Department of Physics

(Office of Humanities, Arts and Sciences)

www.physics.uni.edu

The Department of Physics offers the following undergraduate programs. Specific requirements for these programs are listed within this Department of Physics section in the following order:

Undergraduate Major (B.S.)
- Physics (p. 1)

Undergraduate Major (B.A.)
- Physics (p. 2)
- Physics-Teaching (p. 2)

Minors
- Data Science (p. 3) (also listed in Department of Computer Science and Department of Mathematics)
- Materials Science and Technology (p. 3) (also listed in Department of Chemistry and Biochemistry and Department of Applied Engineering & Technical Management)
- Nanoscience and Nanotechnology (p. 4)
- Physics (p. 4)

Program Certificate
- Physics Teaching (p. 4)

The Department of Physics offers major programs in two baccalaureate areas: the Bachelor of Science and the Bachelor of Arts. The B.S. Physics major is recommended for students who wish to prepare for graduate study in physics, engineering, or other sciences such as geophysics, astronomy, biophysics, or medical physics. The B.A. Physics major is ideal for a student with interdisciplinary interests who wishes to combine physics with courses from another area. The B.A. Physics-Teaching program provides students with the best qualification to teach physics in high school.

The dual-degree program in physics and engineering in cooperation with Iowa State University (ISU) is also offered. The first three years of coursework in liberal arts and physics B.S. are completed at UNI. During the fourth and fifth years, engineering courses are completed at ISU. When finished, a student will have a bachelor’s degree in Physics from UNI and bachelor’s degree in Engineering from ISU.

**Bachelor of Science Degree Program**

**Emphasis-B.S. Physics Major Honors Research**

Students who complete a sustained research project in physics may be invited to do Honors Research. Students must first complete 4 credit hours of PHYSICS 3000 Undergraduate Research in Physics and then 1 credit hour of PHYSICS 4990 Senior Thesis.

**Physics Major**

The B.S. Physics major requires a minimum of 120 total hours to graduate. This total includes UNIFI/General Education requirements and the following specified major requirements, plus electives to complete the minimum of 120 hours.

**Note:** To graduate with a B.S. degree in Physics, a student must earn an overall grade point average of at least 2.50 in all courses applied toward the major.

**Required**

<table>
<thead>
<tr>
<th>Mathematics:</th>
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<tbody>
<tr>
<td>MATH 1420 Calculus I</td>
<td>4</td>
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<tr>
<td>MATH 1421 Calculus II</td>
<td>4</td>
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<tr>
<td>MATH 2422 Calculus III</td>
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<table>
<thead>
<tr>
<th>Physics:</th>
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<tbody>
<tr>
<td>PHYSICS 1100</td>
<td>1</td>
</tr>
<tr>
<td>PHYSICS 1701</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 1702</td>
<td>4</td>
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<td>PHYSICS 2300</td>
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<tr>
<td>PHYSICS 4100/5100</td>
<td>4</td>
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<tr>
<td>PHYSICS 4110/5110</td>
<td>2</td>
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<tr>
<td>PHYSICS 4300/5300</td>
<td>4</td>
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<tr>
<td>PHYSICS 4600/5600</td>
<td>4</td>
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<tr>
<td>PHYSICS 4700/5700</td>
<td>4</td>
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<tr>
<td>PHYSICS 4800/5860</td>
<td>3</td>
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<tr>
<td>PHYSICS 4900/5900</td>
<td>4</td>
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</table>

<table>
<thead>
<tr>
<th>Electives</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Physics, Natural Science, or Math Electives</td>
<td>4</td>
</tr>
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</table>

**Total Hours** 59

* Electives must be mathematics or science courses that count toward a major of the department offering the course. Electives should be selected with the advice of an academic adviser in Physics.

@ This course meets the Bachelor of Science degree undergraduate research requirement.
Bachelor of Arts Degree Program

Physics Major

The B.A. Physics Major is suitable for students who are interested in physics but are looking for a more interdisciplinary experience than the B.S. Physics Major. Potential careers include, for example, computer science, data science, medicine, business, or law. The B.A. Physics Major requires a minimum of 120 total hours for graduation. This includes the major requirements and electives specified below, as well as UNIFI/General Education requirements.

The B.A. Physics major has two emphases: Custom Emphasis and Data Science Emphasis. Students should choose one emphasis. Each emphasis requires completion of a common physics core, a common mathematics core and electives. The Data Science Emphasis has an additional core of data science-related courses and a required project.

