ENGINEERING PHYSICS MAJOR

The Department of Physics is offering a BS program in Engineering Physics. The major is intended for students who wish to acquire knowledge and powerful problem solving skills in engineering and physics.

Science and technology have evolved very rapidly in the past 10 years. The changing landscape requires more interdisciplinary skills and applications of the natural sciences, especially physics. Physics research has driven a large percentage of recent technological advancements, including many important applications to engineering. Those breakthroughs and deep connections have helped inspire the emergence of a new trend in physics: the field of Engineering Physics.

Engineering Physics prepares students to apply physics to modern engineering, science and technology. In coming years, industrial fields will increasingly employ professionals who are prepared in Engineering Physics. Our program in Engineering Physics provides the students with a fundamental knowledge of physics, together with problem-solving skills, and an understanding of engineering. The program is designed to address the needs of students seeking innovative careers in today's technological age. In addition, it allows students to keep their options open between physical sciences and engineering. Furthermore students will be well prepared and competitive for graduate school in engineering and physics.

Engineering Physics majors can work on frontier ideas in technology and science, in either industry or academia. Those areas might include aerospace, biophysics and biomedical engineering, medical physics, electrical engineering, nano and quantum engineering, renewable energy (photovoltaics, battery technology, fuel cells, ...), transportation, quantum information science, semiconductors, or materials development. Careers could also include systems engineering, teaching, medicine, law (especially intellectual property or patent law), science writing, science policy, energy policy, government, or management in technical fields. Successful students from this major are expected to have many opportunities in a wide variety of career areas that are increasingly reliant on data scientists, including technology, finance, the pharmaceutical industry, government, and engineering.

The program of Engineering Physics at Saint Joseph's University offers students a comprehensive and flexible curriculum in the disciplines of physics and engineering. The program offers 3 concentrations (Quantum Engineering, Electrical Engineering and Biomedical Engineering) which will allow students to specialize in variety of areas and prepare for a range of careers. These concentrations are reported in the students' transcripts when they graduate.

The program offer foundational courses in Physics with a core grouping of three introductory physics courses (freshman and sophomore years) in the foundations of Newtonian mechanics and electricity and magnetism, geometrical optics, thermodynamics and fluids along with a onesemester program in nonclassical (modern) physics: this course, based on developments in physics that occurred in the first quarter of the twentieth century, introduce students to quantum theory and special relativity. Each of the introductory physics courses is accompanied by a laboratory , which not only complements the didactic material but also trains the student in the methodology of doing experimental physics.

During this time, students also master mathematics, the language of physics. Students take three semesters of calculus, Differential Equations

and Introduction to Linear Algebra. Students take also a course in Mathematical Methods for Science and Engineering (which is typically required also in Engineering schools). In addition, students are required to take 2 courses that expose them to modern computational techniques. The upper-level foundational physics courses include the study of classical mechanics, statistical mechanics , electricity and magnetism and experimental methods. These physics and mathematics courses in engineering physics.

All the engineering physics students are required to take a course in Engineering Modeling and Design. Students are required to take 3 engineering electives which are selected on the basis of the concentration. There are various choices, depending on student interest: The Quantum Engineering concentration is at the front line of modern technology development (quantum computers and quantum communication, quantum materials) with courses such as Quantum Materials for Scientists and Engineers, Quantum Information Science for Mathematicians , Scientists and Engineers , Electronics and Photonics. In the Biomedical Engineering concentration we also offer subconcentrations in pharmaceutical engineering (drug delivery and other topics) and neuro engineering for students interested in the biophysics and bioengineering aspects of neuroscience.

The Department of Physics at Saint Joseph's University has developed a research-oriented culture for both its faculty and students. Most students will engage in research, alongside faculty mentors, at some point during their four years. The ability to put into practice what is learned in the classroom is paramount to the growth of scientists and professionals. In the research laboratory, students learn to design and perform experiments, to analyze data using computational methods, and draw appropriate conclusions. Students are also exposed to the interface between physics and engineering, including learning how to use physics in tackling engineering problems. All Engineering Physics students are required to do a senior project which involves research and design in the particular area of engineering selected.

