Department of Electrical Engineering and Physics

Chairperson: Mr. Robert R. Taylor

Faculty

Professors: Srinivasan
Associate Professors: Harms, Lucent, Nazzal, Sabouni
Assistant Professors: Du, Sha
Faculty Emeriti: Placek
Staff: Saporito, Stapleton

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 – 19-21

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; Embedded Computing Systems; 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 to have the:

1. Ability to apply knowledge of mathematics, science, and engineering.
2. Ability to design and conduct experiments and 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, 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 and 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.

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.
DEPARTMENT OF ELECTRICAL ENGINEERING AND PHYSICS

Honors in Electrical Engineering

Upon the recommendation and approval of the faculty of the Electrical Engineering and Physics Department, an honor student in Electrical 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 Electrical 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 Activities Council (ESAC). Students also participate in various on-campus activities and design competitions.

Transfer Credit Policy

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

Cooperative Education

An important feature of the electrical engineering program is the Cooperative Education experience, a valuable option usually scheduled between the junior and senior years. An internship is strongly encouraged through summers and senior year even if it isn't taken for credit. 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. The co-op option for credit can only be taken one time for either 3 or 6 credits as described below:

1. The requirements for the 6 credit hours co-op are as follows:
   a) The co-op project should distinctly demonstrate an engineering design & analysis component.
   b) The student, working with his or her manager, should submit weekly project reports to the faculty advisor.
   c) The working hours should not be less than 20 hours per week and the total 300 hours should spread out at least 10 weeks.
   d) The student should make a 15 minute final oral presentation to a general audience.
   e) The student should submit a final project report of approximately 25 pages (double-spaced) for the body of the report with no limit on details to be included in an appendix. The final report should include at least the background of the company, project background, technical work, and project reflection.

2. The requirements for the 3 credit hours co-op are as follows:
   a) The co-op project should distinctly demonstrate an engineering component.
   b) The student, working with his or her manager, should submit bi-weekly project reports to the faculty advisor.
   c) The working hours should not be less than 10 hours per week and the total 150 hours should spread out at least 10 weeks.
   d) The student should make a 10 minute final oral presentation to a general audience.
   e) The student should submit a final project report of approximately 15 pages (double-spaced) for the body of the report with no limit on details to be included in an appendix. The final report should include at least the background of the company, project background, technical work, and project reflection.
COMPUTER ENGINEERING
MINOR

Computer Engineering Minor

A 19 to 21-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:

[[EE-140]] - Scientific Programming or [[CS-125]] – Computer Science I
[[EE-247]] - Programming for Embedded Applications or [[CS-126]] – Computer Science II
[[EE-241]] – Digital Design
[[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)

Computer Science................................................................. 8
Electrical Engineering............................................................. 11
Engineering............................................................................ 16
Mechanical Engineering......................................................... 17
Physics.................................................................................. 20
# ELECTRICAL ENGINEERING

## Electrical Engineering

### Electrical Engineering Major - 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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<tr>
<td>[MTH-111]</td>
<td>Calculus I</td>
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<tr>
<td>[CHM-117]</td>
<td>Chemistry Lab for Engineers</td>
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<td>[CHM-118]</td>
<td>Chemistry for Engineers</td>
<td>3</td>
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<td>[ME-180]</td>
<td>CADD Lab</td>
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<td>[ENG-101]</td>
<td>English Composition</td>
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<td>[FYF-101]</td>
<td>First-Year Foundations</td>
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#### Second Semester

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<tr>
<td>[MTH-112]</td>
<td>Calculus II</td>
<td>4</td>
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<tr>
<td>[PHY-201]</td>
<td>General Physics I</td>
<td>3</td>
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<tr>
<td>[PHY-204]</td>
<td>General Physics I Lab</td>
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<tr>
<td>[EE-140]</td>
<td>Scientific Programming</td>
<td>3</td>
</tr>
<tr>
<td>[EE-216]</td>
<td>Circuit Analysis I</td>
<td>3</td>
</tr>
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<td></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>
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<tr>
<td>[PHY-202]</td>
<td>General Physics II</td>
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<td>[PHY-205]</td>
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<td>[EE-217]</td>
<td>Circuit Analysis II</td>
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<td>[EE-285]</td>
<td>Electrical Circuits Lab</td>
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<td>[ME-231]</td>
<td>Statics</td>
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<tr>
<td>[MTH-212]</td>
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<td>[EE-251]</td>
<td>Electronics I</td>
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<td>[EE-222]</td>
<td>Mechatronics</td>
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</tr>
<tr>
<td>[EE-241]</td>
<td>Digital Design</td>
<td>4</td>
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#### Fifth Semester

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<tr>
<td>[EE-252]</td>
<td>Electronics II</td>
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<tr>
<td>[EE-271]</td>
<td>Semiconductor Devices</td>
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#### Sixth Semester

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<tr>
<td>[EE-381]</td>
<td>Microfabrication Lab</td>
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<td>Technical Elective*</td>
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<td></td>
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<td>3</td>
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#### Seventh Semester

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<tr>
<td>[EGR-399]</td>
<td>Cooperative Education** OR</td>
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<td>Technical Electives*</td>
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<tr>
<td>[PHY-203]</td>
<td>Modern Physics</td>
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<td>[PHY-206]</td>
<td>Modern Physics Lab</td>
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<tr>
<td>[EGR-201]</td>
<td>Professionalism and Ethics</td>
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<td>General Education</td>
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<td>[EGM-320]</td>
<td>Engineering Project Analysis</td>
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<tr>
<td>[EE-339]</td>
<td>Electromagnetics II</td>
<td>4</td>
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<tr>
<td>[EE-382]</td>
<td>Modern Communication Systems</td>
<td>4</td>
</tr>
<tr>
<td>[EE-392]</td>
<td>Senior Projects II</td>
<td>2</td>
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<td></td>
<td>Technical Elective*</td>
<td>3</td>
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<td></td>
<td>Free Elective***</td>
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<td></td>
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*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.