Custom Emphasis

The Custom Emphasis is designed to combine a core understanding of physics with additional course work from other disciplines. The flexibility of this major makes it ideal for students interested in dual majors or one or more minors. The rigor of the program allows students to better prepare themselves for careers in any field, especially those related to science or technology. Students work with an advisor to create an individualized emphasis to best meet their needs.

Required Physics Core:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>PHYSICS 1100</td>
<td>First-Year Projects in Physics</td>
<td>1</td>
</tr>
<tr>
<td>PHYSICS 1701</td>
<td>Physics I for Science and Engineering</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 1702</td>
<td>Physics II for Science and Engineering</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 2300</td>
<td>Physics III: Theory and Simulation</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS 4100/5100</td>
<td>Modern Physics</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 4110/5110</td>
<td>Modern Physics Laboratory</td>
<td>2</td>
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</table>

Required Mathematics Core:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>MATH 1420</td>
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<td>4</td>
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<tr>
<td>MATH 1421</td>
<td>Calculus II</td>
<td>4</td>
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Electives:

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<tr>
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<tbody>
<tr>
<td>PHYSICS 3000</td>
<td>Undergraduate Research in Physics</td>
<td>1</td>
</tr>
<tr>
<td>or PHYSICS 3500</td>
<td>Internship in Applied Physics</td>
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<tr>
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<td>Introduction to Computing</td>
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<tr>
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<td>Data Structures</td>
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<tr>
<td>GEOG 2410</td>
<td>Geographic Information Systems I</td>
<td></td>
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<tr>
<td>GEOG 3410</td>
<td>Geographic Information Systems II</td>
<td></td>
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<tr>
<td>ACT SCI 3780/5780</td>
<td>Mathematics of Finance</td>
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</tr>
<tr>
<td>STAT 3752/5752</td>
<td>Introduction to Probability</td>
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</tr>
<tr>
<td>STAT 3771/5771</td>
<td>Applied Statistical Methods for Research</td>
<td></td>
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<tr>
<td>STAT 3775/5775</td>
<td>Introduction to Mathematical Statistics</td>
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</tr>
</tbody>
</table>

Total Hours: 42-43

Data Science Emphasis

The Data Science Emphasis integrates significant course work in physics, statistics and business analytics with electives from other areas such as Geographic Information Systems and computer programming. The goal is for students to develop broad-based skills in the analysis of data and the extraction of gainful information about a variety of systems.

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<td>STAT 1772</td>
<td>Introduction to Statistical Methods</td>
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<tr>
<td>STAT 4772/5772</td>
<td>Statistical Computing I</td>
<td>3</td>
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<tr>
<td>ECON 1011</td>
<td>Statistics for Business Analytics</td>
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</tr>
<tr>
<td>ECON 2090</td>
<td>Decision Analytics</td>
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Required Data Science Project:

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Total Hours: 42-43

Students who complete a sustained research project in physics education may be invited to do Honors Research. Students must first complete 4 credit hours of PHYSICS 3000 Undergraduate Research in Physics and then 1 credit hour of PHYSICS 4990 Senior Thesis.
Physics Major-Teaching

The B.A. Physics major in teaching requires a minimum of 120 total hours to graduate. This total includes UNIFI/General Education requirements, the Professional Education Requirements, and the following specified major requirements, plus electives to complete the minimum of 120 hours.

This major leads to endorsement #156: 5-12 Physics.

**Required**

**Mathematics:**
- MATH 1420 Calculus I 4
- MATH 1421 Calculus II 4

**Science and Science Education:**
- SCI ED 3300/5300 Orientation to Science Teaching 4
- SCI ED 4800/5800 Methods for Teaching Secondary Science or MTSS 3

**Teaching:**
- TEACHING 3129 Secondary and Special-Area Classroom Management 1

**Physics:**
- PHYSICS 1100 First-Year Projects in Physics 1
- PHYSICS 1701 Physics I for Science and Engineering 4
- PHYSICS 1702 Physics II for Science and Engineering 4
- PHYSICS 2300 Physics III: Theory and Simulation 3
- PHYSICS 4080/5080 Resources for Teaching Physics 2
- PHYSICS 4100/5100 Modern Physics 4
- PHYSICS 4110/5110 Modern Physics Laboratory 2

**Electives**

Physics: all 3000+ level courses 6
Mathematics or non-physics science courses from the College of Humanities, Arts and Sciences * 4

**Total Hours** 46

* Excluding all 820:xxx and mathematics below MATH 1420.

