DEPARTMENT OF ELECTRICAL ENGINEERING AND PHYSICS

Department of Electrical Engineering and Physics

Chairperson: Dr. Gregory Harms

Faculty

Professors: Arora, Gilmer, Srinivasan
Associate Professors: Harms, Nazzal, Sabouni
Assistant Professors: Lucent, Du
Faculty Emeriti: Hostler, Placek
Staff: Saporito

Mission

Our Mission is to mentor the engineering leaders of the future by

• establishing a solid foundation in Science and Mathematics
• intensive development in problem analysis and design in Electrical Engineering
• fostering of students into professionals through internships for Industry or through undergraduate research experiences for Graduate School, both of which improve communication and teamwork skills and introduce life-long learning
• enhancing an awareness of Ethics and Social Responsibilities as consequences of our actions

Electrical Engineering

Total minimum number of credits required for a Bachelor of Science Degree in Electrical Engineering – 130.
Total minimum number of credits required for a minor in Computer Engineering – 20-22

Engineering is a creative profession in which technological problems are met within the framework of scientific possibilities, economic constraints, and cultural preferences. The four-year Bachelor of Science degree program in Electrical Engineering (EE) is dedicated to the principle of preparing its students for industry and graduate study with the expectation of eventual leadership responsibilities. It provides the knowledge and investigative skills, both theoretical and experimental, to responsibly address professional and societal needs through modern curricula, hands-on experience, and a personalized academic environment. Students are encouraged to be well-prepared in the sciences and mathematics. To that end, its faculty and facilities focus on an emphasis of design and industrial experience, student-faculty-industry cooperative projects, teamwork, the adoption of new technologies, and the hands-on student utilization of laboratories and computing systems.

The EE program is designed to achieve a balance among the major areas of Communication Systems, Microelectronics, and Computer Systems. The student may choose to specialize within the EE program in any of the following areas: Communication and Information Systems, Microcontroller Based System Design, and Design and Fabrication of Microelectronic Devices and Circuits.

The Electrical Engineering program maintains professional accreditation by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; Telephone: (410) 347-7700).

Our program objectives are encompassed in the mission statement above. Our program educational outcomes are:

1. Ability to apply knowledge of mathematics, science, and engineering.
2. Ability to design and conduct experiments, as well as to analyze and interpret data.
3. Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
4. Ability to function on multi-disciplinary teams.
5. Ability to identify, formulate, and solve engineering problems.
6. Understanding of professional and ethical responsibility.
7. Ability to communicate effectively.
8. Broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
9. Recognition of the need for, and an ability to engage in life-long learning.
10. Knowledge of contemporary issues.
11. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (Include program educational objectives here.)

A description of individual course outcomes and updated program educational objectives and outcomes is available in the Department office and on the Department Website.

A Master of Science degree in Electrical Engineering (MSEE) and a Master of Science degree in Bioengineering (MSBEGR) are also available. These degree programs are described in the Graduate Bulletin. Engineering students may also elect to complete a minor in Computer Engineering and/or Physics.
Honors in Engineering

Upon the recommendation and approval of the Engineering faculty, the honor student in Engineering will be recognized upon completion of the following requirements:

- achievement of an overall GPA of 3.25 or better;
- receipt of grades of 3.00 or better in all engineering courses of his or her field of study;
- pursuit of independent research or special projects in engineering; and
- presentation of research results or special project at meetings, conferences, or through the publication of a paper.

The distinction "Honors in Engineering" will be recorded on the student's transcript upon graduation.

Student Activities

Professional societies in which students participate include the Institute of Electrical and Electronic Engineers (IEEE), the Society of Women Engineers (SWE), the Pennsylvania Society of Professional Engineers (PSPE), and the Engineering Student Council. Students also participate in various on-campus activities and design competitions.

Transfer Credit Policy

No credits will be transferred to Wilkes University unless their prerequisites have been satisfied. Transfer credits must follow the proper course sequence as specified in the Wilkes bulletin. For transfer credits to be awarded the required prerequisite(s) must be satisfied during the first year at Wilkes.

Cooperative Education

An important feature of the electrical engineering program is the Cooperative Education experience, a valuable option usually scheduled during the junior year. The co-op option may be continued into the summer preceding the senior year. Participants derive three advantages from a co-op experience: a determination of how they wish to fill their elective courses during the senior year; an enhanced ability to conduct a job search; and a greater recognition that career opportunities may be stimulating and fulfilling as well as financially rewarding. The Cooperative Education opportunity provides a natural extension of the college experience.

Student Classification Categories

Students attain Sophomore standing after successfully completing all Freshman year required courses.
Students attain Junior standing after successfully completing all Sophomore year required courses.
Students attain Senior standing after successfully completing all Junior year required courses.
# ELECTRICAL ENGINEERING