*** Free elective may be chosen from any course numbered 101 or above.
## 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

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<th>Course Code</th>
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<th>Credits</th>
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<tr>
<td>MTH-111</td>
<td>Calculus I*</td>
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<tr>
<td>CHM-115</td>
<td>Elements and Compounds* OR [CHM-118] Chemistry for Engineers*</td>
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<td>CHM-113</td>
<td>Elements and Compounds Lab* OR [CHM-117] Intro Chemistry Lab for Engineers*</td>
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<td>ENG-101</td>
<td>Composition</td>
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**Total Credits:** 15

#### Second Semester

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<tr>
<td>MTH-112</td>
<td>Calculus II*</td>
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<td>PHY-201</td>
<td>General Physics I*</td>
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<tr>
<td>PHY-204</td>
<td>General Physics I Lab*</td>
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<td>EE-140</td>
<td>Scientific Programming**</td>
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**Total Credits:** 15

#### Third Semester

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<td>PHY-205</td>
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<td>Physics Elective @</td>
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**Total Credits:** 17

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<td>Modern Physics*</td>
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<td>PHY-206</td>
<td>Modern Physics Lab*</td>
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**Total Credits:** 17

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<th>Course Title</th>
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<tr>
<td>PHY-311</td>
<td>Thermodynamics*</td>
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<td>PHY-312</td>
<td>Analytical Mechanics*</td>
<td>3</td>
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<td>EE-337</td>
<td>Electromagnetics I*</td>
<td>3</td>
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<tr>
<td>Electives@</td>
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**Total Credits:** 15

#### Fifth Semester

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<td>PHY-314</td>
<td>Quantum Mechanics*</td>
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**Total Credits:** 15

#### Sixth Semester

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<tr>
<td>PHY-391</td>
<td>Senior Project I*</td>
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**Total Credits:** 13

#### Seventh Semester

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<td>PHY-392</td>
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<td>Free Electives</td>
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**Total Credits:** 14

*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.**

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-371)] – Teaching Methods in Science with Field Experience - 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
  - Attain a 3.0 GPA
  - Complete 48 credits including six credits in both Mathematics and English
  - Pass a test of basic skills
  - Submit required clearances showing "no record"
- To remain in the Teacher Education Program, candidates must
  - Maintain a 3.0 GPA
  - Adhere to the Code of Professionalism and Academic Honesty
- To be certified as a teacher in Pennsylvania in grades 7-12, candidates must
  - Successfully complete all required Education courses, including student teaching
  - Graduate with a 3.0 cumulative GPA
  - Pass the appropriate exit test(s) in their content area
  - Apply for certification through the Pennsylvania Teacher Information Management System (TIMS).
PHYSICS MINOR

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:

Twelve credits of required introductory courses in Physics:

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<tr>
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<tbody>
<tr>
<td>PHY-201</td>
<td>General Physics</td>
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<td>PHY-202</td>
<td>General Physics II</td>
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<td>PHY-205</td>
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<td>PHY-203</td>
<td>General Physics III</td>
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<tr>
<td>PHY-206</td>
<td>General Physics III Lab</td>
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AND

Three credits of required advanced courses selected from the following:

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<th>Course Title</th>
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<tr>
<td>PHY-311</td>
<td>Thermodynamics and Statistical Mechanics</td>
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<td>PHY-312</td>
<td>Analytical Mechanics</td>
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<td>PHY-314</td>
<td>Quantum Mechanics</td>
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AND

Additional six credits of electives selected from the following: (Classes taken in above list may not be duplicated for credit.)

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<thead>
<tr>
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<tr>
<td>PHY-311</td>
<td>Thermodynamics and Statistical Mechanics</td>
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<tr>
<td>PHY-312</td>
<td>Analytical Mechanics</td>
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<td>PHY-314</td>
<td>Quantum Mechanics</td>
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<tr>
<td>CHM-351</td>
<td>Physical Chemistry I: Quantum and Spectroscopy</td>
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<tr>
<td>CHM-352</td>
<td>Physical Chemistry II: Kinetics and Thermodynamics</td>
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<td>EES-251</td>
<td>Synoptic Meteorology</td>
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<td>EES-280</td>
<td>Principles of Astronomy</td>
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<td>EE-337</td>
<td>Electromagnetics I</td>
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<td>EGR-200</td>
<td>Introduction to Materials Science</td>
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<td>ME-231</td>
<td>Statics</td>
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<td>ME-321</td>
<td>Fluid Mechanics</td>
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<tr>
<td>ME-322</td>
<td>Engineering Thermodynamics</td>
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<tr>
<td>MTH-361</td>
<td>Partial Differential Equations</td>
<td>3</td>
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<td>MTH-362</td>
<td>Advanced Calculus</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.......................................................... 20
Engineering..................................................... 16
Earth and Environmental Sciences......................... 13
CS. COMPUTER SCIENCE

CS-198, CS-298, CS-398. TOPICS IN COMPUTER SCIENCE
Credits: Variable
Study of one or more special topics in computer science. May be repeated for credit if different topics are emphasized. Offered when demand warrants.

Pre-Requisites
Varies with topic

CS-115. COMPUTERS AND APPLICATIONS
Credits: 3
An introduction to computers and computing, with emphasis on personal computing in both the Windows and OS X operating systems. Extensive hands-on experience will involve the application of current commercial software (including word processing, database, and spreadsheet). Not open to students who have received credit in any 200-level CS course. Students majoring in either Computer Science or Computer Information Systems will not receive credit for this course.

CS-125. COMPUTER SCIENCE I
Credits: 4
Introduction to information technology and programming (history of computing, text editors, word processing, spreadsheets, introduction to programming), basic data types, functions, decision structures, loops, one- and two-dimensional list structures, testing, debugging, and an introduction to computer graphics. Three hours of lecture and two hours of lab per week. Offered every fall and spring.

