PHYSICS

Department Overview

Physicists study the properties and behavior of matter and energy in a wide variety of contexts, ranging from the sub-microscopic particles from which all ordinary matter is made (particle physics) to the behavior of the Universe as a whole (cosmology). Physics primarily is the science that deals with exploring the Rules of Nature and the fundamental understanding of nature that comes from the study of physics is central to all the natural sciences, applied sciences and technology, and thus profoundly affects the life of every human along with his or her environment.

The Department of Physics of Saint Joseph's University offers students a comprehensive, challenging, and flexible curriculum in the discipline of physics. The program begins with a core grouping of courses (freshman and sophomore years) in the foundation of classical Newtonian mechanics and Maxwellian electricity and magnetism along with a two semester program in nonclassical (modern) physics, which provides the student with the development of physics ensuing from the development of quantum theory and special relativity that occurred in the first quarter of the twentieth century. Each of these courses is accompanied with a laboratory program, which not only complements the didactic material but also indoctrinates the student into the methodology of doing experimental physics. Also during this time the student is mastering the language of physics, which is mathematics. The student will take three semesters of calculus along with Mathematical Methods of Physics taught by the physics faculty. These physics and mathematics courses will provide the student with the necessary background to explore a vast array of upper division courses, which include opportunity for taking physics electives in particular areas of interest. The upper level palette of courses includes the study of advanced mechanics, classical and statistical thermodynamics, electricity and magnetism, quantum mechanics, and experimental methods of physics. Elective material includes solid state physics, biophysics, nuclear and particle physics, computational physics, and physics of fluids. advanced quantum mechanics.

The Department of Physics at Saint Joseph’s University has developed a research-oriented culture for both its faculty and students. It is expected that most students will experience some sort of research activity over their four-year development in the discipline of physics. The ability to put into practice what is learned in the classroom is paramount to the growth of the young scientist. In the research laboratory, the student will learn to ask appropriate questions, design and perform experiments to answer those questions, analyze data using computational methods, and draw appropriate conclusions. Students will also be exposed to the interfaces of physics where physics meets biology and chemistry and to that end, the student of physics will witness how the methods of physics are central to addressing key problems in the disciplines of biology and chemistry.

Undergraduates can participate in research in three different ways. They may decide to take research for academic credit. Within the major, students must take three physics electives and one or more of these may be used to perform scientific research under the guidance of our physics faculty. The student might opt to do research as a Summer Scholar. Saint Joseph’s University is well known for its 10-week Summer Scholars Research Program and students in physics, through the generosity of its alumni, Dean and Provost, have been able to provide stipends for all physics students who have wanted to do summer research. It should be noted here that students selected to participate in the Summer Scholars Program not only receive a stipend but also are provided low-cost housing by the University. Lastly, students may opt to volunteer in a laboratory at SJU or elsewhere.

Department Mission

At its core, the mission of the Department of Physics at Saint Joseph’s University is to educate students who are broadly trained in the discipline of physics and will have the ability to attack problems and enter professional areas not only in the field of physics per se but also in the areas of biology, chemistry, the applied sciences, and professional careers where the principles of physics and critical thinking skills associated with a degree in physics are used on a routine basis.

In the spirit of the mission of the university, we believe that our students, through the liberal arts training gleaned from the General Education Program, in particular the "ethical dimension in learning", in addition to the concentration curriculum in physics, will become lifelong learners and will use their knowledge and education for the betterment of mankind.

Physics in the GEP (See Curricula)

The GEP requires that all students take EITHER one semester of a lab-based natural science course (6 contact hours) OR two semesters of lecture-only natural science courses. Students who entered SJU in the fall of 2010 or later, or transfer students who entered SJU on the GEP curriculum and who wish to satisfy the natural science GEP by completing courses in Physics may do so by taking the first semester of the science majors, lab-based course sequence, PHY 101/PHY 101L or PHY 105/PHY 105L, or one of the lab-based, one-semester courses for non-science majors, as they become available. Alternatively, students may fulfill one or both semesters of the natural science GEP by completing one or two of the special one-semester lecture-only Physics courses designed for non-science majors listed below.