## Electrical Engineering

### Electrical Engineering Major - Required Courses and Recommended Course Sequence

<table>
<thead>
<tr>
<th>Semester</th>
<th>Courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Semester</strong></td>
<td><strong>[[MTH-111]] Calculus I</strong> 4</td>
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</tr>
<tr>
<td></td>
<td><strong>[[CHM-117]] Introductory Chemistry Lab for Engineers</strong> 1</td>
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<tr>
<td></td>
<td><strong>[[CHM-118]] Chemistry for Engineers</strong> 3</td>
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<td><strong>[[ME-180]] CADD Lab</strong> 1</td>
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<td></td>
<td><strong>[[ENG-101]] Composition</strong> 4</td>
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<td><strong>[[FYF-101]] First-Year Foundations</strong> 3</td>
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<td><strong>Total</strong></td>
<td><strong>16</strong></td>
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<tr>
<td><strong>Second Semester</strong></td>
<td><strong>[[MTH-112]] Calculus II</strong> 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>[[PHY-201]] General Physics I</strong> 4</td>
<td></td>
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<tr>
<td></td>
<td><strong>[[EGR-140]] Scientific Programming</strong> 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>[[EGR-200]] Introduction to Materials Science</strong> 3</td>
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<td></td>
<td><strong>Distribution Requirement</strong> 3</td>
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<td><strong>Total</strong></td>
<td><strong>17</strong></td>
</tr>
<tr>
<td><strong>Third Semester</strong></td>
<td><strong>[[MTH-211]] Intro. to Differential Equations</strong> 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>[[PHY-202]] General Physics II</strong> 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>[[EE-211]] Electrical Circuits and Devices</strong> 3</td>
<td></td>
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<tr>
<td></td>
<td><strong>[[EE-283]] Electrical Measurements Lab</strong> 1</td>
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</tr>
<tr>
<td></td>
<td><strong>[[ME-231]] Statics</strong> 3</td>
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<tr>
<td><strong>Fourth Semester</strong></td>
<td><strong>[[MTH-212]] Multivariable Calculus</strong> 4</td>
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<td></td>
<td><strong>[[EE-251]] Electronics I</strong> 3</td>
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</tr>
<tr>
<td></td>
<td><strong>[[EGR-222]] Mechatronics</strong> 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>[[EE-241]] Digital Design</strong> 4</td>
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<tr>
<td><strong>Fifth Semester</strong></td>
<td><strong>[[EE-252]] Electronics II</strong> 4</td>
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<td><strong>[[EE-271]] Semiconductor Devices</strong> 3</td>
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<td><strong>Sixth Semester</strong></td>
<td><strong>[[EGR-399]] Cooperative Education</strong> OR <strong>Technical Electives</strong> 6</td>
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<td></td>
<td><strong>[[PHY-203]] Modern Physics</strong> 3</td>
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<td></td>
<td><strong>[[PHY-206]] Modern Physics Lab</strong> 1</td>
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<td></td>
<td><strong>[[EGR-201]] Professionalism and Ethics</strong> 1</td>
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<td><strong>Distribution Requirements</strong> 3</td>
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<td></td>
<td><strong>[[EGM-320]] Engineering Project Management &amp; Analysis</strong> 3</td>
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<td><strong>Total</strong></td>
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<tr>
<td><strong>Seventh Semester</strong></td>
<td><strong>[[EE-314]] Control Systems</strong> 3</td>
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</tr>
<tr>
<td></td>
<td><strong>[[EE-337]] Engineering Electromagnetics I</strong> 3</td>
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<td><strong>[[EE-391]] Senior Project I</strong> 1</td>
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<td><strong>[[EE-325]] Energy Conversion Devices</strong> 3</td>
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<td><strong>Eighth Semester</strong></td>
<td><strong>[[EE-339]] Engineering Electromagnetics II</strong> 4</td>
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<td></td>
<td><strong>[[EE-382]] Modern Communication Systems</strong> 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>[[EE-392]] Senior Projects II</strong> 2</td>
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</tr>
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<td></td>
<td><strong>Technical Elective</strong> 3</td>
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</tr>
<tr>
<td></td>
<td><strong>Free Elective</strong> 3</td>
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</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
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</table>

*Technical electives may be chosen from any advisor-approved math, science, or engineering course numbered 200 or above.

**Students must consult with the Cooperative Education Coordinator to determine availability and proper scheduling of the Cooperative Education experience.

### Minor in Computer Engineering

A 20 to 22-credit Computer Engineering minor is a special and highly focused option for students majoring in Engineering and other related disciplines. The minor consists of the following course requirements:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>[[CS-125]]</strong> – Computer Science I or <strong>[[EGR-140]]</strong> - Scientific Programming</td>
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<tr>
<td><strong>[[CS-126]]</strong> – Computer Science II or <strong>[[EE-247]]</strong> Programming for Embedded Applications</td>
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</tr>
<tr>
<td><strong>[[EE-241]]</strong> – Digital Design</td>
<td></td>
</tr>
</tbody>
</table>
Electrical Engineering

[[EE-345]] – Computer Organization
[[EE-342]] – Microcontroller Based System Design

One elective course from an Application Area (e.g., [[EE-314]] – Control Systems; [[CS-355]] – Computer Networks; or [[ME-317]] – Robotics)

Electrical Engineering...7
Physics...13
### Physics

**Physics**

Total minimum number of credits required for a Baccalaureate of Arts Degree in Physics – 123.

Total minimum number of credits required for a Baccalaureate of Arts Degree in Physics with a minor in Secondary Education – 124

Baccalaureate of Arts degree in Physics (BA in Physics) is designed to offer a track for all students who wish to combine a major in Physics with other career goals. Primary among them are those students who wish to become certified in Physics by the PA Department of Education to teach high school physics and other science courses. In addition, the program will support students who may wish to concentrate on careers in medicine, dentistry, or law.

**Physics B.A. Degree- Required Courses and Recommended Course Sequence**

#### First Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>[MTH-111]</td>
<td>Calculus I*</td>
<td>4</td>
</tr>
<tr>
<td>[CHM-115]</td>
<td>Elements and Compounds*</td>
<td>3</td>
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<tr>
<td>[CHM-113]</td>
<td>Elements and Compounds Lab*</td>
<td>1</td>
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<tr>
<td>[ENG-101]</td>
<td>Composition</td>
<td>4</td>
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<td>[FYF-101]</td>
<td>First-Year Foundations</td>
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#### Second Semester

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<thead>
<tr>
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<tbody>
<tr>
<td>[MTH-112]</td>
<td>Calculus II*</td>
<td>4</td>
</tr>
<tr>
<td>[PHY-201]</td>
<td>General Physics I*</td>
<td>4</td>
</tr>
<tr>
<td>[EGR-140]</td>
<td>Scientific Programming*</td>
<td>3</td>
</tr>
<tr>
<td>Physics Elective @</td>
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<td>3</td>
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<tr>
<td>Distribution Requirement</td>
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#### Third Semester

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<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>[MTH-211]</td>
<td>Intro. to Differential Equations*</td>
<td>4</td>
</tr>
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<td>[PHY-202]</td>
<td>General Physics II*</td>
<td>4</td>
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<td>Physics Elective @</td>
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#### Fourth Semester

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<tr>
<td>[MTH-212]</td>
<td>Multivariable Calculus*</td>
<td>4</td>
</tr>
<tr>
<td>[PHY-203]</td>
<td>Modern Physics*</td>
<td>3</td>
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<td>Physics Elective @</td>
<td></td>
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</tr>
<tr>
<td>Distribution Requirement</td>
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#### Fifth Semester

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<thead>
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<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>[PHY-311]</td>
<td>Thermodynamics*</td>
<td>3</td>
</tr>
<tr>
<td>[PHY-312]</td>
<td>Analytical Mechanics*</td>
<td>3</td>
</tr>
<tr>
<td>[EE-337]</td>
<td>Engineering Electromagnetics I*</td>
<td>3</td>
</tr>
<tr>
<td>Physics Elective @</td>
<td></td>
<td>3</td>
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<tr>
<td>Distribution Requirement</td>
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#### Sixth Semester

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<th>Course Title</th>
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<tbody>
<tr>
<td>[PHY-314]</td>
<td>Quantum Mechanics*</td>
<td>3</td>
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#### Seventh Semester

<table>
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<tr>
<td>[PHY-391]</td>
<td>Senior Project I*</td>
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<tr>
<td>Free Electives</td>
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#### Eighth Semester

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<th>Course Title</th>
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<tbody>
<tr>
<td>[PHY-392]</td>
<td>Senior Projects II*</td>
<td>2</td>
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<td><strong>Total</strong></td>
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*Required Core Course for BA in Physics Major.