Pre-Requisites
Secondary mathematics, including geometry and algebra II.

CS-126. COMPUTER SCIENCE II
Credits: 4
A study of advanced programming concepts, structures, and techniques (professional and ethical issues, testing and debugging, fundamentals of programming, basic data structures—strings, lists, multidimensional arrays, objects, hashes, inheritance, polymorphism, recursion, divide and conquer, machine representation of data, hardware components, machine instructions). Three hours of lecture and two hours of lab per week. Offered every fall and spring.

Pre-Requisites
([CS-125]) with grade of 2.0 or better OR equivalent programming experience.

CS-225. COMPUTER SCIENCE III
Credits: 3
A study of the use of a high-level language to implement basic data structures such as strings, lists, arrays, objects, and hashes, and their application to searching, sorting, and hashing. Representation of numbers and strings at the machine level. The course will also include an introduction to the concepts of algorithm design and problem solving with an emphasis on algorithm development, analysis, and refinement. Offered every fall.

Pre-Requisites
([CS-126]) with grade of 2.0 or better

CS-226. COMPUTER SCIENCE IV
Credits: 3
A continuation of ([CS-225]). Topics include programming language paradigms, advanced use of word processors and spreadsheets, including macros, linked data structures, and an introduction to discrete mathematics, including counting, probability, and graphs. Offered every spring.

Pre-Requisites
([CS-225]) with grade of 2.0 or better

CS-246. C AND UNIX
Credits: 3
An introduction to using Unix operating systems, including shells, file manipulation, text editors, filters, and regular expressions. Fundamentals of C programming, including loops, arrays, functions, recursion, pointers, structures, unions, input/output, and system calls.

Pre-Requisites
([CS-125]) with grade of 2.0 or better

CS-265. MEDICAL INFORMATICS
Credits: 3
This course will cover basic principles of computer use and information management in health care (including general medicine, dentistry, optometry, and pharmacy). Topics will include basic computing concepts, the characteristics of medical data, and the use of computers in the administrative, diagnostic, and research oriented medical tasks. The course is primarily directed towards students who intend to pursue careers in health-related fields. Offered every spring.

Pre-Requisites
([CS-226])

CS-283. WEB DEVELOPMENT I
Credits: 3
An introduction to the development of interactive web sites, including HTML, JavaScript, forms and CGI programs; server side includes cookies, web server configuration and maintenance. Offered in the fall semester of odd-numbered years when demand warrants.

Pre-Requisites
([CS-126])

CS-285. MOBILE APPLICATIONS
Credits: 3
An introduction to programming mobile application development. Topics will include cross-platform development; user interface design; touchscreen, GPS, and motion sensing input; memory management; cloud services and network utilization; security and trust considerations; data privacy and ethics.

Pre-Requisites
([CS-126] and [CS-246]).
CS-317. SOFTWARE INTEGRATION
Credits: 3
An introduction to the integration of application programs, including email clients, word processors, spreadsheets, and database systems using Microsoft Office and Visual Basic.
Click here for course fee.
Pre-Requisites
[[CS-126]].

CS-319. PRINCIPLES OF PROGRAMMING LANGUAGES
Credits: 3
A study of the principles that govern the design and implementation of programming languages. Topics include language structure, data types, and control structures. Programming projects will familiarize students with features of programming languages through their implementation in interpreters.
Click here for course fee.
Pre-Requisites
[[CS-226]].

CS-321. SIMULATION AND DATA ANALYSIS
Credits: 3
Methods of handling large databases, including statistical analysis and computer simulations. The emphasis will be upon discrete simulation models with a discussion of relevant computer languages: ARENA, GPSS, and SIMSCRIPT.
Click here for course fee.
Pre-Requisites
[[CS-125]] and [[MTH-111]].

CS-323. THEORY OF COMPUTATION
Credits: 3
This course formalizes many topics encountered in previous computing courses. Topics include languages, grammars, finite automata, regular expressions and grammars, context-free languages, push-down automata, Turing machines, and computability.
Click here for course fee.
Pre-Requisites
[[CS-126]] and [[MTH-231]].

CS-324. SYSTEMS ANALYSIS
Credits: 3
Fees:
A study of the design and implementation of large computer projects. Special emphasis is placed on applications to business systems. Students will use a CASE tool for automated systems analysis and design.
Click here for course fee.
Pre-Requisites
[[CS-225]].

CS-325. DATABASE MANAGEMENT
Credits: 3
Terms Offered: Winter
Practical experience involving the fundamental concepts of database systems including data modeling; query languages; database management system implementation; management of semi-structured and multimedia data; distributed and nosql databases
Click here for course fee.
Pre-Requisites
[[CS-126]].

CS-326. OPERATING SYSTEM PRINCIPLES
Credits: 3
Analysis of the computer operating systems, including Batch, Timesharing, and Realtime systems. Topics include sequential and concurrent processes, processor and storage management, resource protection, processor multiplexing, and handling of interrupts from peripheral devices.
Click here for course fee.
Pre-Requisites
[[CS-226]].

CS-327. COMPILER DESIGN
Credits: 3
A study of compiler design, including language definition, syntactic analysis, lexical analysis, storage allocation, error detection and recovery, code generation, and optimization problems.
Click here for course fee.
Pre-Requisites
[[CS-226]].

CS-328. ALGORITHMS
Credits: 3
Theoretical analysis of various algorithms. Topics are chosen from sorting, searching, selection, matrix multiplication of real numbers, and various combinatorial algorithms.
Click here for course fee.
Pre-Requisites
[[CS-226]] and [[MTH-232]].