It is recommended that sufficient work including current curricula should be taken for licensure approval in a second area. Common teaching combinations are physics-chemistry or physics-mathematics.

Completion of this major will satisfy the requirements of the Iowa Department of Education for licensure.

**Minors**

**Data Science Minor**

The Data Science minor is an interdisciplinary program that integrates computer programming, machine learning, statistics, predictive modeling and visualization to provide students with broad based skills for extracting gainful information from data that originate from a variety of sources. A final project (ideally with corporate or non-profit partnerships) will ensure that students employ their skills to solve a real-world problem.

**Statistics:**
- STAT 1772 Introduction to Statistical Methods 3
- STAT 4784/5784 Introduction to Machine Learning 3

**Computer Science:**
- CS 1510 Introduction to Computing 4
- CS 2150 Computing for Data Science 3-7
- CS 1520 & CS 1800 Data Structures and Discrete Structures
- CS 3140/5140 Database Systems 3

**Physics:**
- PHYSICS 4160/5160 Data Visualization, Modeling and Simulation 3

**Required Data Science Project** 2-3
- CS 4800 Undergraduate Research in Computer Science
- or MATH 4990 Undergraduate Research in Mathematics
- or PHYSICS 3000 Undergraduate Research in Physics

**Total Hours** 21-26

**Materials Science and Technology Minor**

This is an interdisciplinary minor that is jointly offered by the Departments of Chemistry and Biochemistry, Physics, and Applied Engineering & Technical Management.

Materials science and the use of materials in technology requires the use of concepts from multiple disciplines. This interdisciplinary minor gives students the broad foundation they need to learn about the science of materials and an introduction to how these scientific principles are used in the development and application of materials in new technology. This minor is complementary preparation to a major in Chemistry and Biochemistry, Physics or Manufacturing Engineering Technology for students who are interested in working in industry or going on to advanced study in materials science.

**Required:**

Choose one of the following three options: * 5-8

**Option 1 Chemistry (8 hours)**
- CHEM 1110 General Chemistry I
- CHEM 1120 General Chemistry II

**OR**

**Option 2 Chemistry (5 hours)**
- CHEM 1130 General Chemistry I-II

**OR**

**Option 3 Chemistry/Technology (7 hours)**
- CHEM 1020 Chemical Technology &
- TECH 3127 Transport Phenomena for Technologists &

**Additional requirements (all three options)**

Choose one of the following sets of Physics courses: 8
Nanoscience and Nanotechnology Minor

Required
Chemistry and Biochemistry: 5-8

Select one of the following:

CHEM 1110 General Chemistry I
& CHEM 1120 and General Chemistry II

CHEM 1130 General Chemistry I-II

Physics:
PHYSICS 1511 General Physics I
or PHYSICS 1701 Physics I for Science and Engineering
PHYSICS 1512 General Physics II
or PHYSICS 1702 Physics II for Science and Engineering
PHYSICS 4200/5200 Nanoscience
or CHEM 4200/5200 Nanoscience
PHYSICS 4210/5210 Nanotechnology
or CHEM 4210/5210 Nanotechnology

Total Hours 19-22

Electives:

Physics:
3000-level electives in Physics, with no more than 3 hours earned in the following:* 8

PHYSICS 3000 Undergraduate Research in Physics (and/or)

PHYSICS 4450/5450 Laboratory Projects

Total Hours 20

* See course descriptions to reference 4-digit numbers associated with these 3000-level courses.

Program Certificate

The University of Northern Iowa makes available, in addition to traditional programs, the opportunity for students to earn program certificates. Program certificates provide an alternative to programs leading to a degree, a major, or a minor; they certify that an individual has completed a program approved by the university. For information on the following certificates, contact the Department of Physics or the Office of the Registrar, which serves as the centralized registry.

Physics Teaching Certificate

Completion of the certificate for the majors mentioned in the electives section below meets the requirements of endorsement #156: 5-12 Physics.