^Can be substituted with CS 125.

@Physics electives may be chosen from any advisor-approved mathematics, biology, chemistry, computer science, environmental science/engineering, electrical engineering, or mechanical engineering course numbered 200 or above.

### Physics Major In Conjunction with the Secondary Education Major or Minor

Students interested in becoming secondary teachers in Physics should make an appointment with the chairperson of the Education Department or the Coordinator of the Secondary Education Program as early as possible in their course of study to plan their professional studies. These students will declare a major in Physics and as well as a major or minor in Secondary Education. The major in Secondary Education must be taken in conjunction with an approved major; it cannot stand alone as a major. Upon successful completion of the secondary education program, students may become certified in Pennsylvania to teach in grades 7-12 in their chosen field.

Students interested in pursuing either the major or the minor in Secondary Education should refer to the Education Department section of this bulletin for complete details of the curriculum and other degree requirements. Students should also consult carefully with their Education program and Physics program advisors in planning their course of studies.

Total credits required for **Secondary Education minor - 40 cr.**

Total credits required for **Secondary Education major - 47 cr.**
Physics

Required courses for the major(*) or minor in Secondary Education are as follows:

[ED-180] – Educational Psychology - 3 cr.
[ED-190] – Effective Teaching with Field Experience - 3 cr.
[ED-191] – Integrating Technology into the Classroom - 3 cr.
[EDSP-210] – Teaching Students with Special Needs - 3 cr.
[ED-220] – Teaching Culturally and Linguistically Diverse Learners - 3 cr.
[EDSP-225] – Special Education Methods I with Field Experience - 3 cr.
[ED-300] – Teaching of a Foreign Language with Field Experience - 4 cr.

* [ED-345] – Assessment - 3 cr.

* [ED-375] – Middle Level/Secondary School Methods with Field Exp. - 4 cr.
[ED-380] – Content Area Literacy - 3 cr.
[EDSP-388] – Inclusionary Practices (taken concurrently with ED 390) - 3 cr.
[ED-390] – Student Teaching with Seminar - 12 cr.

• These additional courses required in order to complete the major in Secondary Education.

  • All Teacher Education candidates must apply for admission to the Teacher Education Program in the sophomore or junior year.
  • To be admitted into the Teacher Education Program, candidates must
    o Attain a 3.0 GPA
    o Complete 48 credits including six credits in both Mathematics and English
    o Pass a test of basic skills
    o Submit required clearances showing ‘no record’
  • To remain in the Teacher Education Program, candidates must
    o Maintain a 3.0 GPA
    o Adhere to the Code of Professionalism and Academic Honesty
  • To be certified as a teacher in Pennsylvania in grades 7-12, candidates must
    o Successfully complete all required Education courses, including student teaching
    o Graduate with a 3.0 cumulative GPA
    o Pass the appropriate exit test(s) in their content area
    o Apply for certification through the Pennsylvania Teacher Information Management System (TIMS).

Physics Minor

Physics is the study of physical phenomena, including forces, energy, momentum, friction, electricity, electrostatics, magnetics, acoustics, heat, light, and relativity. It is thus the foundation of mechanical, civil, and electrical engineering and also is central to music, sound, and architecture.

Wilkes University offers a minor in Physics, which requires the satisfactory completion of 20 credits, as follows:

Eleven credits of required introductory courses in Physics:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>[PHY-201]</td>
<td>General Physics I</td>
<td>4</td>
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<tr>
<td>[PHY-202]</td>
<td>General Physics II</td>
<td>4</td>
</tr>
<tr>
<td>[PHY-203]</td>
<td>General Physics III</td>
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</table>

AND

Three credits of required advanced courses selected from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>[PHY-311]</td>
<td>Thermodynamics and Statistical Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>[PHY-312]</td>
<td>Analytical Mechanics</td>
<td>3</td>
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<tr>
<td>[PHY-314]</td>
<td>Quantum Mechanics</td>
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AND

Six credits of electives selected from the following:

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>[PHY-311]</td>
<td>Thermodynamics and Statistical Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>[PHY-312]</td>
<td>Analytical Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>[PHY-314]</td>
<td>Quantum Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>[CHM-251]</td>
<td>Physical Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>[CHM-252]</td>
<td>Physical Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>[EEES-251]</td>
<td>Synoptic Meteorology</td>
<td>4</td>
</tr>
<tr>
<td>[EEES-260]</td>
<td>Principles of Astronomy</td>
<td>4</td>
</tr>
<tr>
<td>[EE-337]</td>
<td>Engineering Electromagnetics I</td>
<td>4</td>
</tr>
<tr>
<td>[EGR-200]</td>
<td>Introduction to Materials Science &amp; Engineering</td>
<td>3</td>
</tr>
<tr>
<td>[ME-231]</td>
<td>Statics and Dynamics I</td>
<td>3</td>
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<tr>
<td>[ME-321]</td>
<td>Fluid Dynamics</td>
<td>3</td>
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<tr>
<td>[ME-322]</td>
<td>Engineering Thermodynamics</td>
<td>3</td>
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<tr>
<td>[MTH-361]</td>
<td>Applied Mathematics I</td>
<td>3</td>
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<tr>
<td>[MTH-362]</td>
<td>Applied Mathematics II</td>
<td>3</td>
</tr>
<tr>
<td>[PHY-398]</td>
<td>Topics in Physics</td>
<td>variable</td>
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</tbody>
</table>

Minimum total credits required - 20

Physics........................................................................................................13
Engineering.....................................................................................................12
Earth and Environmental Sciences...............................................................8
EE. ELECTRICAL ENGINEERING

EE-211. ELECTRICAL CIRCUITS AND DEVICES
Credits: 3

Co-Requisites
[[MTH-112]]

EE-241. DIGITAL DESIGN
Credits: 3
The electronics of digital devices, including Bipolar TTL and CMOS, digital logic functions (e.g., AND, OR, INVERT), Boolean algebra, combinational logic, minimization techniques, digital storage devices, synchronous sequential design, state machines, programmable logic. Three one-hour lectures and one two-hour lab per week.
Click here for course fees.

EE-247. PROGRAMMING FOR EMBEDDED APPLICATIONS
Credits: 3
Microcontroller hardware structures. Basic software concepts such as constants, variables, control structures and subroutine calls, based on the ‘C’ language and as translated to machine language. Mapping of compiled software to the memory of a microcontroller. Embedded programming principles. Basic interactions with peripherals. Interrupts and their use. Debugging. Three hours of lecture and lab per week.
Click here for course fees.