CS-330. COMPUTER ARCHITECTURE
Credits: 3
A study of the design, organization, and structure of computers, ranging from the microprocessors to the latest 'supercomputers.' An emphasis will be placed on machine language, instruction formats, addressing modes, and machine representation of numbers.
Click here for course fee.
Pre-Requisites
[[CS-226]].

CS-334. SOFTWARE ENGINEERING
Credits: 3
A course in 'programming in the large.' Topics include software design, implementation, validation, maintenance, and documentation. There will be one or more team projects.
Click here for course fee.
Pre-Requisites
[[CS-226]].
CS-335. DATA SCIENCE AND INFORMATION RETRIEVAL
Credits: 3
Practical experience involving unstructured data collections. Topics cover big data, data mining, predictive modeling, decision analysis and indexing and retrieval including probabilities, clustering, thesauri and passage based retrieval strategies.
Click here for course fee.
Pre-Requisites
[[CS-325]] or [[CS-340]]

CS-340. ARTIFICIAL INTELLIGENCE
Credits: 3
This course will provide an overview of artificial intelligence (AI) application areas and hands-on experience with some common AI computational tools. Topics include search, natural language processing, theorem proving, planning, machine learning, robotics, vision, knowledge-based systems (expert systems), and neural networks.
Click here for course fee.
Pre-Requisites
[[CS-126]].

CS-350. OBJECT-ORIENTED PROGRAMMING
Credits: 3
Object-oriented concepts and their application to human-computer interaction. Concepts to be covered include objects, classes, inheritance, polymorphism, design patterns, GUI interface guidelines, and design of interfaces. There will be programming projects in one or more object-oriented languages using one or more GUI interface guidelines.
Click here for course fee.
Pre-Requisites
[[CS-126]].

CS-355. COMPUTER NETWORKS
Credits: 3
This course introduces basic concepts, architecture, and widely used protocols of computer networks. Topics include the Open System Interconnection (OSI) model consisting of physical link layer, data layer, network layer, transport layer, session layer, presentation layer, and application layer, the medium access sublayer and LAN, various routing protocols, Transmission Control Protocol (TCP), and Internet Protocol (IP) for internetworking.
Click here for course fee.
Pre-Requisites
[[CS-225]] and  [[CS-246]]

CS-363. OPERATIONS RESEARCH
Credits: 3
A survey of operations research topics such as decision analysis, inventory models, queuing models, dynamic programming, network models and linear programming. Cross-listed with [[MTH-363]].
Click here for course fee.
Pre-Requisites
[[CS-125]], and [[MTH-111]].

CS-364. NUMERICAL ANALYSIS
Credits: 3
An introduction to numerical algorithms as tools to providing solutions to common problems formulated in mathematics, science, and engineering. Focus is given to developing the basic understanding of the construction of numerical algorithms, their applicability, and their limitations. Cross-listed with [[MTH-364]]. Offered Spring odd years.
Pre-Requisites
[[MTH-211]]and [[CS-125]] (or equivalent programming experience).

CS-366. 3 DIMENSIONAL ENVIRONMENTS AND ANIMATION
Credits: 3
This course will explore the foundations of 3-dimensional animation processes as they apply to multiple mediums. Students will build computer-based models and environments, texture, light, animate, and render content for Integrative Media projects or as stand-alone pieces. Cross-listed with [[IM-350]].
Click here for course fee.
Pre-Requisites
[[CS-126]] or [[IM-201]].

CS-367. COMPUTER GRAPHICS
Credits: 3
Fees:
Introduction to equipment and techniques used to generate graphical representation by computer. Discussion of the mathematical techniques necessary to draw objects in two- and three-dimensional space. Emphasis on application programming and the use of a high-resolution color raster display.
Click here for course fee.
Pre-Requisites
[[CS-226]].

CS-368. 3 DIMENSIONAL GAME DEVELOPMENT
Credits: 3
An overview of simulation, engine-based, and real-time game systems with a focus on theory, creation, and animation of three-dimensional models used within a game context. Cross-listed with [[IM-368]].
Click here for course fee.
Pre-Requisites
[[CS-366]]/IM 350 or [[CS-367]].

CS-370. SPECIAL PROJECTS
Credits: variable
Requirements: Senior standing and approval of the department chairperson.

CS-383. WEB DEVELOPMENT II
Credits: 3
An introduction to the development of dynamic, database-driven sites, including active server pages, PHP, authentication, session tracking and security, and the development of shopping cart and portal systems.
Click here for course fee.
Pre-Requisites
[[CS-283]], [[CS-325]].
CS-391. SENIOR PROJECTS I  
Credits: 1  
Design and implementation of a software project under the direction of a faculty member. Students will normally work in teams. Detailed requirements and design documents are required and will be presented at the end of the semester. Offered every fall.  
Click here for course fee.  

Pre-Requisites  
[CS-334] or [CS-324].

CS-392. SENIOR PROJECTS II  
Credits: 2  
Design and implementation of a software project under the direction of a faculty member. Students will normally work in teams. Production of a finished product, including software and documentation, is required. There will be an open forum presentation of the project at the end of the semester. Offered every spring.  
Click here for course fee.

Pre-Requisites  
[CS-391].

