (3 Credits)***Typically offered Spring*

This course covers historical development of observational astronomy. Traditional and modern observational techniques. Theories of formation and evolution of stars, planets and galaxies. Current developments in astronomy, cosmology and astrophysics. | Prerequisites: PH-UY 2131 and PH-UY 2033.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 2823 GEOLOGY AND GEOPHYSICS (3 Credits)***Typically offered Fall*

An introduction to physical geology, familiarizing students with basic geological processes, and emphasizing the interdisciplinary interactions involved. | Prerequisites: PH-UY 1013

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3002 JUNIOR PHYSICS LABORATORY (2 Credits)***Typically offered Spring*

An intermediate level laboratory course providing in depth exposure to a selection of classic physics experiments. Students' experimental skill set is expanded and data analysis and communication skills developed. | Prerequisites: PH-UY 2131 and PH-UY 2033; Co-requisites: PH-UY 2344 and MA-UY 2224.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3054 Introduction to Polymer Physics (4 Credits)***Typically offered Spring*

This course introduces polymer physics and its applications in engineering. The course includes polymer assemblies, morphology and motion, mechanical and dielectric response, transitions and relaxations, time-temperature equivalence, yield and fracture, conducting polymers, optics of polymers, oriented structures, nanofibers, composites. | Prerequisite: PH-UY 1013 and CM-UY1004 (or CM-UY 1014); Co-requisite: PH-UY 2023.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3103 Fundamentals of Applied Nuclear Physics (3 Credits)***Typically offered Fall and Spring*

This course surveys the fundamentals of nuclear physics with application to nuclear engineering. Topics include an introduction to quantum mechanics, nuclear forces and nuclear structure, nuclear stability and reactions, natural and induced radioactivity. | Prerequisites: PH-UY 2023

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3234 Electricity and Magnetism (4 Credits)***Typically offered Spring*

The course covers properties of the electrostatic, magnetostatic and electromagnetic field in vacuum and in material media. Maxwell's equations with applications to elementary problems. | Prerequisites: PH-UY 2033 and MA-UY 2114.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3244 Concepts of Nanotechnology (4 Credits)***Typically offered not typically offered*

This course is the first of an interdisciplinary, two-semester sequence on concepts, techniques and applications of nanotechnology. Introduction to nanotechnology, examples of nanoscale systems. Systematics in miniaturization from the mm to the nm scale. Limits to miniaturization. Quantum concepts and elementary Schrodinger theory. Quantum effects in the behavior of chemical matter. Examples of self-assembled nanosystems from nature and from contemporary industrial products. | Prerequisite: PH-UY 2004 or PH-UY 2033.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No

**Prerequisites:** (PH-UY 2004 with a Minimum Grade of D OR PH-UY 2004H with a Minimum Grade of D OR PH-UY 2033 with a Minimum Grade of D OR PH-UY 2033H with a Minimum Grade of D).

**PH-UY 3424 Light and Lighting (4 Credits)***Typically offered not typically offered*

The course explores physical concepts in conversion of electric energy into visible light. Nature of light. Visualization of light. Principles of operation and characteristics of modern light sources. Incandescent and tungsten halogen lamps. Fluorescent mercury lamps. Low-pressure sodium lamps. High intensity discharge (HID) lamps. Solid-state light sources. Latest trends in lighting technology. (Crosslisted as EE-UY 3424.) | Prerequisites: CM-UY 1004, and PH-UY 2033 or PH-UY 2004.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No

**Prerequisites:** (PH-UY 2004 with a Minimum Grade of D OR PH-UY 2033 with a Minimum Grade of D OR PH-UY 2033H with a Minimum Grade of D) AND CM-UY 1003 with a Minimum Grade of D.

**PH-UY 3474 Introduction to Modern Optics and Photonics (4 Credits)***Typically offered Spring*

This course covers the physics of optics using both classical and semi-classical descriptions. The classical and quantum interactions of light with matter. Diffraction of waves and wave packets by obstacles. Fourier transform optics, holography, Fourier transform spectroscopy. Coherence and quantum aspects of light. Geometrical optics. Matrix optics. Crystal optics. Introduction to electro-optics and nonlinear optics. | Prerequisites: PH-UY 2033.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3503 Introduction to Radiation Physics and Dosimetry (3 Credits)***Typically offered Fall*

The course examines the basic theory and practice of Radiation and Health Physics. Atomic and nuclear radiation. X-ray and gamma radiation. Interaction of radiation with matter, and the effects on living tissue. Principles of radiation detection, radiation measurement, external and internal dosimetry. Radiation Protection. | Prerequisite: PH-UY 2023.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 2023.



