The Applied Physics Program (https://www.appliedphysics.northwestern.edu/) is a joint program between the McCormick School of Engineering & Applied Science and the Weinberg College of Arts & Sciences, and spans the departments of Physics & Astronomy, Biomedical Engineering, Chemistry, Earth & Planetary Sciences, Electrical & Computer Engineering and Materials Science & Engineering. The program offers interdisciplinary PhD research opportunities for graduate students with a strong undergraduate background in Physics.

The Applied Physics Program is designed to allow students to complete their PhD studies in as little as five years. Students can complete the required courses during the first year, allowing them to fully focus their efforts on research starting as of the second year. Unlike programs based in a single department, Applied Physics students can take advantage of the scholarships, learning opportunities, and other resources offered by both the McCormick School of Engineering, the Weinberg College of Arts & Sciences, and nearby Argonne National Laboratory and Fermi National Accelerator Laboratory.

The program prepares graduates for professional careers in science and technology, either in academics or in industry, and seeks to ensure that our graduates recognize and take advantage of scientific and technological opportunities wherever they may arise.

Additional resources:

- Program website (https://www.appliedphysics.northwestern.edu/)
- Program handbook(s) (https://northwestern.box.com/s/1carg2kbt6jg3h294x5qp4af8rneuge/)

Degrees Offered:

- Applied Physics PhD (https://catalogs.northwestern.edu/tgs/applied-physics/applied-physics-phd/)

Applied Physics Course Descriptions

APP_PHYS 499-0 Independent Study (1-3 Units)
See Dept for section number - May be repeated for credit. Permission of instructor required.

APP_PHYS 590-0 Research (1-3 Units)
See Dept for section number - Independent investigation of selected problems pertaining to thesis or dissertation. May be repeated for credit.

Computational Methods of Applied Physics

CHEM 448-0 Computational Chemistry (1 Unit)
The theory and application of molecular electronic structure methods, techniques for determining vibrational eigenfunctions and scattering properties, and molecular mechanics, molecular mechanics and Monte Carlo calculations. Included are extensive applications to chemical problems using Unix workstations.

CHEM_ENG 451-0 Applied Molecular Modeling (1 Unit)
Introduction to modern computational methods for calculating properties of reaction systems, as well as thermodynamics, transport, and structural properties of materials.

CHEM_ENG 458-0 Atomic Scale Computational Materials Science (1 Unit)
Theory and application of atomic-scale computational materials tools to model, understand, and predict the properties of real materials.

MECH_ENG 417-0 Multi-scale Modeling and Simulation in Solid Mechanics (1 Unit)
Introduction to modern computational methods such as molecular dynamics and continuum mechanics. Applications will be nanostructure and polymer composites.

MECH_ENG 418-0 Multi-Scale Modeling and Simulation in Fluid Mechanics (1 Unit)
Introduction to modern computational methods such as molecular dynamics and continuum mechanics. Applications will be Biological and bioinspired materials: Biopolymer, Protein, DNA, Lipids.

MECH_ENG 423-0 Intro to Computational Fluid Dynamics (1 Unit)
Discretization methods, solution of Navier-Stokes equations, algorithms for fluid flow problems (pressure-based algorithms, fractional time-stepping schemes, etc.), three-dimensional, steady, unsteady flows.

MECH_ENG 426-1 Advanced Finite Element Methods I (1 Unit)
Discretization methods, weak and strong forms, Newton methods for constrained and unconstrained problems, explicit methods, continuation methods. Prerequisite: MECH_ENG 327-0 or equivalent.

MECH_ENG 426-2 Advanced Finite Element Methods II (1 Unit)
Alternative mesh descriptions, Langrangian, Eulerian, and arbitrary Langrangian Eulerian, meshless methods and particle methods, continuum based shell formations, contract-impact. Prerequisite: MECH_ENG 426-1.