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

EE. ELECTRICAL ENGINEERING

EE-140. SCIENTIFIC PROGRAMMING  
Credits: 3  
Fees: $115  
This course presents an introduction to computer programming with an emphasis on the techniques needed for data analysis and numerical problem solving for scientific and engineering applications. Basic programming idioms are presented including control structures, data types, methods for handling input and output as well as numerical methods such as array computing and vectorization. Emphasis is placed on proper software engineering practice as well as data analysis and presentation. Two hours of lecture and two hours of lab per week.  
Pre-Requisites  
Or Concurrent [MTH-100] or [MTH-111]

EE-211. ELECTRICAL CIRCUITS AND DEVICES  
Credits: 3  
Basic DC and sinusoidal AC analysis of circuits. Introductory principles of electronic circuits, operational amplifiers, filters, digital logic, energy conversion devices, and energy conversion schemes.  
Co-Requisites  
[EE-283] and [MTH-112] Or Concurrent

EE-216. CIRCUIT ANALYSIS I  
Credits: 3  
Fees: $115  
Analysis of dc and sinusoidal ac circuits and power calculations. Network theorems. 2-hour lecture and 2-hour lab per week.  
Pre-Requisites  
Or Concurrent [MTH-111]

EE-217. CIRCUIT ANALYSIS II  
Credits: 3  
Three-phase circuits, mutually coupled circuits, filter circuits, transient circuits, two-port parameters. Introduction to electronic circuits.  
Pre-Requisites  
[MTH-112] or Concurrent and [EE-216] or [EE-211]

EE-222. MECHATRONICS  
Credits: 3  
Fees: $115  
Introduction to mechatronics system design. Use of sensors to convert engineering system information into an electrical domain. Sensor conditioning and digital conversion. Microcontroller resources and programming. Actuators, including brushed and brushless motor types and driver electronics. System integration and modeling.  
Pre-Requisites  
[EE-211], [EE-283], [EE-140], [PHY-202]  
OR Concurrent [EE241], [EE251]

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.  
Pre-Requisites  
[EE-283] or [EE-285]

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 fee.  
Pre-Requisites  
[EE-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] or [EE-216]
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], [MTH-112], [PHY-202], and either [EE-283] or [EE-285]

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. Homojunction and heterojunction bipolar transistors. Unipolar devices including MOS capacitor and MOSFET. Microwave and photonic devices. Three hours of lecture and one two-hour lab per week.

Pre-Requisites
[CHM-117], [CHM-118], [PHY-202], [MTH211]

EE-283. ELECTRICAL ENGINEERING LAB
Credits: 1
Fees: $115
Exercises on DC and AC circuits, resonant and filter circuits, operational amplifiers, and digital logic circuits. One two-hour lab per week.

Co-Requisites
Or Concurrent [EE-211]

EE-285. ELECTRICAL CIRCUITS LAB
Credits: 1
Fees: $115
Exercises on DC and AC circuits, three-phase circuits, operational amplifiers, resonant and filter circuits, and basic electronic circuits. One two-hour lab per week.

Pre-Requisites
Or Concurrent [EE-217]

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
[PHY-214] and [EE-217] (or [EE-211])

EE-325. ENERGY CONVERSION DEVICES
Credits: 3

Pre-Requisites
[EE-251] and [EE-217]

EE-337. ENGINEERING ELECTROMAGNETICS I
Credits: 3
Terms Offered: Fall
Obtain an understanding of Maxwell’s equations and be able to apply them to solving practical electromagnetic field problems. Fundamental concepts covered will include laws governing electrodynamics, plane wave propagation in different media, power flow, polarization, transmission and reflection at an interface, microwave networks, waveguides, radiation, and antennas. Experiment and computer simulation based laboratories are used to reinforce the course material. Three hours of lecture and one three-hour lab per week.

Pre-Requisites
[CHM-117], [CHM-118], [PHY-202]

EE-339. ENGINEERING ELECTROMAGNETICS II
Credits: 4
Terms Offered: Spring
Obtain an understanding of Maxwell’s equations and be able to apply them to solving practical electromagnetic field problems. Fundamental concepts covered will include laws governing electrodynamics, plane wave propagation in different media, power flow, polarization, transmission and reflection at an interface, microwave networks, waveguides, radiation, and antennas. Experiment and computer simulation based laboratories are used to reinforce the course material. Three hours of lecture and one three-hour lab per week.

Pre-Requisites
[CHM-117], [CHM-118], [PHY-202]

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.

Pre-Requisites
Or Concurrent [EE-217]

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-337. ENGINEERING ELECTROMAGNETICS I
Credits: 3
Terms Offered: Fall
Obtain an understanding of Maxwell’s equations and be able to apply them to solving practical electromagnetic field problems. Fundamental concepts covered will include laws governing electrodynamics, plane wave propagation in different media, power flow, polarization, transmission and reflection at an interface, microwave networks, waveguides, radiation, and antennas. Experiment and computer simulation based laboratories are used to reinforce the course material. Three hours of lecture and one three-hour lab per week.

Pre-Requisites
[CHM-117], [CHM-118], [PHY-202]

EE-339. ENGINEERING ELECTROMAGNETICS II
Credits: 4
Terms Offered: Spring
Obtain an understanding of Maxwell’s equations and be able to apply them to solving practical electromagnetic field problems. Fundamental concepts covered will include laws governing electrodynamics, plane wave propagation in different media, power flow, polarization, transmission and reflection at an interface, microwave networks, waveguides, radiation, and antennas. Experiment and computer simulation based laboratories are used to reinforce the course material. Three hours of lecture and one three-hour lab per week.

Pre-Requisites
[CHM-117], [CHM-118], [PHY-202]

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.

Pre-Requisites
Or Concurrent [EE-217]

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 three-hour lab per week. Requirement: Junior engineering standing (All Freshman and Sophomore EE courses and ENG 101 completed)  
Click here for course fee.

Pre-Requisites  
Or Concurrent [[EE-271]], [[EE-251]]

EE-382. MODERN COMMUNICATION SYSTEMS  
Credits: 4  
Terms Offered: Spring  
The modern communication system course is intended to provide an introduction to communication systems from a signal processing point of view. The main topics covered include the fundamentals of analog and digital modulation, modeling random signals and noise in communication systems, and elements of digital receivers. Laboratories provide hands-on experience with circuits and measurement instruments as well as an introduction to communication system simulation using Matlab/Simulink.  
Click here for course fee.

Pre-Requisites  
[[EE-252]], [[PHY-214]], [[MTH-212]]

EE-391. SENIOR PROJECTS I  
Credits: 1  
Design and development 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. A professional paper and detailed progress report are required. Requirement: Senior standing in engineering.  
Click here for course fees.

