

PHYSICS

Robert A. Pritzker Science Center, Room 182
 3101 S. Dearborn St.
 Chicago, IL 60616
 312.567.3579
 kersh@iit.edu
 science.iit.edu/physics

Chair

Grant Bunker

Associate Chair

Sally Laurent-Muehleisen

Faculty with Research Interests

For information regarding faculty visit the Department of Physics website.

The undergraduate physics programs at the Illinois Institute of Technology provide an excellent foundation for a number of professions including research, teaching, law (patent and intellectual property), health (radiation) physics, business, and technical management. Graduates are prepared for immediate entry into positions in industrial, government, and small business/venture research laboratories, and for graduate study in areas such as biophysics, condensed matter, high energy, accelerator, astrophysics, or computational physics. Many undergraduates go on to obtain graduate degrees, not only in physics, but in related natural sciences, engineering disciplines, health sciences, or computer science.

A student completing a Bachelor of Science (B.S.) degree in one of the physics programs will:

- Develop exceptional problem-solving ability
- Gain experience with experimental techniques, instrumentation, and measurement processes
- Develop mathematical, computational, and data analytical skills
- Gain a wide knowledge of fundamental physics as it applies both to the everyday world and to understanding nature's secrets

Degree Programs

- Bachelor of Science in Applied Physics
- Bachelor of Science in Astrophysics
- Bachelor of Science in Physics

Co-Terminal Options

The Department of Physics also offers the following co-terminal degrees, which enables a student to simultaneously complete both an undergraduate and graduate degree in as few as five years:

- Bachelor of Science in Physics/Master of Science in Physics
- Bachelor of Science in Physics/Master of Health Physics
- Bachelor of Science in Physics/Master of Computer Science
- Bachelor of Science in Physics/Master of Science in Computer Science

These co-terminal degrees allow students to gain greater knowledge in specialized areas while, in most cases, completing a smaller number of credit hours with increased scheduling flexibility. For more information, please visit the Department of Physics website (science.iit.edu/physics).

Co-Terminal Bachelor of Science in Physics/Master of Health Physics Degree Program

Illinois Institute of Technology offers a five-year, co-terminal Bachelor of Science in Physics/Master of Health Physics degree program for students who wish to combine a Bachelor of Science in Physics degree with a professional-track Master of Health Physics degree leading to a career as a radiation health physicist. This program is designed for students seeking careers in government, industry, the military, and environmental and health-related fields where radiation protection and planning are critical.

The Nuclear Regulatory Commission, the Department of Energy, and the Health Physics Society (HPS) have all foreseen a significant need for new radiation health physicists. According to the HPS, "A projected shortfall in sufficiently educated radiation safety professionals

has placed a burden on industries using radiation to support our nation's energy, security, and health needs." The current workforce in government and industry is aging and those positions need to be filled.

The unique opportunity to take classes online, as well as on campus, sets Illinois Institute of Technology apart from other health physics programs. Illinois Tech is one of only a handful of universities that offer this five-year, co-terminal opportunity and at Illinois Tech, faculty help students find an appropriate health physics internship.

Minors

- Minor in Astrophysics
- Minor in Physics

Course Descriptions

PHYS 100

Intro to the Profession

Introduction to the physical sciences, scientific method, computing tools, and interrelations of physical sciences with chemistry, biology and other professions.

Lecture: 2 Lab: 0 Credits: 2

Satisfies: Communications (C)

PHYS 120

Astronomy

A descriptive survey of observational astronomy, the solar system, stellar evolution, pulsars, black holes, galaxies, quasars, the origin and fate of the universe.

Lecture: 3 Lab: 0 Credits: 3

PHYS 123

General Physics I: Mechanics

Vectors and motion in one, two and three dimensions. Newton's Laws. Particle dynamics, work and energy. Conservation laws and collisions. Rotational kinematics and dynamics, angular momentum and equilibrium of rigid bodies. Gravitation. Oscillations.

Prerequisite(s): MATH 151*, An asterisk (*) designates a course which may be taken concurrently.