PHYSICS 430-0 Nonlinear Dynamics & Chaos (1 Unit)
This course covers the mathematics of nonlinear oscillations, fractal geometry, chaotic dynamics, the dynamics of complex systems, and physics applications of these ideas. Projects involving applications of nonlinear dynamics and chaos are integral to this course. Prerequisites: Undergraduate level classical mechanics and familiarity with computer programming.

PHYSICS 465-0 Advanced Topics in Nonlinear Dynamics (1 Unit)
Specialized lectures on current research topics in nonlinear dynamics.
PHYSICS 411-1 Methods of Theoretical Physics (1 Unit)
First quarter of a two-quarter class on Electrodynamics. Topics covered: Principles of Special Relativity and invariance. Relativistic electrodynamics as a classical field theory and action principles: for point particles, scalar fields, and vector fields, including Lagrangian formulation, principle of least action, symmetry principles, gauge invariance, the electromagnetic field tensor, covariant equations of electrodynamics and mechanics. Constant electromagnetic fields.

PHYSICS 412-1 Quantum Mechanics (1 Unit)
1. Vector spaces, linear operators, Hermitian operators, stationary states, bound states, harmonic oscillator, symmetry and conservation laws, intrinsic spin, Stern-Gerlach experiment, and spherically symmetric potentials. 2. Schrödinger’s equation, electromagnetic potentials, approximation methods, variational principles, Dirac’s theory of the electron, electron spin, magnetic moment of the electron, and fine structure of hydrogen. 3. Identical particles, exchange symmetry, atomic and molecular structure, coherent states, time-dependent perturbations, transition amplitudes, spontaneous emission, photoelectric effect, scattering theory, and light scattering.

PHYSICS 412-2 Quantum Mechanics (1 Unit)
1. Vector spaces, linear operators, Hermitian operators, stationary states, bound states, harmonic oscillator, symmetry and conservation laws, intrinsic spin, Stern-Gerlach experiment, and spherically symmetric potentials. 2. Schrödinger’s equation, electromagnetic potentials, approximation methods, variational principles, Dirac’s theory of the electron, electron spin, magnetic moment of the electron, and fine structure of hydrogen. 3. Identical particles, exchange symmetry, atomic and molecular structure, coherent states, time-dependent perturbations, transition amplitudes, spontaneous emission, photoelectric effect, scattering theory, and light scattering.

PHYSICS 414-1 Electrodynamics (1 Unit)
First quarter of a two-quarter class on Electrodynamics. Topics covered: Principles of Special Relativity and invariance. Relativistic electrodynamics as a classical field theory and action principles: for point particles, scalar fields, and vector fields, including Lagrangian formulation, principle of least action, symmetry principles, gauge invariance, the electromagnetic field tensor, covariant equations of electrodynamics and mechanics. Constant electromagnetic fields.

PHYSICS 422-1 Condensed-Matter Physics (1 Unit)
1. Periodic potentials, x-ray diffraction; electrons in metals: semiclassical approximation, Fermi surface, and band structure; electronic, electrical, and thermal transport; Boltzmann equation; electron-electron interactions. 2. Phonons: classical and quantum theory; electron-phonon interaction and scattering; optical properties of solids; intrinsic and extrinsic semiconductors; heterostructures and quantum Hall effect. 3. In-depth treatment of selected topics, such as diamagnetism, paramagnetism, ferromagnetism, and formation of local moments. Phenomenological theory of superconductivity, transport and magnetic properties of superconductors, and superconducting devices.

GEN_ENG 519-0 Responsible Conduct for Research Training (0 Unit)
The primary focus of this course will be on education in the responsible conduct of research (RCR), especially as it pertains to the engineering disciplines. Ethical and moral reasoning will be developed through analysis of case studies on the topics of conflict of interest, mentoring and lab management, collaborative research, data ownership and management, peer review, authorship, misconduct and the processes for handling misconduct.

PHYSICS 519-0 Responsible Conduct of Research Training (0 Unit)
CHEM 519-0 Responsible Conduct of Research Training (0 Unit)