Pre-Requisites
[[EGR-140]] or [[CS-125]].

EE-251. ELECTRONICS I
Credits: 3
Circuit concepts involving nonideal components, particularly diodes, bipolar transistors, and MOS transistors. Bias, load line and signal amplification principles. Analysis and design of power supply and amplifier circuits, including power amplifiers. Simulation of circuits for design and analysis.

Pre-Requisites
[[EE-211]].

EE-252. ELECTRONICS II
Credits: 4
Multi-transistor amplifiers, operational amplifiers. Frequency response and the design of filters and amplifiers to meet frequency specifications. Feedback in amplifier design and oscillators. Three one-hour lectures and one three-hour lab per week.
Click here for course fees.

Pre-Requisites
[[EE-251]], [[EE-283]], [[MTH-112]], and [[PHY-202]].

EE-271. SEMICONDUCTOR DEVICES
Credits: 3
Basic properties of semiconductors and their conduction processes, with special emphasis on silicon and gallium arsenide. Physics and characterizations of p-n junctions. Homo junction and heterojunction bipolar transistors. Unipolar devices including MOS capacitor and MOSFET. Microwave and photonic devices.

Pre-Requisites
[[CHM-117]], [[PHY-202]].

EE-283. ELECTRICAL MEASUREMENTS LAB
Credits: 1
A laboratory for the development of measurement techniques and use of electrical instruments for the measurement of various electrical quantities. One two-hour lab per week.
Click here for course fees.

Co-Requisites
[[EE-211]]

EE-298. TOPICS IN ELECTRICAL ENGINEERING
Credits: 1-3
Selected topics in the field of electrical engineering. Requirements: Sophomore standing and permission of the instructor.
Click here for course fee for lab courses.

Pre-Requisites
Sophomore standing and permission of the instructor.

EE-314. CONTROL SYSTEMS
Credits: 3
Click here for course fees.

Pre-Requisites
[[EE-211] and [[EGR-214]] (or [[PHY-214]])

EE-325. ENERGY CONVERSION DEVICES
Credits: 3
Magnetic circuit calculations. Principle of operation and applications of transformers, DC machines, synchronous machines, and induction motors. Applications of power electronics. Direct energy conversion schemes. Lecture and lab.

Pre-Requisites
[[EE-251]].

EE-337. ENGINEERING ELECTROMAGNETICS I
Credits: 3
Waves and phasors; concepts of flux and fields; transmission line, Smith chart, and impedance matching; vector calculus; Maxwell’s equations for electrostatic and magnetostatic fields.
Click here for course fees.

Pre-Requisites
[[EGR-214]] (or [[PHY-214]]), [[PHY-202]].
EE-339. ENGINEERING ELECTROMAGNETICS II  
Credits: 4  
Maxwell's equation for time-varying fields; boundary conditions and 
boundary value problems; plane wave propagation; reflection, refraction, 
and wave guides; stripline; s-parameters and microwave devices; directional 
coupler, attenuator; radiation and antennas; satellite communication 
systems and radar sensors. Three hours of lecture and one three-hour lab 
per week. 
Click here for course fees.

Pre-Requisites  
[[EE-337]].

EE-342. MICROCONTROLLER BASED SYSTEM DESIGN  
Credits: 3  
Microprocessor architecture, the microcontroller based system design 
context, and peripheral interfacing. C and machine language programming 
and debugging, and embedded applications. Associated laboratory 
exercises include topics such as stand-alone system programming, 
interfacing to peripherals, interrupts, timers, analog data acquisition, and 
intercomputer communications. Two hours of lecture and one two-hour lab 
per week. 
Click here for course fees.

Pre-Requisites  
[[EE-241]], and either [[EE-247]] or [[CS-126]] as corequisites.

EE-345. COMPUTER ORGANIZATION  
Credits: 3  
Number representation, digital storage devices, and computational units, 
bus structures; execution sequences and assembly language concepts; 
control units with horizontal and vertical microcoding; addressing principles 
and sequencing; microprocessors; basic input and output devices; 
interrupts; survey of RISC principles including pipelined execution. Lecture 
and lab.  
Click here for course fees.

Pre-Requisites  
[[EE-241]].

EE-381. MICROFABRICATION LAB  
Credits: 3  
The theoretical and practical aspects of techniques utilized in the fabrication 
of bipolar junction transistors (BJTs). Includes crystal characteristics, wafer 
cleaning, oxidation, lithography, etching, deposition, diffusion, metallization, 
process metrics, and device characterization. One-and-a-half hour lecture 
and one four-hour lab per week. Requirements: Junior engineering standing 
Click here for course fees.

EE-382. MODERN COMMUNICATION SYSTEMS  
Credits: 4  
Introduction to probability and statistics and their use in communication 
systems. Fundamental properties of signals, principles of signal processing, 
multiplexing, modulator-demodulator design, noise and its effects. Sampling 
theorem and Nyquist's criteria for pulse shaping; signal distortion over a 
channel; line coding; signal to noise ratios, and performance comparison of 
various communication systems.  
Click here for course fees.

Pre-Requisites  
[[EE-252]], [[EE-337]], [[EGR-214]] (or [[PHY-214]])

EE-391. SENIOR PROJECTS I  
Credits: 1  
Design and development of selected projects in the field of electrical 
ingineering under the direction of a staff member. Technical as well as 
economic factors will be considered in the design. A professional paper 
and detailed progress report are required. Requirement: Senior standing in 
ingineering. 
Click here for course fees.

EE-392. SENIOR PROJECTS II  
Credits: 2  
Design and development of selected projects in the field of selected projects 
in the field of electrical engineering under the direction of a staff member. 
Technical as well as economic factors will be considered in the design. This 
is a continuation of the [[EE-391]]. A professional paper to be presented and 
discussed in an open forum is required. 
Click here for course fees.

Pre-Requisites  
[[EE-391]].

EE-398. TOPICS IN ELECTRICAL ENGINEERING  
Credits: 3  
Requirement: Junior standing in engineering.
EES-105. PLANET EARTH  
Credits: 3
The nature of our planet and how it works are examined in the context of Earth as a constantly changing dynamic system. An emphasis on global scale processes and the interaction of humans and their physical environment is coupled with in-depth coverage of how science is done and the scientific principles that influence our planet, its rocks, rivers, atmosphere, and oceans. Major sub-topical areas in the Planet Earth series may include geology (Forces of Geologic Change), oceanography (The Restless Ocean), astronomy (The Cosmic Perspective), geography (Global Regions and Geography), and the relationship between people and their physical surroundings (The Global Environment). Intended for students who are not majoring in science, engineering, pre-pharmacy, nursing, or B.S. programs in mathematics or computer science. Two hours of lecture and two hours of lab per week.
Click here for course fees.