Non-science majors Physics GEP lecture-only courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHY 110</td>
<td>Understanding Natural World</td>
<td>3</td>
</tr>
<tr>
<td>PHY 111</td>
<td>The Astronomical Universe</td>
<td>3</td>
</tr>
<tr>
<td>PHY 112</td>
<td>Energy: Problems &amp; Promises</td>
<td>3</td>
</tr>
<tr>
<td>PHY 114</td>
<td>Tech Breakthroughs of 20th Cen</td>
<td>3</td>
</tr>
</tbody>
</table>

Non-science majors Physics GEP lab-based courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHY 113</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>PHY 115</td>
<td>Investigations in Astronomy</td>
<td>4</td>
</tr>
</tbody>
</table>

Five Year Combined B.S. in Physics/M.S. in Education Option

The Pennsylvania Department of Education requirements and program of study sequence for students under the GEP have not yet been finalized. This section of the catalog will be updated as soon as the requirements are in place. Students interested in the five year program should speak to their academic advisors and to Chair of the Department of Physics as early in their academic careers as possible.

Professor:  Piotr Habdas, Ph.D.
Associate:  Douglas A. Kurtze, Ph.D.; Paul J. Angiolillo, Ph.D.
Assistant:  Jesse M. Goldman
Lab Coordinator: Brian M. Forster, Ph.D.
Alexander D. Urban

Chair: Habdas

**Undergraduate Major**

- Physics (https://academiccatalog.sju.edu/arts-sciences/physics/bs-physics) Major (https://academiccatalog.sju.edu/arts-sciences/physics/bs-physics)

**Undergraduate Minor**

- Physics (https://academiccatalog.sju.edu/arts-sciences/physics/minor-physics)

**PHY 101 General Physics I (3 credits)**
This two-semester sequence is an algebra-based physics course intended primarily for students majoring in biological and health sciences. Emphasis is on understanding fundamental principles and applying them to the analysis of physical phenomena, with several applications that arise in biology. Topics include classical kinematics and dynamics, fluids, waves, optics, electricity and magnetism, and optics.

**PHY 102 General Physics II (3 credits)**
This two-semester sequence is an algebra-based physics course intended primarily for students majoring in biological and health sciences. Emphasis is on understanding fundamental principles and applying them to the analysis of physical phenomena, with several applications that arise in biology. Topics include classical kinematics and dynamics, fluids, waves, optics, electricity and magnetism, and optics.

**PHY 105 University Physics I (3 credits)**
This two-semester sequence is a calculus-based physics course intended primarily for students majoring in physics, chemistry, mathematics, or computer science. Emphasis is on developing both qualitative and quantitative understanding of fundamental physical principles, and the ability to apply those principles to analyze physical phenomena. Topics include classical kinematics and dynamics, electricity and magnetism, waves, and optics.

**PHY 106 University Physics II (3 credits)**
This two-semester sequence is a calculus-based physics course intended primarily for students majoring in physics, chemistry, mathematics, or computer science. Emphasis is on developing both qualitative and quantitative understanding of fundamental physical principles, and the ability to apply those principles to analyze physical phenomena. Topics include classical kinematics and dynamics, electricity and magnetism, waves, and optics.

**PHY 110 Understanding Natural World (3 credits)**
This course offers the non-science major an opportunity to explore how physics impacts everyday life. Topics will vary depending upon the interests of the class, but may include: the physics of sports, why musical instruments sound different from each other, rainbows and other optical phenomena, the physics of toys, Einstein's theory of relativity, and how a laser works. Although mathematics will not be the focus of the course, a working knowledge of algebra, geometry, and simple trigonometry is necessary. Emphasis is placed on developing critical thinking and scientific observation skills. Successful completion of this course satisfies one of the Natural Science requirements in the GEP.

**PHY 111 The Astronomical Universe (3 credits)**
In this course designed for the non-science major, the student is introduced to modern astronomical knowledge and theories. The planets, stars, and galaxies are investigated. Space exploration is discussed. Minimal mathematics is used and no previous science is required. Successful completion of this course satisfies one of the Natural Science requirements in the GEP.