Required:

Physics:
PHYSICS 1511 General Physics I
or PHYSICS 1701 Physics I for Science and Engineering

Nanoscience and Nanotechnology Minor

Required
Chemistry and Biochemistry: 5-8

Select one of the following:

CHEM 1110 General Chemistry I
& CHEM 1120 and General Chemistry II

CHEM 1130 General Chemistry I-II

Physics:
PHYSICS 1511 General Physics I
or PHYSICS 1701 Physics I for Science and Engineering
PHYSICS 1512 General Physics II
or PHYSICS 1702 Physics II for Science and Engineering
PHYSICS 4200/5200 Nanoscience
or CHEM 4200/5200 Nanoscience
PHYSICS 4210/5210 Nanotechnology
or CHEM 4210/5210 Nanotechnology

Total Hours 19-22

Electives:

Physics:
3000-level electives in Physics, with no more than 3 hours earned in the following:* 8

PHYSICS 3000 Undergraduate Research in Physics (and/or)

PHYSICS 4450/5450 Laboratory Projects

Total Hours 20

* See course descriptions to reference 4-digit numbers associated with these 3000-level courses.

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Physics Teaching Certificate

Completion of the certificate for the majors mentioned in the electives section below meets the requirements of endorsement #156: 5-12 Physics.

Required:

Physics:
PHYSICS 1511 General Physics I
or PHYSICS 1701 Physics I for Science and Engineering

Nanoscience and Nanotechnology Minor

Required
Chemistry and Biochemistry: 5-8

Select one of the following:

CHEM 1110 General Chemistry I
& CHEM 1120 and General Chemistry II

CHEM 1130 General Chemistry I-II

Physics:
PHYSICS 1511 General Physics I
or PHYSICS 1701 Physics I for Science and Engineering
PHYSICS 1512 General Physics II
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PHYSICS 4200/5200 Nanoscience
or CHEM 4200/5200 Nanoscience
PHYSICS 4210/5210 Nanotechnology
or CHEM 4210/5210 Nanotechnology

Total Hours 19-22

Electives:

Physics:
3000-level electives in Physics, with no more than 3 hours earned in the following:* 8

PHYSICS 3000 Undergraduate Research in Physics (and/or)

PHYSICS 4450/5450 Laboratory Projects

Total Hours 20

* See course descriptions to reference 4-digit numbers associated with these 3000-level courses.
A student who has earned a bachelor’s degree in physics from the University of Northern Iowa must demonstrate competence at the introductory (second-year) level in all three content areas (experimental, theoretical, and computational) through course-level outcomes aligned with each branch. A student with the Custom Emphasis must also acquire and demonstrate knowledge of physics beyond the introductory level.

**Physics: Data Science, B.A.**
1. Apply Techniques of Experimental Physics
2. Understand Principles of Theoretical Physics
3. Apply Techniques of Computational Physics

A student who has earned a bachelor’s degree in physics from the University of Northern Iowa must demonstrate competence at the introductory (second-year) level in all three content areas (experimental, theoretical, and computational) through course-level outcomes aligned with each branch. A student with the Data Science Emphasis must also meet learning outcomes of courses in statistics and data analytics taken outside of the Physics Department.

**Physics Teaching, B.A.**
1. Apply Techniques of Experimental Physics
2. Understand Principles of Theoretical Physics
3. Apply Techniques of Computational Physics
4. Understand and Practice Modern Physics Pedagogy

A student who has earned a bachelor’s degree in physics from the University of Northern Iowa must demonstrate competence at the introductory (second-year) level in all three content areas (experimental, theoretical, and computational) through course-level outcomes aligned with each branch. A successful B.A. Physics Teaching student must also demonstrate knowledge and understanding of physics pedagogy. Competence in both content and pedagogy are necessary for the successful practice of high-school physics teaching.

**Physics/Engineering Dual Degree Program, B.S.**
1. Apply Techniques of Experimental Physics
2. Understand Principles of Theoretical Physics
3. Apply Techniques of Computational Physics
4. Integrate and Apply Classroom Learning
5. Be Prepared for Employment or Graduate Study

A student who has earned a bachelor’s degree in physics from the University of Northern Iowa must demonstrate competence at the introductory (second-year) level in all three content areas (experimental, theoretical, and computational) through course-level outcomes aligned with each branch. A successful B.S. student must also acquire and demonstrate skills in career preparation as well as advanced knowledge in three areas: classical mechanics, thermodynamics and statistical mechanics, and computational physics. A successful student in the dual-degree program must also demonstrate competence in engineering principles and practice according to the learning outcomes of the institution that houses the engineering program.
Courses

PHYSICS 1000. Physics in Everyday Life — 3 hrs.
Basic laws and concepts of physics introduced and demonstrated through operation of everyday devices and systems. Emphasis on understanding physical principles behind working of modern technologies and interplay between science and technology. (Fall and Spring)