Undergraduates participate in research in three different ways. First, they may decide to take research for academic credit. Within the major, students take three physics electives and one or more of these may be used to perform scientific research under the guidance of our physics faculty. Second, students may opt to do research as a Summer Scholar. Saint Joseph's University is well known for its 10 week Summer Scholars Research Program. Historically, the Physics Department, through the generosity of its alumni, Dean and Provost, has been able to provide stipends for all physics students who have wanted to do summer research. 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.

Learning Goals and Outcomes

<u>Goals</u>

The Program aims to produce graduates who will:

- 1. Be prepared for diverse career paths within Engineering, Science and Technolo
- 2. Adapt to advanced interdisciplinary, technological and analytical environments in the work place
- 3. Contribute to profession and society

Learning Outcomes

After successful completion of the program, students will demonstrate the following competencies:

Application of Proficiency: students will be able to solve problems across diverse scientific and technological areas by utilizing a strong foundation in physics and engineering (Goal 1)

Technical Proficiency: students will be able to exhibit technical expertise in the engineering workplace or in the pursuit of an advanced engineering degree, demonstrating mastery of relevant concepts and methodologies (Goal 2).

Effective Communication: students will be able to communicate technical data and findings to non-specialist audiences in a professional manner and will be committed to teamwork and life-long learning throughout their careers (Goal 2).

Contribute to Profession and Society: students will be able to engage in the engineering and physics professions in alignment with the Jesuit tradition, to contribute to the advancement of society and upholding ethical standards in their professional endeavors (Goal 3).

Requirements

Cornerstone Core Curriculum Requirements

Consist of 14 core and 2 overlay requirements. See below for additional detailed information on each of these requirements.

| Code | Title | Hours |
|---|--|---------|
| First Year Course | Requirements | |
| ENG 101 | Craft of Language | 3 |
| World History Cou | irse Area | 3 |
| Philosophy Requi | rements | |
| Either Level On designated. If a student's Writin count the same Overlay course | e or Level Two (but not both) must be Ethics approved, philosophy courses may count for a ng Intensive overlay. Students may not double- e course as Philosophy Level Two and as a Missic | on |
| Philosophy Level | One | 3 |
| Philosophy Level | Тwo | 3 |
| Theology & Religi | ous Studies Requirements | |
| If approved, Th a student's Wri count the same course. | eology & Religious Studies courses may count fo ting Intensive overlay. Students may not double- e course as CCC Theology and as a Mission Overl | r ay |
| Theology | | 3 |
| Religious Studies | | 3 |
| Diversity & INT 15 | 51 Requirements | |
| A student's Div course area rec approved, Diver Intensive Overl other CCC requ years | rersity course may not count for any other CCC quirement or as their Mission Overlay course. If rsity courses may count for a student's Writing ay requirement. INT 151 may not count for any nirements. This course must be taken in the first to | WO |
| Diversity | | 3 |
| INT 151 | Inequality in American Society | 1 |
| Math & Natural Science Requirements | | |
| | | |

If approved, Math & Natural Science Requirements may count toward overlay requirements. **Mathematics** Natural Science Social Science Requirement

3-4

4

3

3-4

3

3

3

3

47-49

If approved, such Social Science Requirement may count toward a student's overlay requirements.

Non-Native Language Requirement

A single Non-Native Language course may not count as an overlay course but a second language course fulfills a student's Mission Overlay requirement.

Literature Requirement

If approved, Literature courses may count toward a student's overlay requirements.

Fine and Performing Arts, Creativity, and Design Requirement

If approved, Fine and Performing Arts, Creativity, and Design courses may count toward a student's overlay requirements.

Overlay Requirements

Writing-Intensive If approved, Writing-Intensive courses may double count as major courses, minor courses, electives, or as any CCC course area requirement except for the first-year courses (World History and Rhetoric and Composition).

Mission-Overlay

Mission Overlay courses may double count as major courses, minor courses, elective courses, or any of the following CCC course areas: Fine and Performing Arts, Creativity, and Design, Literature, Mathematics, Natural Science, or Social Science.

