PHYSICS

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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 225
General Physics III Lab only
General Physics III laboratory. The laboratory portion of PHYS 223.
Prerequisite(s): PHYS 224 and PHYS 221
Lecture: 0 **Lab:** 3 **Credits:** 1

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 297
Energy and Environmental Sustainability
With increases in world population and in per capita energy use, we must understand the fundamentals of energy production and the consequences of our energy use pattern. Avoiding serious problems both at the global level (acid rain, and global climate change) and at the local level (urban air and water pollution) requires an understanding of energy use pattern and its implication on human life. The overall objective of this course is to provide the student with an understanding of the costs and benefits of the various methods for meeting society's energy needs. This course aims to deal with topics like energy demands and energy resources, production of non-renewable energy, nuclear energy, renewable energy sources (e.g., hydro, wind, solar, and bio -energy). After providing an in-depth understanding of the sources of energy and its efficient use, the course will teach how to reduce negative environmental impacts from energy production, conversion, and distribution. Since energy security is arguably the one of the biggest global challenges of the modern society, the course will conclude with a brief discussion on socioeconomic consequences and policy issues of energy use.
Lecture: 50 **Lab:** 0 **Credits:** 3

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): ((CHEM 122 and CHEM 123) or CHEM 124) and PHYS 221
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): ((CHEM 123 and CHEM 122) or CHEM 124) and (PHYS 360 and PHYS 221)
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) or Graduate standing
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 223 or Graduate standing) and PHYS 224
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): (MATH 252 or Graduate standing) and (PHYS 224 or PHYS 223)
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 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

PHYS 407
Introduction to Quantum Computing
An introductory course in quantum physics and quantum computing for non-physics majors suitable for upper division STEM majors and graduate students. Topics to be covered include quantum physics basics, types of physical qubit systems in current use, methods of qubit measurement, fault tolerance in quantum computing, and quantum algorithms including quantum teleportation, quantum cryptography, Deutch-Jozsa, Simon's, Bernstein-Vazirani, Grover, Shor, and quantum Fourier transforms. Course will include hands-on exercises with online quantum computing resources. Previous experience with linear algebra and complex numbers preferred.
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 224 or PHYS 223
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): (CS 105 or Graduate standing) and (PHYS 223 or PHYS 224)
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) or Graduate standing
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 223 or Graduate standing or PHYS 224
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 224 or Graduate standing or PHYS 223
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 patterrning 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 224 or Graduate standing or PHYS 223
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): ((MATH 252 and MATH 251) or Graduate standing) and (PHYS 224 or PHYS 223)
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 224 or Graduate standing or PHYS 223
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 427 or Graduate standing
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 405 or Graduate standing
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 or Graduate standing) and (PHYS 223 or PHYS 224)
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 or Graduate standing
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