**PHY 112 Energy: Problems & Promises (3 credits)**
The goal of this course is to teach the student how to read, analyze, and intelligently comment on news articles about energy and the environment. The physics is straightforward and requires no more than basic business mathematics. Topics include: fossil fuels, large scale renewables, small scale renewables, nuclear power, megawatt accounting for conservation, transportation, and emissions control. The course emphasizes how real data shapes economics and policy, so the exact content will vary with current events. Successful completion of this course satisfies one of the Natural Science requirements in the GEP.

**PHY 105L University Physics Lab I (1 credit)**
A two-semester laboratory sequence to accompany PHY 105-106.

**PHY 106L University Physics Lab II (1 credit)**
A two-semester laboratory sequence to accompany PHY 105-106.

**PHY 101L General Physics Laboratory I (1 credit)**
A two-semester laboratory sequence to accompany PHY 101-102.

**PHY 102L General Physics Laboratory II (1 credit)**
A two-semester laboratory sequence to accompany PHY 101-102.

**PHY 105L University Physics Lab I (1 credit)**
A two-semester laboratory sequence to accompany PHY 105-106.

**PHY 106L University Physics Lab II (1 credit)**
A two-semester laboratory sequence to accompany PHY 105-106.

**Attributes:** GEP Natural Science, Science Course w/Lab (Sci Maj), Undergraduate

**Restrictions:** Students cannot enroll who have a major in Biology, Chemistry, Chemical Biology, Environmental Science or Physics.
PHY 114 Tech Breakthroughs of 20th Cen (3 credits)
This course will explore a smorgasbord of major technological advances that occurred during the 20th century. Many of these developments occurred as a result of the historical, political, and economic factors that shaped much of the landscape of the previous century. The scientific achievements will be discussed in the historical context upon which they occurred paying particular emphasis on the interesting personalities that were responsible for many of the discoveries. Successful completion of this course satisfies one of the Natural Science requirements in the GEP:
Attributes: GEP Natural Science

PHY 115 Investigations in Astronomy (4 credits)
This course, designed for the non-science major, provides an introduction to the science of astronomy. Topics include the roles of observation, theory, philosophy, and technology in the development of the modern conception of the Universe. The Copernican Revolution, the birth and death of stars, our Milky Way galaxy, time, and our ancestral heritage in the cosmos will be discussed and explored. No previous science, nor mathematics beyond the level of high school algebra, is required. Successful completion of this course and lab satisfies the Natural Science requirement for students under the GEP:
Restrictions: Students cannot enroll who have a major in Biology, Chemistry, Chemical Biology, Environmental Science or Physics.
Attributes: GEP Natural Science, Science Course w/Lab (Sci Maj), Undergraduate

PHY 115L Investigations in Astro Lab (0 credits)

PHY 251 Modern Physics I (4 credits)
An analytical survey of the experiments, theories, and principles that led to the modern view of physical reality. Topics include: an introduction to special relativity theory, the dual nature of waves and particles, uncertainty relations, Bohr theory of hydrogen, fundamental aspects of quantum mechanics, the quantum theory of the hydrogen atom, and, if time permits, many-electron atoms.
Prerequisites: PHY 106
Attributes: Undergraduate

PHY 252 Modern Physics II (4 credits)
An extension of PHY 251 to include specific applications of the quantum theory. Topics include: structure and spectra of many-electron atoms and molecules, classical and quantum statistics, theory of solids, nuclear structure and dynamics, and an introduction to elementary particles.
Prerequisites: PHY 251
Attributes: Undergraduate

PHY 253 Survey of Nanotechnology (3 credits)
Nanotechnology embraces the disciplines of applied physics, materials science, supramolecular chemistry, and biological engineering to name a few. An overview of this highly interdisciplinary field will be given with a focus on the role of physics principles that guides this technology and on the new and exotic materials used.
Prerequisites: PHY 106
Attributes: Undergraduate

PHY 257 Math Methods in Physics (3 credits)
Advanced mathematical methods for physics: includes linear vector spaces, orthogonal functions, partial differential equations, complex variables, and transform techniques. Emphasis is on application of these mathematical techniques in solving problems in physics.
Prerequisites: PHY 106
Attributes: Undergraduate