Total Hours

Recommended CCC Courses

| Code | Title | Hours |
|-----------------|-------|-------|
| Mission-Overlay | | |

Second Semester of Non-Native Language

Major Requirements

| Code | Title | Hours |
|----------|---|-------|
| MAT 161 | Calculus I (will count for CCC: Mathematics) | 4 |
| MAT 162 | Calculus II | 4 |
| MAT 213 | Calculus III | 4 |
| MAT 226 | Introduction to Linear Algebra | 3 |
| MAT 238 | Differential Equations | 3 |
| MAT 311 | Numerical Analysis | 3 |
| CHM 120 | General Chemistry I | 3 |
| CHM 120L | General Chemistry Lab I | 1 |
| CHM 125 | General Chemistry II | 3 |
| CHM 125L | General Chemistry Lab II | 1 |
| PHY 105 | University Physics I (will count for CCC: Natural Science) | 3 |
| PHY 105L | University Physics Lab I (will count for CCC: Natural Science) | 1 |
| PHY 106 | University Physics II | 3 |
| PHY 106L | University Physics Lab II | 1 |
| PHY 213 | Physics III | 3 |

| PHY 213L | Intro. Physics III Laboratory | 1 |
|---|--------------------------------|---|
| PHY 251 | Modern Physics I | 3 |
| PHY 282 | Modeling, Simulation & Design | 4 |
| PHY 301 | Classical Mechanics | 3 |
| PHY 307 | Electricity and Magnetism | 3 |
| PHY 305 | Intro to Invention and Patents | 1 |
| PHY 312 | Experimental Methods in Phy II | 3 |
| PHY 313 | Comp Methods for Sci and Eng | 3 |
| PHY 390 | Physics Seminar | 0 |
| PHY 409 | Statistical Mechanics | 3 |
| PHY 482 | Math Meth Physics & Engineer | 3 |
| PHY 488 | Senior Design Project | 3 |
| Concentration | | 9 |
| Students must complete 3 electives (9 credits) within their concentration. See Concentrations section. | | |

Total Hours

Free Electives

Students are required to take 2 free electives for a total of 6 credits. Graduation requires 120 credits. Any credits necessary to reach that number outside of the CCC and major requirements are considered free electives.

Concentrations

Students must complete at least nine credits for their concentration. There are 3 concentrations: Biomedical Engineering, Electrical Engineering and Quantum Engineering.

Biomedical Engineering

| Code | Title | Hours |
|--|---|-------|
| Required: | | |
| PHY 419 | Biophysics | 3 |
| Students intereste | ed in the following areas select two classes. | 6 |
| Students interested in Drug Delivery and Development Engineering need to take the following courses. For prerequisites students can | | |
| use the free electi | ves. | |
| PHS 413 | Drug Development II | |
| PHS 414 | Advanced Pharmaceutical Analys (Prerequisites CHM210/CHM210L; CHM215/CHM215L) | |

PHS 414L Advanced Pharma Analysis Lab

Students interested in Bio-Engineering need select a minimum of 2 of the following 4*** level courses). For prerequisites students can use the free electives.

| BIO 405 | Biomechanics | |
|---|---|--|
| PHY 412 | Medical Instrument & Imaging | |
| BIO 424 | Biotechnology (Needs BIO101/L,BIO102/L and BIO201 as prerequisites) | |
| BIO 411 | Molecular Genetics (Needs BI0101/L,BI0102/L and BI0201 as prerequisites) | |
| BIO 420 | Bioinformatics (Needs BIO101/L,BIO102/L and BIO201 as prerequisites) | |
| Students interested in Neuro-Engineering select a minimum of 2 of | | |

Students interested in Neuro-Engineering select a minimum of 2 of the following courses

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PHY 425 Biophysics of the Brain
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| Code | Title | | |
|------------------------|-----------|-----------------------|--|
| Electrical Engineering | | | |
| PHY 332 | Intro. to | Network Science | |
| PHY 331 | Nonlinea | ar Dynamics and Chaos | |

| Code | litle | Hours |
|----------------|-------------------------------|-------|
| Required: | | |
| PHY 380 | Engineering Circuit Analysis | 3 |
| PHY 380L | Engineer Circuit Analysis Lab | 1 |
| Choose two (2) | of the following: | 6 |
| PHY 426 | Electronics and Photonics | |
| PHY 440 | Introduction to Nanoscience | |
| PHY 405 | Solid State Physics | |