Pre-Requisites
No previous background in science or college-level mathematics is required.

EES-211. PHYSICAL GEOLOGY  
Credits: 4
Description, analysis, and laboratory studies of earth materials, structure, and processes, including earth’s surface, interior, age, and origin. Three hours of lecture and three hours of lab per week. Requirements: For CS, Engineering, Math, and Science majors only. Cross listed with [GEO-211].
Click here for course fees.

Pre-Requisites
[CHM-115].

EES-212. HISTORICAL GEOLOGY  
Credits: 3
A study of the geologic record of the earth’s formation and evolution, including methods of dating. Two hours of lecture and three hours of lab per week. Cross listed with [GEO-212].
Click here for course fees.

Pre-Requisites
[CHM-115] or permission of the instructor.

EES-213. CLIMATE MODELING  
Credits: 1
Students will utilize software to construct basic models of Earth Systems. No prior knowledge of the software is assumed or required. Weekly assignments will consist of computer-based modeling exercises, each progressively building upon previous assignments. Specifically, students will utilize software to construct relatively simple models of world population growth, fossil fuel consumption, the global carbon cycle, and the Earth’s energy balance. The final modeling exercise couples the population growth, carbon cycle, and Earth energy balance assignments in an effort to explore the effect of future population growth and carbon dioxide emissions on global mean temperature. Two hours of lab per week.

Pre-Requisites
[CHM-115] or permission of the instructor.

EES-218. ENVIRONMENTAL ETHICS  
Credits: 3
An examination of the central problems of environmental ethics as viewed from the perspectives of science and of philosophy. The value of nature and ‘natural objects,’ differing attitudes toward wildlife and the land itself, implications of anthropocentrism, individualism, ecocentrism, and ecofeminism, bases for land and water conservation, and other topics will be examined within a framework of moral and scientific argument. Cross-listed with [PHL-218].

Pre-Requisites
[CHM-115] or [EE-240] or permission of the instructor.

EES-220. BIOGEOCHEMISTRY  
Credits: 3
Fundamentals of the circulation of materials through the earth’s air, soils, waters, and living organisms are examined from the perspective of introductory chemical principles. Global cycles of water, carbon, nitrogen, phosphorus, and sulfur are investigated in detail with emphasis on the roles of microorganisms, chemical equilibrium, and oxidation-reduction processes in biogeochemical cycling. Laboratory focuses on 1) student designed projects to gather data that illustrate key concepts in chemical weathering processes in aqueous solutions, oxidation-reduction reactions, and microbial mediation of elemental cycling and 2) building problem solving skills. Two hours of lecture and three hours of lab per week.
Click here for course fees.

Pre-Requisites
[CHM-115].

EES-220. BIOLICAL GEOLOGY  
Credits: 3
The nature and function of earth’s global climate are examined from a unified system perspective. Major questions focus on scientific versus public understanding of trends in global temperature, precipitation, and sea level. The course emphasizes negative and positive feedback processes that force key changes in the earth’s climate system: past, present, and future. Topics include fundamentals of global and regional heat and water balance, the role of elemental cycles in controlling climate (e.g., the carbon cycle), descriptive climate classification, long-term, short-term, and catastrophic climatic change (e.g., ice ages and bolide impacts), and human effects on climate (e.g., enhanced greenhouse, rising sea level). This course integrates a scientific understanding of climatic change and explores contemporary social and economic policy responses to change scenarios. Three hours of lecture per week.
Click here for course fees.

EES-230. OCEAN SCIENCE  
Credits: 4
An interdisciplinary approach to the study of the fundamentals of oceanography emphasizing physical, chemical, and biological interrelationships. Three hours of lecture and three hours of lab. Requirements: For CS, Engineering, Math, and Science majors only.
Click here for course fees.
Course Descriptions

EES-240. PRINCIPLES OF ENVIRONMENTAL ENGINEERING & SCIENCE
Credits: 4
A study of physical, chemical, and biological components of environmental systems and a discussion of processes involved in water quality management, air quality management, waste management, and sustainability. Three hours of lecture and three hours of lab per week. Click here for course fees.

Pre-Requisites
[[MTH-111]] or higher. Requirements For CS, Engineering, Math, and Science majors only.

EES-242. ENVIRONMENTAL HEALTH
Credits: 3
To provide students with an understanding of man’s impact on the environment and how those impacts can be controlled or mitigated. Students completing this course should be able to recognize environmental problems and understand control and preventative measures. Three hours of lecture.

Pre-Requisites
Introductory physics and chemistry. Students who have taken [[EES-240]] will be admitted only with the consent of the instructor.

EES-251. SYNOPTIC METEOROLOGY
Credits: 4
Topics include surface and upper air weather systems, weather phenomena, climate, and local weather influences. Synoptic map analysis and interpretation are emphasized. Three hours of lecture and three hours of lab per week. Requirements: For CS, Engineering, Math, and Science majors only. Click here for course fees.

EES-261. REGIONAL GEOGRAPHY
Credits: 3
Topics covered include maps and charts and basic elements of physical, cultural, historical, and economic geography as applied to specific geographic regions. Three hours of lecture per week.

EES-271. ENVIRONMENTAL MAPPING I: INTRODUCTION TO GPS AND GIS
Credits: 3
Information Systems (GIS), and environmental mapping concepts and applications. Topics include coordinate systems, reference ellipsoids, geodetic datums, map projections, history of GIS, relational database management, quality control, GIS as a decision support tool, and data manipulation, processing, and analysis. Practical field use of GPS is emphasized within the context of understanding system components, satellite signal processing, selective availability, base station differential correction, and data export to GIS. Geospatial data science is discussed within the context of real-world locational phenomena. Two hours of lecture and two hours of lab per week. Click here for course fees.

EES-272. ENVIRONMENTAL MAPPING II: ADVANCED GIS AND REMOTES SENSING
Credits: 3
Terms Offered: Spring
An advanced course on Geographic Information Systems (GIS) and Remote Sensing. GIS topics build upon introductory-level coursework in EES 271, and introduce more advanced applications of GIS software such as density mapping and interpolation of point data (geostatistical methods), surface analysis and 3D modeling of environmental data, open source alternatives to ArcGIS, and web map development and design. Remote sensing topics include aerial and satellite visual imagery, digital image processing, photogrammetry, Light Detection and Ranging (LiDAR), and multispectral remote sensing systems and theory. The course will also include case studies of remote sensing and GIS techniques applied in environmental studies. Field use of GPS is emphasized, in addition to the use of small Unmanned Aerial Systems (sUAS) to capture aerial digital imagery. Laboratory component emphasizes practical skills and tools in achieving desired results in processing geospatial data, particularly raster data types. Two hours of lecture and three hours of lab per week. Click here for course fees.