Lecture: 3 Lab: 3 Credits: 4

Satisfies: Communications (C)

PHYS 200

Introduction to Energy, Waves, Materials, and Forces

This course will address the basic physical principles and concepts associated with energy, power, heat, light, sound, circuits, materials, fluids, and forces. Although quantitative at times, the course will stress conceptual understanding and practical applications.

Lecture: 4 Lab: 0 Credits: 4

Satisfies: Natural Science (N)

PHYS 221

General Physics II: Electricity and Magnetism

Waves charge, electric field, Gauss' Law and potential. Capacitance, resistance, simple a/c and d/c circuits. Magnetic fields, Ampere's Law, Faraday's Law, induction, and Maxwell's equations. Traveling waves, electromagnetic waves, and light.

Prerequisite(s): (MATH 149 or MATH 151) and MATH 152* and PHYS 123, An asterisk (*) designates a course which may be taken concurrently.

Lecture: 3 Lab: 3 Credits: 4

Satisfies: Communications (C)

PHYS 223

General Physics III

Sound, fluid mechanics and elasticity. Temperature, first and second laws of thermodynamics, kinetic theory and entropy. Reflection, refraction, interference and diffraction. Special relativity. Quantization of light, charge and energy.

Prerequisite(s): PHYS 221

Lecture: 3 Lab: 3 Credits: 4

Satisfies: Communications (C)

PHYS 224

General Physics III for Engineers

Sound and fluid mechanics. Temperature, first and second laws of thermodynamics, kinetic theory and entropy. Reflection, refraction, interference and diffraction. Special relativity. Light and quantum physics, structure of the hydrogen atom. Atomic physics, electrical conduction in solids, nuclear physics, particle physics and cosmology.

Prerequisite(s): PHYS 123 and MATH 152 and PHYS 221

Lecture: 3 Lab: 0 Credits: 3

PHYS 240

Computational Science

This course provides an overview of introductory general physics in a computer laboratory setting. Euler-Newton method for solving differential equations, the trapezoidal rule for numerical quadrature and simple applications of random number generators. Computational projects include the study of periodic and chaotic motion, the motion of falling bodies and projectiles with air resistance, conservation of energy in mechanical and electrical systems, satellite motion, using random numbers to simulate radioactivity, the Monte Carlo method, and classical physical models for the hydrogen molecule and the helium atom.

Prerequisite(s): PHYS 221 and (CS 104 or CS 105 or CS 115)

Lecture: 2 Lab: 3 Credits: 3

Satisfies: Communications (C)

PHYS 300

Instrumentation Laboratory

Basic electronic skills for scientific research. Electrical measurements, basic circuit analysis, diode and transistor circuits. Transistor and integrated amplifiers, filters, and power circuits. Basics of digital circuits, including Boolean algebra and design of logic circuits.

Prerequisite(s): PHYS 221

Lecture: 2 Lab: 4 Credits: 4

Satisfies: Communications (C)

PHYS 301**Mathematical Methods of Physics**

Real and complex numbers and their properties. Vectors, matrices, eigenvalues, eigenvectors, diagonalization of matrices and quadratic forms, and applications. Fourier series, integrals, and transform. Basic probability. Orthogonal polynomials and special functions. Partial differential equations and separation of variables method. Calculus of complex variables.

Prerequisite(s): MATH 252 and MATH 251

Lecture: 3 Lab: 0 Credits: 3

PHYS 304**Thermodynamics and Statistical Physics**

Statistical basis of thermodynamics, including kinetic theory, fundamentals of statistical mechanics, fluctuations and noise, transport phenomena and the Boltzmann equation. Thermodynamic functions and their applications, first and second laws of thermodynamics.

Prerequisite(s): PHYS 223 or PHYS 224

Lecture: 3 Lab: 0 Credits: 3

PHYS 308**Classical Mechanics I**

Newton's Laws, one-dimensional motion, vector methods, kinematics, dynamics, conservation laws, and the Kepler problem. Collisions, systems of particles, and rigid-body motion. Approximation techniques, Lagrangian and Hamiltonian formulations of classical mechanics, small oscillations.