PHY 301 Classical Mechanics (4 credits)
Newtonian particle dynamics is presented with special emphasis on damped and forced simple harmonic motion and central-force motion. Generalized coordinates are introduced, and both Lagrange’s formulation and Hamilton’s formulation of classical mechanics are developed.
Prerequisites: PHY 106
Attributes: Undergraduate

PHY 303 Thermal Physics (3 credits)
The laws of thermodynamics are introduced and studied in the classical manner and the statistical mechanical foundations of thermodynamics are developed, including quantum statistics.
Prerequisites: PHY 251
Attributes: Undergraduate

PHY 307 Electricity and Magnetism (4 credits)
The classical (non-quantum) theory of electric and magnetic fields and charge interactions is presented. The appropriate tools of vector analysis are developed as they are needed. The Maxwell equations in both differential and integral form are introduced.
Prerequisites: PHY 106 and PHY 257
Attributes: Undergraduate

PHY 308 Waves and Optics (4 credits)
The study of electromagnetic waves and their associated boundary-value problems. Other topics include a brief analysis of geometrical optics, and detailed study of interference, diffraction, and polarization phenomena associated with electromagnetic waves.
Prerequisites: PHY 106 and PHY 257
Attributes: Undergraduate

PHY 311 Experimental Methods of Phy I (3 credits)
Laboratory intensive with some lecture. A broad exposure to instrumentation and techniques of experimental physics. Focus on electromagnetism, electronics, optics, and fundamental ideas from modern physics. Emphasis placed on written and oral communication skills and team work. One four-hour laboratory meeting per week.
Prerequisites: PHY 251
Attributes: Undergraduate

PHY 312 Experimental Methods in Phy II (3 credits)
Extends the laboratory work begun in PHY 311. Focus on atomic, molecular, solid-state, and nuclear physics. Greater reliance on independent work by the student. One four-hour laboratory meeting per week.
Prerequisites: PHY 311
Attributes: Undergraduate

PHY 321 Quantum Mechanics I (4 credits)
The Schrodinger formulation of quantum theory is developed with its constructs of wave packets, differential operators, and eigenvalue equations. Special emphasis is given to the quantum theory of measurement. Applications include various one-dimensional problems, central potentials and angular momenta. The transition to the matrix formulation of quantum theory is developed.
Prerequisites: PHY 251 and MAT 213
Attributes: Undergraduate

PHY 390 Physics Seminar (0 credits)
Topics and agenda may include outside speakers, local speakers, and discussion of special topics in physics and related areas. Physics majors are required to attend each semester. Physics minors are also encouraged to attend. Graded on a P/NP basis.
Attributes: Undergraduate
PHY 401 Advanced Mechanics (3 credits)
This course will further develop the Lagrangian and Hamiltonian formulations of classical mechanics. Additional emphasis will be given to such topics as: collision theory, noninertial reference frames, nonlinear mechanics and chaos, continuum mechanics, and topics in special relativity.
Prerequisites: PHY 301
Attributes: Undergraduate

PHY 403 Quantum Mechanics II (3 credits)
A continuation of the development of quantum theory started in PHY 321. Topics to include: identical particles including fundamental molecular quantum theory, time-independent and time dependent perturbation theory, the WKB and adiabatic approximations, scattering, and an introduction to field theory.
Prerequisites: PHY 321
Attributes: Undergraduate

PHY 405 Solid State Physics (3 credits)
A study of matter in its solid state. Topics include crystal structure, electrical conduction in metals and semiconductors, dielectrics, magnetic materials, and superconductivity. Includes applications to solid-state devices.
Prerequisites: PHY 251 and PHY 257
Attributes: Undergraduate

PHY 407 Soft Condensed Matter Physics (3 credits)
This course will study the physics of materials such as fluids, liquid crystal, polymers (including biological polymers such as proteins and DNA), colloids, emulsions, foams, gels, and granular materials.
Prerequisites: PHY 251 and PHY 252 and PHY 257
Attributes: Undergraduate

PHY 409 Statistical Mechanics (3 credits)
Topics include ensembles and distribution functions, quantum statistics, Bose-Einstein and Fermi-Dirac statistics, and partition functions.
Prerequisites: PHY 251 and PHY 257
Attributes: Undergraduate