EES-280. PRINCIPLES OF ASTRONOMY
Credits: 4
Topics include orbital mechanics, results of planetary probes, spectra and stellar evolution, and cosmology. Three hours of lecture and three hours of lab per week. Requirements: For Science majors only. Click here for course fees.

EES-302. LITERATURE METHODS
Credits: 1
The nature and use of important sources of information in earth and environmental sciences are developed through retrospective searching methods and current awareness techniques. The use of computer databases, the design of personal computer information files, information search strategies, and manual search procedures are included. Literature preparation for Senior Projects (EES 391-392).

Pre-Requisites
Junior standing.

EES-304. ENVIRONMENTAL DATA ANALYSIS
Credits: 2
To acquaint students majoring in earth and environmental sciences with the techniques and methods of data acquisition and analysis, including environmental sampling methodology and data management. Emphasis will be placed on examination of real data sets from various areas of the earth and environmental sciences with particular emphasis placed on using and applying graphical and statistical procedures used in [[EES-391]];392 (Senior Projects). Two hours of lecture per week.

Pre-Requisites
[[MTH-150]] and Junior standing or permission of the instructor.

EES-340. CONSERVATION BIOLOGY
Credits: 3
This course will cover the major topics of conservation biology including an introduction to biodiversity, threats to biodiversity, and solutions to diminish extinctions and population declines. Lecture: three hours per week. Cross-listed with [[BIO-340]].

Pre-Requisites
BIO 121-122, BIO 225-226 or permission of the instructor.
EES-341. FRESHWATER ECOSYSTEMS
Credits: 3
A study of the biological and ecological aspects of streams, lakes, and
wetlands from a watershed perspective. An initial introduction to physical,
chemical, and geological principles of limnology is followed by a focus
on freshwater biology. Laboratories include field-based watershed
investigations and lake management assessments using geographic
information systems techniques. Cross-listed with [[BIO-341]]. Two hours of
lecture and three hours of lab per week. Offered in alternate years.
Click here for course fees.
Pre-Requisites
[[EES-211]] or 240 or [[BIO-121]]-122 or permission of the instructor.

EES-343. MARINE ECOLOGY
Credits: 3
An examination of the biology of marine life within the context of modern
ecological principles. The structure and physiology of marine organisms
will be studied from the perspectives of adaptation to the ocean as habitat,
biological productivity, and interspecific relationships. Emphasis will be
placed on life in intertidal zones, estuaries, surface waters, and the deep
sea. Two hours of lecture and three hours of lab per week. Cross-listed with
[[BIO-343]]. Offered in alternate years.
Click here for course fees.
Pre-Requisites
[[EES-230]] and [[BIO-121]]-122 or permission of the instructor.

EES-344. ECOLOGY
Credits: 4
Ecology examines contemporary ecological thinking as it pertains to the
interrelationships of organisms and their environments. Interactions at the
populations and community level are emphasized. Two hours of lecture
and three hours of lab per week. Cross-listed with [[BIO-344]]. Offered in alternate years.
Click here for course fees.
Pre-Requisites
[[BIO-121]]-122, 223-224, or permission of the instructor.

EES-366. FIELD BOTANY
Credits: 3
This is a specialized summertime field course, which emphasizes a
taxonomic, phylogenetic, and ecological survey of higher plants indigenous
to Northeastern Pennsylvania. Due to the extensive field work, enrollment
is somewhat more restricted than in other courses; therefore, written
permission from the instructor is the primary prerequisite for those
upperclassmen who wish to register for the course. Cross-listed with
[[BIO-366]]. Offered in alternate years.
Click here for course fees.
Pre-Requisites
[[BIO-121]]-122, 223-224, or permission of the instructor.

EES-370. GEOMORPHOLOGY
Credits: 3
Land forms, their evolution, and the human role in changing the surface
of the earth, utilization of geologic and hydrologic information, and field
investigations. Two hours of lecture and three hours of lab per week. Cross
listed with [[GEO-370]].
Click here for course fees.

Pre-Requisites
[[EES-381]]

EES-381. MINERALOGY
Credits: 4
Terms Offered: Not Currently Offered
The systematic study of the major classes of the mineral kingdom utilizing
the department's collection. Concepts in crystal chemistry, crystal structure,
mineral behavior, crystallography and optical mineralogy are studied and
advanced techniques in mineral analysis are used. Three hours of lecture and
three hours of lab per week. Cross listed with [[GEO-281]].
Click here for course fees.
Pre-Requisites
[[EES-211]] and [[CHM-115]].

EES-382. PETROLOGY
Credits: 3
A study of the identification, classification, composition, genesis, and
alteration of igneous, sedimentary, and metamorphic rocks and their relation
to crustal processes and tectonic environments. Two hours of lecture and
three hours of lab per week. Cross listed with [[GEO-282]].
Click here for course fees.
Pre-Requisites
[[EES-381]]

EES-390. SENIOR PROJECTS I
Credits: 3
This course is presented seminar-style, focusing on Environmental Science
topics relevant to current problems, trends, and news. The course serves
as an open and constructive venue where students will have an opportunity
to delve into themed topics and more holistically discuss environmental
science issues. The theme of the course will change each term, but
will remain within the Environmental Sciences: ecology, environmental
chemistry, sustainability, climate change, hazardous waste, etc. Students
are required to read and actively discuss scientific literature, assemble
and analyze relevant data, formulate and criticize quantitative/qualitative
theories, and explore case studies. Three hours of seminar per week.
Requirement: students with senior standing only.

EES-391. SENIOR PROJECTS I
Credits: 1
Design and development of selected projects in earth and environmental
sciences and other related fields under the direction of a staff member.
Technical as well as economical factors will be considered in the design. A
professional paper and detailed progress report are required. Requirements:
Senior standing in Earth and Environmental Sciences and department
permission. (See the department for more details about the department
permission.)
Click here for course fees.
EES-392. SENIOR PROJECTS II
Credits: 2
Design and development of selected projects in earth and environmental sciences and other related fields under the direction of a staff member. Technical as well as economical factors will be considered in the design. A professional paper to be presented and discussed in an open forum is required.

Pre-Requisites: EES-391 or department permission. (See the department for more details about the department permission.)