PHYSICS 1010. Physics in Everyday Life Laboratory — 1 hr.
Laboratory activities involving energy, temperature and heat, waves and sound, electricity and magnetism, light and color; and the atomic and nuclear structure of matter. Emphasis on observation, interpretation, and conceptual understanding of physical phenomena. Lab, 2 periods. Prerequisite(s) or corequisite(s): PHYSICS 1000 or consent of department head. (Fall and Spring)

PHYSICS 1100. First-Year Projects in Physics — 1 hr.
An introduction to the basic elements of physics research and applications. Students will complete a series of projects designed to integrate theory, measurement and computation to create instruments and devices that interact with the physical world. In doing so, students will learn how to create and control electro-mechanical devices and gain experience in techniques used in both industry and research. Prerequisite(s) or corequisite(s): PHYSICS 1701, Physics I for Science and Engineering, or the consent of the department head. (Fall)

PHYSICS 1511. General Physics I — 4 hrs.
Algebra-based introductory course covering Newtonian mechanics, gravitation, and thermal physics. Emphasis on conceptual understanding of physical principles through group investigations and lab activities. Discussion/lab, 5 periods. Prerequisite(s): satisfactory ALEKS score or equivalent. (Fall and Spring)

PHYSICS 1512. General Physics II — 4 hrs.
Algebra-based introductory course covering electricity, magnetism, optics, and modern physics. Emphasis on conceptual understanding of physical principles through group investigations and lab activities. Discussion/lab, 5 periods. Prerequisite(s): PHYSICS 1511 or PHYSICS 1701. (Fall and Spring)

Calculus-based introductory course covering Newtonian mechanics, gravitation, and thermal physics. Lab activities. Discussion/lab, 5 periods. Prerequisite(s) or corequisite(s): satisfactory mathematical preparation for calculus. (Fall)

Calculus-based introductory course covering electricity, magnetism, and optics. Lab activities. Discussion/lab, 5 periods. Prerequisite(s): PHYSICS 1701 (minimum grade of B) or PHYSICS 1511. Prerequisite(s) or corequisite(s): MATH 1421. (Spring)

Calculus-based course covering the more advanced topics in introductory physics. Emphasis on developing analytical and computational skills needed to study physics at a more advanced level. Topics include Newtonian mechanics and applications, Maxwell’s equations and applications. Prerequisite(s): PHYSICS 1702. (Fall)

PHYSICS 2700. Mathematical Methods of Physics — 3 hrs.
Introduction to the mathematical methods used in upper-level Physics courses, illustrated with applications from all areas of Physics. Applications will illustrate electrodynamics, thermodynamics, classical mechanics and quantum mechanics. Prerequisite(s): MATH 1420; MATH 1421; MATH 2422; PHYSICS 1701; PHYSICS 1702; PHYSICS 2300. (Spring)

PHYSICS 3000. Undergraduate Research in Physics — 1-6 hrs.
Research activities under direct supervision of sponsoring staff members or at a national laboratory. Should normally be taken after the first year of the major. Successful completion of the research experience requires both a written and oral report. Prerequisite(s): minimum overall 2.50 GPA; consent of department. (Fall and Spring)

PHYSICS 3030. Robotics and Sensors — 3 hrs.
Students will build their own autonomous robot. Students will learn and apply basic electronics, programming, physics concepts to develop their robot and create an interactive presentation on their creation. These robotics concepts will also be applied to important issues for industry and sustainability in the areas of automation, energy, and transportation. Lecture 1 period, Lab, 3 periods. Prerequisite(s): PHYSICS 1511 and PHYSICS 1512, or PHYSICS 1701 and PHYSICS 1702, or TECH 1037 or CS 1510. Other interested students with some experience in coding and/or electronics experience are encouraged to contact the instructor. (Same as TECH TEE 3030) (Variable)

PHYSICS 3179. Cooperative Education.
Applied physics internship under PHYSICS 3179 should be taken during the junior or senior year. If unable to do so, the internship may be done under PHYSICS 3500 with consent of department. Successful completion of either PHYSICS 3179 or PHYSICS 3500 requires both a written and an oral report. Offered on credit/no credit basis only. (Fall and Spring)

PHYSICS 3500. Internship in Applied Physics — 1-3 hrs.
Departmentally approved work in applied physics (at an industrial, medical, or government laboratory) followed by oral and written reports given on completed work. Offered on credit/no credit basis only. Prerequisite(s): minimum overall 2.50 GPA; consent of department. (Fall and Spring)