**PH-UY 3513 NUCLEAR AND RADIATION INSTRUMENTATION AND METHODS (3 Credits)***Typically offered Fall*

An intermediate level undergraduate course focusing on the theory and practice of nuclear and radiation measurements and instrumentation. Detector properties and principles, pulse electronics and counting statistics will be discussed in detail in the lecture classes. The experiments will illustrate the lecture topics and compliment the companion theory courses. This course meets five hours per week. | Prerequisite: PH-UY 3103; Co-requisite: PH-UY 3503.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 3103; Co-requisite: PH-UY 3503.**PH-UY 3604 MATHEMATICAL METHODS FOR PHYSICS AND ENGINEERING (4 Credits)***Typically offered Fall*

First course of two-semester lecture sequence in mathematical physics for undergraduate students in physics and engineering. Line, surface and volume integrals, gradient, divergence, and curl. Cylindrical and spherical coordinate systems. Tensors and tensor transformations. The Dirac delta function, and integrals and derivatives of the delta function. Functions of complex variables, analytic functions, and residue theorem. Fourier series, integrals, and transforms. | Prerequisites: PH-UY 2023 and MA-UY 2114; Co-requisites: PH-UY 2033 and (MA-UY 2034 or MA-UY 3044 or MA-UY 3054).

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3613 Mathematical Foundations for Quantum Computing (3 Credits)***Typically offered Fall*

This course provides a rigorous mathematical foundation tailored to support advanced studies in quantum computing. It is designed to bridge the gap between general mathematics education and the specialized mathematical understanding required for in-depth quantum computing work. Topics covered are linear algebra, probability and statistics, differential equations, fourier transforms, complex analysis, and discrete mathematics. | Prerequisites: MA-UY 1124 and PH-UY 2002

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3614 COMPUTATIONAL PHYSICS (4 Credits)***Typically offered Spring term of odd numbered years*

An introduction to numerical methods. Solving ordinary differential equations, root finding, fourier transforms, numerical integration, linear systems. Techniques are applied to projectile motion, oscillatory motion, planetary motion, potentials and fields, waves and quantum mechanics. This class meets four hours per week for lectures | Prerequisites: PH-UY 2033, CS-UY 1133 (or CS-UY 1114), and MA-UY 1124.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3703 MATHEMATICAL PHYSICS II (3 Credits)***Typically offered Spring term of even numbered years*

Second course of two-semester lecture sequence in mathematical physics for undergraduate students in physics and engineering. Review of ordinary differential equations, including first and second order linear equations. Series solutions of differential equations, involving Legendre polynomials, Bessel functions, Hermite functions, and Laguerre functions. Partial differential equations, including Laplace's equation, the diffusion equation, the wave equation, and Poisson's equation. Integral transforms, including Laplace and Fourier Transforms, convolution, and Green functions. | Prerequisites: PH-UY 2033 and PH-UY 3603.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3801 Guided Studies in Physics (1 Credit)***Typically offered Spring and Summer*

These guided studies courses in physics are supervised by staff member. | Prerequisites: Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3802 Guided Studies in Physics (2 Credits)***Typically offered Spring and Summer*

These guided studies courses in physics are supervised by staff member. | Prerequisites: Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3803 Guided Studies in Physics (3 Credits)***Typically offered Spring and Summer*

These guided studies courses in physics are supervised by staff member. | Prerequisites: Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** Yes**PH-UY 3804 Guided Studies in Physics (4 Credits)***Typically offered Spring and Summer*

These guided studies courses in physics are supervised by staff member. | Prerequisites: Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3812 READING COURSE IN INTERDISCIPLINARY PHYSICS (2 Credits)***Typically offered Fall*

Special topics in interdisciplinary physics supervised by staff member. Prerequisites: PH-UY 2344, must be an interdisciplinary physics major.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 3814 READING COURSE IN INTERDISCIPLINARY PHYSICS (4 Credits)***Typically offered Fall*

Special topics in interdisciplinary physics supervised by staff member. Prerequisites: PH-UY 2344, must be an interdisciplinary physics major.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No

**PH-UY 4124 Thermodynamics and Statistical Physics (4 Credits)***Typically offered Spring*

The course covers fundamental laws of macroscopic thermodynamics, heat, internal energy and entropy. Topics include an introduction to statistical physics, and applications of Maxwell, Fermi-Dirac and Bose-Einstein distributions. | Prerequisites: PH-UY 2344, MA-UY 2114, and MA-UY 2224.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 4244 Techniques and Applications of Nanotechnology (4 Credits)***Typically offered not typically offered*