Quantum Engineering

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|-------------------|-------------------------------|-------|
| Code | Title | Hours |
| Required: | | |
| PHY 321 | Quantum Mechanics I | 3 |
| Choose two (2) of | the following: | 6 |
| PHY 451 | Quantum Mat Sci & Engineer | |
| PHY 327 | Quantum Inform Science & Engr | |
| PHY 426 | Electronics and Photonics | |
| PHY 440 | Introduction to Nanoscience | |

Typical Course Sequence

| Course | Title | Hours |
|--------------------------|--------------------------------------|-------|
| First Year | | |
| Fall | | |
| PHY 390 | Physics Seminar | 0 |
| PHY 105 | University Physics I | 3 |
| PHY 105L | University Physics Lab I | 1 |
| MAT 161 | Calculus I | 4 |
| Non-Native Language | | 3-4 |
| World History | | 3 |
| | Hours | 14-15 |
| Spring | | |
| PHY 390 | Physics Seminar | 0 |
| PHY 106 | University Physics II | 3 |
| PHY 106L | University Physics Lab II | 1 |
| MAT 162 | Calculus II | 4 |
| Non-Native Language (CCC | Mission- Global Citizenship Overlay) | 3 |
| ENG 101 | Craft of Language | 3 |
| Diversity | | 3 |
| | Hours | 17 |
| Sophomore | | |
| Fall | | |
| PHY 213 | Physics III | 3 |
| PHY 213L | Intro. Physics III Laboratory | 1 |
| MAT 238 | Differential Equations | 3 |
| MAT 213 | Calculus III | 4 |
| CHM 120 | General Chemistry I | 3 |
| CHM 120L | General Chemistry Lab I | 1 |
| PHY 390 | Physics Seminar | 0 |
| | Hours | 15 |
| Spring | | |
| PHY 251 | Modern Physics I | 3 |
| MAT 226 | Introduction to Linear Algebra | 3 |
| Philosophy Level One | | 3 |

79

| CHM 125 | General Chemistry II | 3 |
|----------------------------|--------------------------------|----|
| CHM 125L | General Chemistry Lab II | 1 |
| INT 151 | Inequality in American Society | 1 |
| PHY 390 | Physics Seminar | 0 |
| Religious Studies | | 3 |
| | Hours | 17 |
| Junior | | |
| Fall | | |
| PHY 301 | Classical Mechanics | 3 |
| PHY 482 | Math Meth Physics & Engineer | 3 |
| PHY 312 | Experimental Methods in Phy II | 3 |
| PHY 390 | Physics Seminar | 0 |
| Theology | | 3 |
| Philosophy Level Two | | 3 |
| | Hours | 15 |
| Spring | | |
| PHY 307 | Electricity and Magnetism | 3 |
| PHY 313 | Comp Methods for Sci and Eng | 3 |
| PHY 305 | Intro to Invention and Patents | 1 |
| MAT 311 | Numerical Analysis | 3 |
| Engineering Physics Conc | entration (1 of 3) | 3 |
| Free Elective | | 3 |
| | Hours | 16 |
| Senior | | |
| Fall | | |
| PHY 282 | Modeling, Simulation & Design | 4 |
| Fine & Performing Arts, De | sign & Creativity | 3 |
| Engineering Physics Conce | entration (2 of 3) | 3 |
| Engineering Physics Conc | entration (3 of 3) | 3 |
| PHY 390 | Physics Seminar | 0 |
| Free Elective | | 3 |
| | Hours | 16 |
| Spring | | |
| PHY 409 | Statistical Mechanics | 3 |
| PHY 488 | Senior Design Project | 3 |
| PHY 390 | Physics Seminar | 0 |
| Literature | | 3 |
| Social Science | | 3 |
| Overlay or Free Elective | | 3 |
| | Hours | 15 |
| | | |