PHY 411 Nuclear Physics (3 credits)
The phenomena of natural and artificial radioactivity are investigated. Various models of nuclear structure are introduced and examined. Nuclear reactions are studied with emphasis upon fission and fusion. Some of the apparatus of nuclear physics, such as particle accelerators and radiation detection devices, are analyzed.
Prerequisites: PHY 251 and PHY 257
Attributes: Undergraduate

PHY 413 Materials of Electronics (3 credits)
This course will focus on the materials used to conduct electrical charge and spin and hence information from one region in space and time to another. Conduction processes in metals, traditional semiconductors, and in organic conducting and semi-conducting materials will be explored with a particular emphasis on the underlying physics principles employed.
Prerequisites: PHY 251 and PHY 252 and PHY 257
Attributes: Undergraduate

PHY 415 Computational Physics (3 credits)
Introduction to problem solving in physics using mathematical modeling, numerical methods, computer simulations and the fundamentals of programming. Topics may include: numerical solutions of Laplace and Poisson equations for electrostatic boundary-value problems, Monte Carlo simulation techniques, chaos theory.
Prerequisites: PHY 106 and MAT 213
Attributes: Undergraduate

PHY 417 Astrophysics (3 credits)
Application of the principles of classical and modern physics to astronomical phenomena. Topics include the acquisition and analysis of primary astronomical data; stellar energy production, structure, and evolution, including red giants, white dwarfs, neutron stars, and black holes; galactic structure and evolution; and cosmology.
Prerequisites: PHY 251 and PHY 257
Attributes: Undergraduate

PHY 419 Biophysics (3 credits)
Application of physics to biological systems. Topics include: molecular biomechanics, fluids, interaction of photons and charged particles with matter, transport phenomena, electrical properties of membranes and nerves, Fourier techniques and signal analysis, image reconstruction, fundamentals of radiology, and health physics issues.
Prerequisites: PHY 251 and PHY 257
Attributes: Undergraduate

PHY 421 Physics of Fluids (3 credits)
The mechanics of continuous media, including balance laws for mass and momentum. Hydrostatic equilibrium, compressible and incompressible flow, vorticity and circulation. Pressure and shear, viscosity, and an introduction to Newtonian and non-Newtonian fluids. Applications may include geophysical flows.
Prerequisites: PHY 106 and PHY 257
Attributes: Undergraduate

PHY 423 Biomechanics (4 credits)
The role played by physical forces in shaping our natural world can be seen in the morphology, behavior, material composition, and spatial distribution of every organism, whether aquatic or terrestrial, plant or animal. This course exposes students to the role of physics in biological systems at the organismic and super-organismic level. Each week the course will focus on a different sub-discipline of Biomechanics presenting the underlying physical principles and the biological ramifications of those principles. In addition, laboratory exercises will present techniques and experimental approaches available to measure forces relevant to biological systems, as well as the quantitative and analytical skills necessary to work in this field.
Prerequisites: PHY 101 or PHY 105 or PHY 1051
Attributes: Undergraduate

PHY 423L BioMechanics Lab (0 credits)

PHY 470 Adv Special Topics in Physics (3 credits)
The topics to be discussed are decided upon by agreement between students and teacher. This sequence is designed for Honors and other qualified students.
Attributes: Undergraduate

PHY 492 Internship in Physics (3 credits)

PHY 493 Research Project in Physics (2-4 credits)
Students need to complete the application form for independent study (available in the Dean's Office) and have the approval of the department chair and Associate Dean in order to register. Honors Research Project (6 credits) Must be elected in junior year to allow adequate research time. Students need to complete the application form for independent study (available in the Dean's Office) and have the approval of the department chair, Associate Dean and the Honors Program Director in order to register.
Attributes: Undergraduate
PHY 494 Research Project in Physics (2-4 credits)
Students need to complete the application form for independent study (available in the Dean's Office) and have the approval of the department chair and Associate Dean in order to register. Honors Research Project (6 credits) Must be elected in junior year to allow adequate research time. Students need to complete the application form for independent study (available in the Dean's Office) and have the approval of the department chair, Associate Dean and the Honors Program Director in order to register.
Attributes: Undergraduate