This is the second of a two-course sequence on concepts and techniques of nanotechnology. Novel function and performance can occur with materials or devices of size scales of one to 100 nanometers, a range extending from molecular scale to that of typical linewidths in contemporary microelectronics. Nanosystems may provide entirely new functions, by virtue of access enabled by the small size. Photo and x-ray lithographic patterning. Scanning probe microscopes for observation and for fabrication. Molecular machines as envisioned by Drexler. The role of Van der Waals force. Questions of machine manufacturability on the nm scale. The IBM GMR hard-drive read head. Micro- and nano-electromechanical devices and systems. Single-electron electronics. Molecular electronics. | Prerequisite: PH-UY 3244.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 3244 with a Minimum Grade of D.**PH-UY 4364 Introduction to the Quantum Theory (4 Credits)***Typically offered occasionally*

The course introduces quantitative introduction to the quantum theory, which describes understanding light, electrons, atoms, nuclei and solid matter. Superposition principle, expectation values, momentum operator and wave function, duality, current vector, Hermitian operators, angular momentum, solution of the radial equation, electron in a magnetic field, perturbation theory, WKB approximation, identical particles. Applications include alpha decay, electrons in a periodic lattice, hydrogen spectrum, helium atom, neutron-proton scattering, and quark model of baryons. | Prerequisites: PH-UY 2344, MA-UY 2114, and MA-UY 2224.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 4444 QUANTUM OPTICS (4 Credits)**

Beginning with a review of classical optics and quantum mechanics, this course covers foundations of spectroscopy, including atomic transition rates, selection rules and spectral line shapes. The course explores the quantum nature of light. Topics include photon statistics, coherent states, squeezed light, resonant light-atom interactions, atoms in cavities and laser cooling. | Prerequisite: PH-UY 3474.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**Prerequisites:** PH-UY 3474 with a Minimum Grade of D.**PH-UY 4553 Introduction to the Physics of Quantum Computing (3 Credits)***Typically offered Fall*

This course aims to introduce undergraduate students to the foundational principles of quantum computation and quantum information processing. Topics covered are Hilbert space, Bloch vector, unitary and Hermitian operators, quantum measurement, electron spin, multi-qubit systems, quantum algorithms, and quantum error correction. | Prerequisites: PH-UY 3613

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 4554 SOLID STATE PHYSICS (4 Credits)***Typically offered not typically offered*

The course covers basic concepts in condensed matter physics and preparation for the advanced quantum theory of solid state. | Prerequisites: PH-UY 2344, MA-UY 2114, and MA-UY 2224.

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** No**PH-UY 4601 SPECIAL TOPICS IN PHYSICS (1 Credit)**

Variable credit special topics courses in physics. | Prerequisites: PH 2344 and Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** Yes**PH-UY 4602 SPECIAL TOPICS IN PHYSICS (2 Credits)***Typically offered not typically offered*

Variable credit special topics courses in physics. | Prerequisites: PH 2344 and Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** Yes**PH-UY 4603 Special Topics in Physics (3 Credits)***Typically offered occasionally*

Variable credit special topics courses in physics. | Prerequisites: CS-UY 1133 and Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** Yes**PH-UY 4604 SPECIAL TOPICS IN PHYSICS (4 Credits)**

Variable credit special topics courses in physics. | Prerequisites: PH-UY 2344 and Physics adviser approval. (Course may be repeated for additional credit.)

**Grading:** Ugrd Tandon Graded**Repeatable for additional credit:** Yes**PH-UY 4902 Introduction to Senior Project in Physics (2 Credits)***Typically offered Fall, Spring, and Summer terms*

A qualified senior physics student or group of students work with a faculty member (and possibly graduate students) on an advanced problem in physics. In this introductory phase the student(s) and adviser select a suitable theoretical or experimental problem in the subject area and use various resources to solve it.

**Grading:** Satisfactory/Unsatisfactory**Repeatable for additional credit:** No

**PH-UY 4904 Senior Project in Physics (4 Credits)**

*Typically offered occasionally*

In the project's concluding phase, senior physics students or group of students work with a faculty member (and possibly graduate students) to solve an advanced problem in interdisciplinary physics. The conclusion of the project is a written report and an oral presentation made to the supervising faculty. | Prerequisite: PH-UY 4902

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

**Prerequisites:** PH-UY 4902.

**PH-UY 4912 Senior Seminar in Physics (2 Credits)**

*Typically offered Fall and Spring*

Senior physics students, in consultation with the instructor, study and prepare presentations on several current research topics in the general area of interdisciplinary physics. Students' performance is based on the mastery of the material chosen and also on the quality of the presentation made to the instructor and the seminar members.

**Grading:** Ugrd Tandon Graded

**Repeatable for additional credit:** No

**PH-UY 4994 Bachelor's Thesis in Physics (4 Credits)**

*Typically offered Fall and Spring*

Cannot receive credits for both PH-UY 4904 and PH-UY 4994.

**Grading:** Satisfactory/Unsatisfactory

**Repeatable for additional credit:** Yes