Prerequisite(s): MATH 252 and (PHYS 223 or PHYS 224)

Lecture: 3 Lab: 0 Credits: 3

PHYS 309**Classical Mechanics II**

Newton's Laws, one dimensional motion, vector methods, kinematics, dynamics, conservation laws, and the Kepler problem. Collisions, systems of particles, and rigid-body motion. Approximation technique, Lagrangian and Hamiltonian formulations of classical mechanics, small oscillations.

Prerequisite(s): MATH 252 and (PHYS 223 or PHYS 224) and PHYS 308

Lecture: 3 Lab: 0 Credits: 3

PHYS 348**Modern Physics for Scientists and Engineers**

An introduction to modern physics with the emphasis on the basic concepts that can be treated with elementary mathematics. Subjects covered include Bohr atom, elementary wave mechanics and an introduction to quantum mechanics, atom and molecular spectra, nuclear, and particle physics.

Prerequisite(s): PHYS 223

Lecture: 3 Lab: 0 Credits: 3

PHYS 360**Introduction to Astrophysics**

This course provides an overview of astrophysics and introduces the student to the many conventions, units, coordinate systems, and nomenclature used in astrophysics. The course will survey observational, stellar, and extragalactic astrophysics as well as cosmology. The course will also include planetary astronomy including extrasolar planets.

Prerequisite(s): PHYS 221 and (CHEM 122 or CHEM 124)

Lecture: 3 Lab: 0 Credits: 3

Satisfies: Natural Science (N)

PHYS 361**Observational Astrophysics**

This lecture/lab class covers the basics of multiwavelength observational astrophysics. Topics covered include statistical analysis techniques, multi-wavelength telescope design, instrument design (including CCDs, spectrographs and PMTs), and best practices applicable in different observational bands.

Prerequisite(s): PHYS 221 and PHYS 360 and (CHEM 122 or CHEM 124)

Lecture: 3 Lab: 1 Credits: 4

Satisfies: Natural Science (N)

PHYS 403**Relativity**

Introduction to the special and general theories of relativity. Lorentz covariance. Minkowski space. Maxwell's equations. Relativistic mechanics. General coordinate covariance, differential geometry, Riemann tensor, the gravitational field equations. Schwarzschild solution, astronomical and experimental tests, relativistic cosmological models.

Prerequisite(s): PHYS 308 and MATH 251

Lecture: 3 Lab: 0 Credits: 3

PHYS 404**Subatomic Physics**

Historical introduction; general survey of nuclear and elementary particle physics; symmetries and conservation laws; leptons, quarks, and vector bosons; unified electromagnetic and weak interactions; the parton model and quantum chromodynamics.

Prerequisite(s): PHYS 348

Lecture: 3 Lab: 0 Credits: 3

PHYS 405**Fundamentals of Quantum Theory I**

A review of modern physics including topics such as blackbody radiation, the photoelectric effect, the Compton effect, the Bohr model of the hydrogen atom, the correspondence principle, and the DeBroglie hypothesis. Topics in one-dimensional quantum mechanics such as the particle in an infinite potential well, reflection and transmission from potential wells, barriers, and steps, the finite potential well and the quantum harmonic oscillator. General topics such as raising and lowering operators, Hermitian operators, commutator brackets and the Heisenberg Uncertainty Principle are also covered. Many particle systems and the Pauli Exclusion Principle are discussed. Three-dimensional quantum mechanical systems, orbital angular momentum, the hydrogen atom.

Prerequisite(s): PHYS 348 and MATH 252

Lecture: 3 Lab: 0 Credits: 3

PHYS 406**Fundamentals of Quantum Theory II**

Zeeman and Stark Effects. Addition of spin and orbital angular momenta, the matrix representation of quantum mechanical operators, the physics of spin precession and nuclear magnetic resonance. Time independent and time dependent perturbation theory, Fermi's Golden Rule and the physics of radiation emitted in the course of atomic transitions. Indistinguishable particles in quantum mechanics, the helium atom. Scattering theory, using partial wave analysis and the Born approximation.