Click here for course fees.

EES-394. FIELD STUDY
Credits: 1-3
On-site study of an earth or environmental problem or situation incorporating field documentation and investigative techniques. May be repeated for credit when no duplication of experience results. One hour of lecture, plus field trips.

Pre-Requisites: EES-211 and EES-240.

Click here for course fees.

EES-399. COOPERATIVE EDUCATION
Credits: 1-6
Professional cooperative education placement in a private or public organization related to the student's academic objectives and career goals. In addition to their work experience, students are required to submit weekly reaction papers and an academic project to a Faculty Coordinator in the student's discipline. See the Cooperative Education section of this bulletin for placement procedures.

Pre-Requisites: Sophomore standing; minimum 2.0 cumulative GPA; consent of the academic advisor; and approval of placement by the department chairperson.

EES-498. TOPICS
Credits: Varies with topic
Departmental courses on advanced topics of special interest, not extensively treated in regularly scheduled offerings, will be presented under this course number on an occasional basis. Available for either undergraduate or graduate credit. May be repeated for credit.

Pre-Requisites: EGR-200, EGR-201, EGR-214, EGR-219, EGR-222, EGR-327

EGR. ENGINEERING

EGR-200. INTRODUCTION TO MATERIALS SCIENCE
Credits: 3
Application of materials properties to engineering design. Introduction to atomic arrangements, crystal structures, imperfection, phase diagrams, and structure-property relations. Fundamentals of iron, steel, and non-ferrous materials. The behavior of materials in environmental conditions.

Pre-Requisites: CHM-118

EGR-201. PROFESSIONALISM AND ETHICS
Credits: 1
Responsibility of an engineer as a professional; ethics in science and engineering; role of professional societies; recent trends in technological innovations; career planning. Review of professional exam. Requirement: Senior standing in engineering.

EGR-214. MODELING OF PHYSICAL SYSTEMS
Credits: 3
Modeling of physical systems. Engineering applications of Laplace transforms, Fourier series, matrices, statistics and probability, and related topics to solve problems in electromagnetics, heat and mass transfer, control systems, fluid mechanics, robotics, engineering management, and communication systems. Emphasis on the use of simulation packages.

Pre-Requisites: EEE-211, MTH-112.

Click here for course fee.

EGR-219. INTRODUCTION TO WEAPONS SYSTEMS
Credits: 3
Introduction to military weapons and warfare, with a focus on how the modern period has resulted in greater complexity and the development of weapons systems. Basic principles of explosives, internal and exterior ballistics, calculation of probabilities of hit given randomness, fire control, guidance algorithms, radar and other sensors, detection and tracking, nuclear weapons and their effects.


EGR-222. MECHATRONICS
Credits: 3
Introduction to mechatronics system design with emphasis on using sensors to convert engineering system information into an electrical domain, signal conditioning and hardware integration, programming, and using actuators to effect system changes.

Pre-Requisites: EEE-211, EEE-283, ME-140, PHY-202.

Click here for course fees.

EGR-327. THIN FILM PROCESSING
Credits: 3
Nucleation and growth theory; crystalline, amorphous, epitaxial growth morphology. Deposition techniques like DC, RF, magnetron sputtering, ion beam sputtering, evaporation, chemical vapor deposition, physical vapor deposition. Structure, properties, and applications for specific thin film processing techniques.

Pre-Requisites: EEE-211, EEE-283, ME-140, PHY-202.

Click here for course fees.

EGR-391. SENIOR PROJECTS I
Credits: 1
Design and development of selected projects in the field of engineering under the direction of a staff member. Technical as well as economic factors will be considered in the design. A professional paper and detailed progress report are required.

Pre-Requisites: Senior standing in engineering.

Click here for course fees.
EGR-392. SENIOR PROJECTS II
Credits: 2
Design and development of selected projects in the field of engineering under the direction of a staff member. Technical as well as economic factors will be considered in the design. This is a continuation of EGR-391. A professional paper to be presented and discussed in an open forum is required.

Click here for course fees.

Pre-Requisites
[EGR-391]

EGR-399. COOPERATIVE EDUCATION
Credits: 1-6
Professional cooperative education placement in a private or public organization related to the student’s academic objectives and career goals. In addition to their work experiences, students are required to submit weekly reaction papers and an academic project to a Faculty Coordinator in the student’s discipline. See the Cooperative Education section of this bulletin for placement procedures. Requirements: Junior standing; minimum 2.0 cumulative GPA; consent of the academic advisor; and approval of placement by the department chairperson.

EGR-498. LABORATORY TOPICS
Credits: Varies with topic
A study of topics of special interest not extensively treated in regularly offered laboratory courses.

Click here for course fee.

Pre-Requisites
Will vary according to the specific topics course.

PHY. PHYSICS

PHY-198-298-398. TOPICS IN PHYSICS
Credits: variable
Selected topics in the field of physics. These may include one or more of the following: astronomy; geophysics; biophysics; nuclear power and waste; relativity; quantum mechanics; semi-conductors; cryogenics; health physics. May be repeated for credit.

Pre-Requisites
Varies with topic studied.

PHY-395-396. INDEPENDENT RESEARCH
Credits: 1 - 3
Independent study and research for advanced students in the field of physics under the direction of a staff member. A research paper at a level significantly beyond a term paper is required.

Pre-Requisites
Senior standing and approval of the department chairperson.

PHY-105. CONCEPTS IN PHYSICS
Credits: 3
Basic concepts of physical science, including the scientific method, will be studied. Theories, laws, and experiments from mechanics, electricity and magnetism, thermodynamics, optics, and atomic and nuclear physics may be included. Viewpoints will be classical and modern, including quantum and relativistic. Class meets for four hours per week: two hours of lecture and one two-hour lab each week.

Click here for course fees.

Pre-Requisites
No previous background in either science or college-level mathematics is required.

PHY-170. CONCEPTS IN PHYSICS AND CHEMISTRY
Credits: 4
An overview of Classical Mechanics, Thermodynamics, and the elementary principles of modern physics, including selected topics in basic chemistry and applications to human health. Emphasis is placed on basic physical and chemical principles and on algebraic calculations, scaling, units conversions, Cartesian graphing, acid and base reactions, and numerical problem solving. Three hours of demonstration and lecture, one hour of recitation, and two hours of lab per week.

Click here for course fees.

Pre-Requisites
Previous courses in chemistry, algebra, and geometry.