Pre-Requisites  
[[EGM-320]]

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-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.

Co-Requisites  
[[EES-210]]

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  
[[PHL-101]] or [[EES-240]] or permission of the instructor.

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.

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 permission of the instructor.  
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  
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.  
Prerequisite: EES 271 or permission of the instructor.  
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.  
Prerequisite: EES 271 or permission of the instructor.  
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. SCIENCE RESEARCH AND COMMUNICATION
Credits: 1
The aim for this course is to provide students with the necessary foundation to think critically about scientific research and communication. The course introduces students to the (1) philosophy of science, (2) design, execution, and evolution of scientific projects, (3) exploration, evaluation, and management of scientific literature, (4) methods and ethics of scientific communication, and (5) proposal design for a project to be continued into Senior Project (EES/GEO 391/392) that includes a literature review, definition of research questions, objectives, or testable hypotheses, and the methods used to carry out the project. The broader social and political context in which scientific research is situated and must respond to and interact with is also explored. More than that, this course explores the important connections between research design and communication by having students focus on the application of learned theory and skills to projects with Senior Project advisor.

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.

Pre-Requisites
[GEO-211] or [EES-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.

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.

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.

Pre-Requisites
[BIO-121]-122, 223-224, or permission of the instructor.

EES-390. ENVIRONMENTAL SCIENCE SEMINAR
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, critique and critique quantitative/qualitative theories, and explore case studies. Three hours of seminar per week. Requirement: students with senior standing only.
Course Descriptions

**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.]

**Pre-Requisites**
Department permission

**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.
[Click here for course fees.]

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

**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.
[Click here for course fees.]

**Pre-Requisites**
[[EES-211]] and [[EES-240]].

**EES-395. AND 396. INDEPENDENT RESEARCH**
**Credits:** Varies with topic
Independent study or research of specific earth or environmental science topic at an advanced level under the direction of a departmental faculty member.
[Click here for course fees.]

**Pre-Requisites**
Upper class standing and approval of academic advisor, research advisor, and department chairperson.

**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.
[Click here for fee for courses with a lab.]

**Pre-Requisites**
Senior or graduate standing

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**EGR. ENGINEERING**

**EGR-200. 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]] or [[CHM-115]].

**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: Junior standing in engineering.

**EGR-202. ENGINEERING PROFESSIONAL DEVELOPMENT I**
**Credits:** 1
The subjects the student will learn and develop in this course are important in securing an internship, a spot in graduate school, or a professional position. This professional development course will allow the student to experience a variety of communicative activities that prepare a student to be an experienced, informed, and professional engineer. The student will be introduced to networking with professionals as well as provided with the ability to communicate skills to employers at job fairs or on-campus mentoring events. Emphasis will be placed on professional interactions as well as attendance at events and mastering the fundamentals of written resumes, cover letters, and creating professional profiles.

**Pre-Requisites**
Permission of the instructor.
EGR-203. ENGINEERING PROFESSIONAL DEVELOPMENT II
Credits: 1
The subjects the student will learn and develop in this course are important in securing an internship, a spot in graduate school, or a professional position. This professional development course will allow the student to experience a variety of communicative activities that prepare a student to be an experienced, informed, and professional engineer. The student will be introduced to networking with professionals as well as provided with the ability to communicate skills to employers at job fairs or on-campus mentoring events. Emphasis will be placed on professional interactions as well as attendance at events and mastering the fundamentals of written resumes, cover letters, and creating professional profiles.

Pre-Requisites
Permission of the instructor.

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.

Co-Requisites
[[PHY-202]] concurrent or before

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
[[EE-211]], [[EE-283]], [[ME-140]] and [[PHY-202]]

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
[[EGR-200]], [[PHY-203]].

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

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.

Pre-Requisites
[[EGR-391]]

EGR-399. COOPERATIVE EDUCATION
Credits: 0-6
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.

ME. MECHANICAL ENGINEERING

ME-140. SCIENTIFIC PROGRAMMING
Credits: 3
This course presents an introduction to computer programming with an emphasis on the techniques needed for data analysis and numerical problem solving for scientific and engineering applications. Basic programming idioms are presented including control structures, data types, methods for handling input and output as well as numerical methods such as array computing and vectorization. Emphasis is placed on proper software engineering practice as well as data analysis and presentation.

ME-175. MACHINING
Credits: 1
Familiarizing with traditional machining processes and measuring equipment used in manufacturing. Hands-on experience with traditional and numerical control (NC) machines; various manufacturing processes and fundamentals of metrology.

ME-180. CADD LAB
Credits: 1
An introduction to the symbolic and visual languages used in the various engineering fields. The use of the computer in design and drafting and familiarization with various software packages in the CADD (Computer Aided Design and Drafting) laboratory. Blueprint reading and printed circuit layouts. Emphasis will also be placed on the representation and interpretation of data in graphical form as well as the fundamentals of 2-dimensional and 3-dimensional graphic formats.
ME-215. MANUFACTURING PROCESSES  
Credits: 3  
An introduction to manufacturing which examines traditional processes such as metal forming and casting and advanced manufacturing processes associated with thin film deposition, microfabrication and piezoelectric devices. Quality assurance and quality control issues in manufacturing.

Pre-Requisites  
[[ME-232]]

ME-231. STATICS  
Credits: 3  
Statics of particles, including resolution of forces into components, vector sums, and concurrent force systems. Statics of rigid bodies and the study of moments. Equilibrium of bodies in two- and three-dimensions and determination of reactions. Analysis of trusses and frames. Determination of centroids and moments of inertia. Kinematics of particles, including displacement, velocity, and acceleration.