Prerequisite(s): PHYS 405

Lecture: 3 Lab: 0 Credits: 3

PHYS 410**Molecular Biophysics**

The course covers thermodynamic properties of biological molecules, irreversible and open systems, information theory, biophysical measurements, the structure and properties of proteins, enzyme action, the structure and properties of nucleic acids, genetics at the molecular level, and molecular aspects of important biological systems.

Prerequisite(s): CHEM 343 or PHYS 348

Lecture: 3 Lab: 0 Credits: 3

PHYS 412**Modern Optics and Lasers**

Geometrical and physical optics. Interference, diffraction, and polarization. Coherence and holography. Light emission and absorption. Principles of laser action, characterization of lasers, and laser applications.

Prerequisite(s): PHYS 348 and CS 105

Lecture: 3 Lab: 0 Credits: 3

PHYS 413**Electromagnetism I**

Differentiation and integration of vector fields, and electrostatics and magnetostatics. Calculation of capacitance, resistance, and inductance in various geometries.

Prerequisite(s): PHYS 221 and MATH 252

Lecture: 3 Lab: 0 Credits: 3

PHYS 414**Electromagnetism II**

Propagation and generation of electromagnetic radiation. Antennas and waveguides. Maxwell's equations. Electromagnetic properties of materials. Classical electrodynamics; special relativity.

Prerequisite(s): PHYS 413

Lecture: 3 Lab: 0 Credits: 3

PHYS 415**Solid State Electronics**

Energy bands and carrier transport in semi-conductors and metals. Physical principles of p-n junction devices, bipolar junction transistors, FETS, Gunn diodes, IMPATT devices, light-emitting diodes, semiconductor lasers.

Prerequisite(s): PHYS 348

Lecture: 3 Lab: 0 Credits: 3

PHYS 418**Introduction to Lasers**

Nature of light. Coherence and holography. Light emission and absorption. Principles of laser action. Characteristics of gas lasers, organic dye lasers, solid state lasers. Laser applications.

Prerequisite(s): PHYS 348

Lecture: 3 Lab: 0 Credits: 3

PHYS 420**Bio-Nanotechnology**

In this multidisciplinary course, we will examine the basic science behind nanotechnology and how it has infused itself into areas of nanofabrication, biomaterials, and molecular medicine. This course will cover materials considered basic building blocks of nanodevices such as organic molecules, carbon nanotubes, and quantum dots. Top-down and bottom-up assembly processes such as thin film patterning through advanced lithography methods, self-assembly of molecular structures, and biological systems will be discussed. Students will also learn how bionanotechnology applies to modern medicine, including diagnostics and imaging and nanoscale, as well as targeted, nanotherapy and finally nanosurgery.

Prerequisite(s): PHYS 348

Lecture: 3 Lab: 0 Credits: 3

PHYS 425**High Energy Astrophysics**

High-energy astrophysics covers interactions in the most extreme physical conditions across the cosmos. Included in this course are the physics of black holes, neutron stars, large scale jets, accretion, shocks, and particle acceleration. Emission mechanisms resulting from relativistic particle acceleration are covered including synchrotron radiation and Bremsstrahlung and Compton processes. Recent observations of X-ray to TeV gamma-ray energies have contributed significantly to understanding these phenomena and will be highlighted.

Prerequisite(s): PHYS 348 and MATH 251 and MATH 252

Lecture: 3 Lab: 0 Credits: 3

PHYS 427**Advanced Physics Laboratory I**

Experiments related to our present understanding of the physical world. Emphasis is on quantum phenomena in atomic, molecular, and condensed matter physics, along with the techniques of measurement and data analysis. The second semester stresses project-oriented experiments on modern topics including spectroscopy, condensed matter physics, and nuclear physics.