PHY-171. PRINCIPLES OF CLASSICAL AND MODERN PHYSICS
Credits: 4
An introductory course designed to promote and understanding of the more important fundamental laws and methods of mechanics and electricity and magnetism. Laboratory work to emphasize basic principles and to acquaint the student with measuring instruments and their use, as well as the interpretation of experimental data. Three hours of demonstration and lecture, one hour of recitation, and two hours of lab per week. Co-requisite: [MTH-111]

Click here for course fees.

PHY-174. APPLICATION OF CLASSICAL AND MODERN PHYSICS
Credits: 4
An introductory course designed to promote an understanding of the more important fundamental laws and methods of heat, optics, and modern physics. Laboratory work to emphasize basic principles and to acquaint the student with measuring instruments and their use, as well as the interpretation of experimental data. Three hours of demonstration and lecture, one hour of recitation, and two hours of lab per week. Co-requisite: [MTH-111]

Click here for course fees.

PHY-201. GENERAL PHYSICS I
Credits: 4
A thorough grounding in the concepts, principles, and laws of mechanics, thermodynamics, and wave motion. Instruction by demonstration and lecture, recitation, problem solving, and experimental work. Three hours of demonstration and lecture, one hour of recitation, and two hours of lab per week. Co-requisite: [MTH-111]

Click here for course fees.
PHY-202. GENERAL PHYSICS II  
**Credits:** 4  
Electricity and magnetism, optics and light. Three hours of demonstration and lecture, one hour of recitation, and two hours of lab per week.  
*[Click here for course fees.]*

**Pre-Requisites**  
[[PHY-201]]. Co-requisite [[MTH-112]].

PHY-203. MODERN PHYSICS  
**Credits:** 3  
Modern physics including the experimental basis, concepts, and principles of atomic and nuclear physics. Three hours of demonstration and lecture per week.

**Pre-Requisites**  
[[PHY-202]].

PHY-206. MODERN PHYSICS LAB  
**Credits:** 1  
Experiments leading to the development of relativity and quantum theory to reinforce abstract concepts in EM theory, relativity, statistical mechanics, quantum mechanics, solid state physics, and nuclear physics.  
*[Click here for course fee.]*

**Pre-Requisites**  
[[PHY-202]].

**Co-Requisites**  
[[PHY-203]].

PHY-214. MODELING OF PHYSICAL SYSTEMS  
**Credits:** 3  
Modeling of various problems in physical, chemical, biological, and environmental sciences, particularly physical dynamical systems; Includes application of ordinary differential equations, and Laplace, Fourier, and Z transforms to continuous and discrete processes, matrix mechanics and eigenvalue problems, statistics and probability, random processes and distribution functions.  
2 hours of lecture and 2 hours of laboratory per week.  
*[Click here for course fee.]*

**Pre-Requisites**  
[[MTH-211]], [[EGR-140]] or [[CS-125]].

PHY-311. THERMODYNAMICS & STATISTICAL MECHANICS  
**Credits:** 3  
This course focuses on the laws of thermodynamics and other thermodynamic concepts including entropy, free energy, equilibrium, and fluctuations as well as their pivotal role in physics and other scientific disciplines. Topics in statistical mechanics will be covered including partition functions, ensembles, kinetic theory, and phase transitions. Three hours of lecture per week.

**Pre-Requisites**  
[[PHY-203]] and [[MTH-211]].

PHY-312. ANALYTICAL MECHANICS  
**Credits:** 3  
Employs advanced mathematical tools to study applications in complex mechanical systems. It offers an advanced differential reformulation of Newton’s laws to study dynamical systems in multiple dimensions, conservative force fields, damped and driven oscillations, two-body problem, central forces and planetary motion, and the rotational dynamics of rigid bodies. Additionally, the course delivers a thorough grounding on the calculus of variations, Lagrange’s formalism and Hamiltonian mechanics, all being the essential foundations for the development of modern physics (relativity, quantum mechanics, and quantum field theory). Three hours of lecture per week.

**Pre-Requisites**  
[[PHY-202]] and [[MTH-211]].

PHY-314. QUANTUM MECHANICS  
**Credits:** 3  
This course presents an intermediate level of Quantum Mechanics using the abstract formulation of linear vector spaces in the Dirac formalism. Topics covered include: spin, addition of angular momentum, scattering and bound particles, the harmonic oscillator, two-body problem and central potential wells in 3D, H-atom and H-like atoms, time-independent perturbation theory, identical particles and the He-atom. In addition to the foundations of Quantum Mechanics, the course offers a selection of advanced and modern topics like entanglement and quantum teleportation. Three hours of lecture per week.

**Pre-Requisites**  
[[PHY-203]], [[CHM-115]], [[MTH-211]], and [[MTH-212]].

PHY-374. IMAGING IN BIOMEDICINE  
**Credits:** 3  
This course will cover different aspects of imaging important to medicine and biomedicine including optical microscopy, scanning probe microscopy, scanning electron microscopy, magnetic resonance, ultrasound X-ray, nuclear radiation, microwave and electro-/magnetoencephalographic techniques as well as image processing. Three hours of lecture and three hours of lab per week.  
*[Click here for course fee.]*

**Pre-Requisites**  
[[PHY-201]] & [[PHY-202]] or [[PHY-171]] & [[PHY-174]], [[MTH-112]].

PHY-377. BIOPHYSICS  
**Credits:** 3  
This course presents an overview of the important physical principles governing the behavior of cells and macromolecules. Upper-level mathematics that are useful to understand these phenomena are introduced in a way that is comprehensible to biology majors lacking background beyond basic calculus. In addition to the physical models governing the most ubiquitous molecular and cellular processes, the physics behind the most common experimental techniques used in biology, bioengineering, and biophysics are covered. Three hours of lecture and two hours of lab per week.

**Pre-Requisites**  
[[PHY-201]] & [[PHY-202]] or [[PHY-171]] & [[PHY-174]], [[MTH-112]].
PHY-391. SENIOR PROJECT I  
Credits: 1  
Students will plan and execute a research project in the field of physics or at the intersection of physics and another related discipline. Projects can be theoretical, experimental or both and can include the design of unique experiments and simulations. A detailed progress report and presentation are required. Students pursuing a dual degree or double major may be eligible to combine this project with the capstone project of another program (subject to the approval of their advisors in both programs).  
Click here for course fee.  

Pre-Requisites  
Senior standing in Physics  

PHY-392. SENIOR PROJECT II  
Credits: 2  
Students will plan and execute a research project in the field of physics or at the intersection of physics and another related discipline. This is a continuation of PHY 391. A professional paper and progress report are required. Students will present the results of their work in an open-forum. Students pursuing a dual degree or double major may be eligible to combine this project with the capstone project of another program (subject to the approval of their advisors in both programs).  
Click here for course fee.  

Pre-Requisites  
[PHY-391]