Pre-Requisites  
[[PHY-201]]  
Co-Requisites  
[[MTH-112]] concurrent or before  
[[ME-180]] concurrent or before

ME-232. STRENGTH OF MATERIALS  
Credits: 3  
Analysis of statically determinate and indeterminate structural systems; computation of reactions, shears, moments, and deflections of beams, trusses, and frames. Bending and torsion of slender bars; buckling and plastic behavior.

Pre-Requisites  
[[ME-231]], [[ME-180]], [[MTH-112]], and [[EGR-200]] or [[CHM-115]].

ME-234. DYNAMICS  
Credits: 3  
This course continues the development of Newtonian mechanics with application to the motion of free bodies and mechanisms. Topics include rectilinear motion, vector calculus, particle motion, inertial and rotating reference frames, rigid body motion, rotational dynamics, linear and rotational momentum, work and kinetic energy, virtual work and collision.

Pre-Requisites  
[[ME-231]], [[ME-180]], and [[MTH-112]].

ME-298. TOPICS IN MECHANICAL ENGINEERING  
Credits: 1-3  
Selected topics in the field of mechanical engineering.

Pre-Requisites  
Sophomore standing and permission of the instructor.

ME-312. MANUFACTURING SYSTEM ENGINEERING  
Credits: 3  

Pre-Requisites  
Junior standing in mechanical engineering.

ME-314. INVERSE PROBLEMS IN MECHANICS  
Credits: 3  
Inverse problems are very common in engineering where the outputs are known but the inputs are unknown. This course will show how to properly setup a well-posed inverse problem, how to solve matrix inverses, and conduct hands on experiments by creating strain gage based force transducers.

Pre-Requisites  
[[ME-333]]

ME-317. ROBOTICS  
Credits: 3  
The analysis and design of robots. Class covers the mechanical principles governing the kinematics of robotics. Course topics include forward kinematics and the determination of the closed form kinematic inversion, as well as workspace and trajectory generation. Class also covers the formation and computation of the manipulator Jacobian matrix.

Click here for course fee.

Pre-Requisites  
[[EGR-222]] and [[ME-234]]  
Co-Requisites  
[[MTH-212]] concurrent or before

ME-321. FLUID MECHANICS  
Credits: 3  
Thermodynamics and dynamic principles applied to fluid behavior and to ideal, viscous and compressible fluids under internal and external flow conditions.

Pre-Requisites  
[[ME-231]]

Co-Requisites  
[[ME-322]] concurrent or before

ME-322. THERMODYNAMICS  
Credits: 3  

Pre-Requisites  
[[MTH-112]]

ME-323. FLUID MECHANICS LABORATORY  
Credits: 1  
Experiments with and analysis of basic fluid phenomena, hydrostatic pressure, Bernoulli theorem, laminar and turbulent flow, pipe friction, and drag coefficient.

Click here for course fees.

Pre-Requisites  
[[IME-321]] concurrent or before  
[[IME-322]] concurrent or before
ME-324. HEAT TRANSFER
Credits: 3
Fundamental principles of heat transmission by conduction, convection, and radiation; application of the laws of thermodynamics; application of these principles to the solution of engineering problems.

Pre-Requisites
[[ME-321]] and [[MTH-211]]

ME-325. ENERGY SYSTEMS
Credits: 3
Fundamental principles of energy transmission and energy conversion. Comprehension of the physical systems in which the conversion of energy is accomplished. Primary factors necessary in the design and performance analysis of energy systems.

Pre-Requisites
[[ME-322]].

ME-326. HEAT TRANSFER LABORATORY
Credits: 1
Basic heat transfer modes are demonstrated experimentally. This includes conduction, convection, and radiation of heat as well as fin and heat exchanger.

Click here for course fees.

Pre-Requisites
[[ME-321]].

Co-Requisites
[[ME-324]] concurrent or before

ME-328. COMBUSTION ENGINES
Credits: 3
Investigation and analysis of internal and external combustion engines with respect to automotive applications. Consideration of fuels, carburetion, combustion, detonation, design factors, exhaust emissions and alternative power plants.

Pre-Requisites
[[ME-232]].

ME-330. VIBRATIONS LABORATORY
Credits: 1
Fees: 115
Experiments that complement vibration theories in ME 332, including spring and damper elements, underdamped vibration, torsional pendulum, resonance, transient and steady-state behaviors, base excitation, rotating unbalance, impulse response, and modal testing.

Click here for course fees.

Pre-Requisites
[[ME-234]], [[MTH-211]]

Co-Requisites
[[ME-324]] concurrent or before

ME-332. VIBRATIONS
Credits: 3
An introductory course in mechanical vibration dealing with free and forced vibration of single and multi-degrees of freedom for linear and nonlinear systems.

Pre-Requisites
[[ME-234]], [[MTH-211]]

ME-333. MACHINE DESIGN
Credits: 3
The first course of a two-course sequence in design of machine elements dealing with theories of deformation and failure, strength and endurance limit, fluctuating stresses, and design under axial, bending, torsional, and combined stresses. A study of column buckling, fasteners, and gears.

Pre-Requisites
[[ME-232]].

ME-335. FINITE ELEMENT METHODS
Credits: 4
Introduction to finite element method for static and dynamic modeling and analysis of engineering systems. Finite element formulation and computer modeling techniques for stress, plane strain, beams, axisymmetric solids, heat conduction, and fluid flow problems. Solution of finite element equation and post processing of results for further use in the design problem.

Click here for course fee.

Pre-Requisites
[[ME-232]].

Co-Requisites
[[MTH-211]] concurrent or before

ME-337. MICRO-ELECTRO-MECHANICAL SYSTEMS ENGINEERING
Credits: 3
This course explores the principles of MEMS by understanding materials properties, micro-machining, sensor and actuator principles. The student will learn that MEMS are integrated micro-devices combining mechanical and electrical systems, which convert physical properties to electrical signals and, consequently, detection. This course provides the theoretical and exercises the hands-on experience by fabricating a micro-pressure sensor.