Prerequisite(s): PHYS 348

Lecture: 3 Lab: 2 Credits: 3

Satisfies: Communications (C)

PHYS 428**Advanced Physics Laboratory II**

Experiments related to our present understanding of the physical world. Emphasis is on quantum phenomena in atomic, molecular, and condensed matter physics, along with the techniques of measurement and data analysis. The second semester stresses project-oriented experiments on modern topics including spectroscopy, condensed matter physics and nuclear physics.

Prerequisite(s): PHYS 348

Lecture: 2 Lab: 3 Credits: 3

PHYS 437**Solid State Physics**

Crystal structure and binding, lattice vibrations, phonons, free electron model, band theory of electrons. Electrical, thermal, optical, and magnetic properties of solids. Superconductivity.

Prerequisite(s): PHYS 348

Lecture: 3 Lab: 0 Credits: 3

PHYS 440**Computational Physics**

Root finding using the Newton-Raphson method; interpolation using Cubic Splines and Least Square Fitting; solving ordinary differential equations using Runge-Kutta and partial differential equations using Finite Difference and Finite Element techniques; numerical quadrature using Simpson's Rule, Gaussian Quadrature and the Monte Carlo method; and spectral analysis using Fast Fourier Transforms. These techniques are applied to a wide range of physics problems such as finding the energy levels of a finite quantum well using a root finding technique, solving the Schrodinger equation using the Runge-Kutta-Fehlberg method, using random numbers to simulate stochastic processes such as a random walk, using the Fast Fourier Transform method to perform a spectral analysis on non-linear chaotic systems such as the Duffing oscillator, and using auto-correlation functions to simulate sonar or radar ranging problems.

Prerequisite(s): PHYS 240 and PHYS 348

Lecture: 1 Lab: 4 Credits: 3

PHYS 460**Stellar Astrophysics**

This course will cover the formation, structure, and evolution of stars. Stellar remnants (white dwarfs, neutron stars, and black holes) will also be covered. Aspects of the interstellar medium relevant to star formation will be covered as well.

Prerequisite(s): PHYS 360

Lecture: 3 Lab: 0 Credits: 3

PHYS 461**Extragalactic Astrophysics**

This course will cover galaxy morphology, dynamics, and structure. This course will also cover cosmology including dark matter, dark energy, and fate of the universe.

Prerequisite(s): PHYS 360

Lecture: 3 Lab: 0 Credits: 3

PHYS 465**Electrical, Magnetic, and Optical Properties**

Electronic structure of solids, semiconductor devices, and their fabrication. Ferroelectric and piezoelectric materials. Magnetic properties, magnetocrystalline anisotropy, magnetic materials and devices. Optical properties and their applications, generation, and use of polarized light. Same as MMAE 465.

Lecture: 3 Lab: 0 Credits: 3

PHYS 485**Physics Colloquium**

Lectures by prominent scientists. This course exposes students to current and active research in physics both within and outside the IIT community. It helps prepare students for a career in research. It is complementary to our academic courses and provides examples of professional/scientific presentations. This course may not be used to satisfy the natural science general education requirement.

Prerequisite(s): PHYS 223 or PHYS 224

Lecture: 1 Lab: 0 Credits: 1

PHYS 491**Undergraduate Research**

Recommendation of advisor and approval of the department chair. Student participation in undergraduate research, usually during the junior or senior year.

Credit: Variable

PHYS 494**Research Project**

Special research and development projects in X-ray optics, instrumentation, X-ray techniques for industrial applications, mechanical and opto-mechanical design and instrumentation, and thermal management techniques and systems.

Credit: Variable

PHYS 497**Special Topics in Physics**

Special topics in physics.

Credit: Variable

PHYS 498**Research Honors Thesis Preparation**

Background and research following a summer research honors project, preparing to write a research honors thesis in Physics 499. Student will organize a review committee to direct and review the research.

Credit: Variable

PHYS 499**Research Honors Thesis**

Background and laboratory research and thesis writing following a summer research project and thesis preparation. The student will meet regularly with his or her committee during thesis preparation and will write and defend thesis.

Credit: Variable