Click here for course fees.

Pre-Requisites
Junior standing in engineering

ME-338. ADVANCED MACHINE DESIGN
Credits: 3
An advanced course in machine design topics that expands upon the concepts of Machine Design ([[ME-333]]). This course goes into more detail of the basic machine fundamentals introduced previously such as levers, belts, pulleys, gears, cams and power screws. Emphasis is also placed on 3D printing and the future of additive manufacturing.

Pre-Requisites
[[ME-333]].

ME-340. HEATING, VENTILATION AND AIR CONDITIONING
Credits: 3

Pre-Requisites
[[ME-322]].
ME-380. ADVANCED CADD  
Credits: 3  
An advanced course in Computer-Aided Drafting and Design (CADD) using SolidWorks. This course will introduce topics such as advanced modeling, advanced assemblies, Finite Element Analysis (FEA), and sheet metal.  
Pre-Requisites  
[[ME-180]], [[ME-335]]

ME-384. MECHANICAL DESIGN LABORATORY  
Credits: 3  
A laboratory for the development of open-ended problems in mechanical systems. Emphasis on experimental performance, data collection, evaluations, analysis, and design. This course provides hands-on experience with strain gauge application, measurement techniques, and analysis of topics in mechanical engineering.  
Pre-Requisites  
[[ME-333]] and [[ME-335]]

ME-391. SENIOR PROJECTS I  
Credits: 1  
Design and development of selected projects in the field of mechanical engineering under the direction of a staff member. Technical as well as economic factors will be considered in the design. A detailed progress report is required.  
Pre-Requisites  
Senior standing in Mechanical Engineering or departmental permission.

ME-392. SENIOR PROJECTS II  
Credits: 2  
Design and development of selected projects in the various fields of mechanical 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 reports are required. This is a continuation of [[ME-391]]. An open-forum presentation and discussion of the professional paper are required.  
Pre-Requisites  
[[ME-391]]

ME-395. INDEPENDENT RESEARCH  
Credits: 1 - 3  
Independent study and research for advanced students in the field of mechanical engineering under the direction of a staff member. A research paper at a level significantly beyond a term paper is required.  
Pre-Requisites  
Senior standing in mechanical engineering and approval of the department chairperson is required.

ME-396. INDEPENDENT RESEARCH  
Credits: 1 - 3  
Independent study and research for advanced students in the field of mechanical engineering under the direction of a staff member. A research paper at a level significantly beyond a term paper is required.  
Pre-Requisites  
Senior standing in mechanical engineering and approval of the department chairperson is required.

ME-397. SEMINAR  
Credits: 1-3  
Presentations and discussions of selected topics.  
Pre-Requisites  
Junior or Senior standing in mechanical engineering or special departmental permission.

ME-398. TOPICS IN MECHANICAL ENGINEERING  
Credits: 1-3  
Click here for course fees.  
Pre-Requisites  
Junior or senior standing in mechanical engineering.

ME-399. COOPERATIVE EDUCATION  
Credits: 0-6  
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: minimum junior standing in Engineering; 2.0 cumulative GPA; consent of the academic advisor; and approval of placement by the department chairperson. The co-op option for credit can only be taken one time for either 3 or 6 credits.

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-140. SCIENTIFIC PROGRAMMING
Credits: 3
This course presents an introduction to computer programming with an emphasis on the techniques needed for data analysis and numerical problem solving for scientific and engineering applications. Basic programming idioms are presented including control structures, data types, methods for handling input and output as well as numerical methods such as array computing and vectorization. Emphasis is placed on proper software engineering practice as well as data analysis and presentation. Two hours of lecture and two hours of laboratory per week.

Pre-Requisites
Or Concurrent
[MTH-100] or [MTH-111]

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: 3
A thorough grounding in the concepts, principles, and laws of mechanics, and wave motion. Instruction by demonstration and lecture, recitation, and problem solving. Four hours of demonstration and lecture per week.
Click here for course fee.

Co-Requisites
([MTH-111]) and ([PHY-204])

PHY-202. GENERAL PHYSICS II
Credits: 3
A thorough grounding in the concepts, principles, and laws of Electricity and magnetism, optics and light. Instruction by demonstration and lecture, recitation, and problem solving. Four hours of demonstration and lecture per week.
Click here for course fee.

Pre-Requisites
([PHY-201])

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-204. GENERAL PHYSICS I LAB
Credits: 1
Fees: $100
This is a one-semester introductory physics laboratory course for science and engineering students. Experiments are performed to reinforce the concepts learned in PHY 201. Includes one two-hour laboratory exercise per week.

Co-Requisites
([PHY-201])
Course Descriptions

**PHY-205. GENERAL PHYSICS II LAB**
**Credits:** 1
**Fees:** $100
This is a one-semester introductory physics laboratory course for science and engineering students. Experiments are performed to reinforce the concepts learned in PHY 202. Includes one two-hour laboratory exercise per week.

**Pre-Requisites**
[[PHY-204]]

**Co-Requisites**
[[PHY-202]]

**PHY-206. MODERN PHYSICS LAB**
**Credits:** 1
**Fees:** $150
This intermediate level laboratory course offers a modern view of some of the famous experiments in the history of physics leading to the development of relativity and quantum theory. Additionally, the experiments are designed to prepare students to conduct experiments in contemporary physics labs. In doing so, this course presents a hands-on experience to reinforce the learning of fundamental concepts in EM theory, relativity, statistical mechanics, quantum mechanics, solid state physics, atomic physics, and nuclear physics.

Click here for course fee.

**Pre-Requisites**
[[PHY-201]] and [[PHY-202]]

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

**PHY-214. APPLIED PHYSICS**
**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]]

**PHY-219. INTRODUCTION TO WEAPON 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.

**Pre-Requisites**
OR Concurrent [[PHY-202]]

**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 in 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-/magneto-encephalographic 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]]