PHYSICS 3700. Physics Seminar — 1 hr.
Seminar course covering aspects important for life after graduation. Participation in physics colloquia; oral report on research topic or internship, drafting resume/CV, interview, perform job and graduate school search. Prerequisite(s): PHYSICS 3179. (Fall and Spring)

PHYSICS 3800. Undergraduate Research in Physics — 1-6 hrs.
Research activities under direct supervision of sponsoring staff members or at a national laboratory. Should normally be taken after the first year of the major. Successful completion of the research experience requires both a written and oral report. Prerequisite(s): minimum overall 2.50 GPA; consent of department. (Fall and Spring)

PHYSICS 3900. Undergraduate Research in Physics — 1-6 hrs.
Research activities under direct supervision of sponsoring staff members or at a national laboratory. Should normally be taken after the first year of the major. Successful completion of the research experience requires both a written and oral report. Prerequisite(s): minimum overall 2.50 GPA; consent of department. (Fall and Spring)

PHYSICS 4050/5050. Optical Science — 3 hrs.
An introduction to optics and applied optics. Topics include: geometric optics, wave optics, quantum optics, and introductions to lasers and optical spectroscopy. Discussion, 2 periods; lab, 2 periods. Prerequisite(s): PHYSICS 1512 or PHYSICS 1702; junior standing or consent of department head. (Even Falls)

PHYSICS 4060/5060. Mechanics for Physics Education — 3 hrs.
Experiences in motion, force, energy, and momentum using physics education curricular resources with emphasis on practices aligned with the Next Generation Science Standards (NGSS). The course is designed for current and future middle-level and secondary science teachers. Prerequisite(s): PHYSICS 1511 or PHYSICS 1701 or permission of the instructor; junior standing. (Even Summers)

PHYSICS 4070/5070. Electricity and Magnetism for Physics Education — 3 hrs.
Experiences in waves, electricity, magnetism, and light using physics education curricular resources with emphasis on practices aligned with the Next Generation Science Standards (NGSS). The course is designed for current and future middle-level and secondary science teachers. Prerequisite(s): PHYSICS 1512 or PHYSICS 1702 or permission of the instructor; junior standing. (Odd Summers)
PHYSICS 4080/5080. Resources for Teaching Physics — 2 hrs.
A physics course that focuses on topics recommended for high school physics programs, with an emphasis on various physics education resources in the context of science education initiatives. This course is designed for both current science teachers and science education undergraduates. Prerequisite(s): PHYSICS 1511 or PHYSICS 1701; PHYSICS 1512 or PHYSICS 1702; junior standing. (Spring)

PHYSICS 4100/5100. Modern Physics — 4 hrs.
Special relativity; quantum phenomena; wave-particle duality; atomic and nuclear structure; properties of solids, interaction of radiation with matter; and elementary particles. Prerequisite(s): PHYSICS 1702; junior standing. (Spring)

PHYSICS 4110/5110. Modern Physics Laboratory — 2 hrs.
Experiments on interactions of photons and electrons; mass and charge of electrons; atomic spectroscopy; nuclear detection and spectroscopy; spin resonance; and properties of solids. Requires detailed lab reports, including error analysis. Prerequisite(s): junior standing. Prerequisite(s) or corequisite(s): PHYSICS 4100/5100. (Spring)

PHYSICS 4160/5160. Data Visualization, Modeling and Simulation — 3 hrs.
This course focuses on the theory and practice of designing effective visualizations of various data sets, processing images, modeling and finding patterns in these data sets. The course covers visualization toolkits, scientific visualization, medical visualization, and information visualization. Topics include image processing techniques and the associated toolboxes, methods to visualize and analyze the evolution of data sets including images, and finding predictive models and simulation methods that can generate and explain data. Prerequisite(s): CS 1510; junior standing. (Spring)

PHYSICS 4200/5200. Nanoscience — 3 hrs.
Study of nanoscale materials and processes, with emphasis on the preparation and characterization of materials with nanometer scale dimensions; investigation of how nanoscale dimensions produce unique chemical and physical properties; nanoscale microscopy and spectroscopic methods of investigation. Prerequisite(s): CHEM 1110 and CHEM 1120 (or CHEM 1130); PHYSICS 1511 or PHYSICS 1701; PHYSICS 1512 or PHYSICS 1702; junior standing. [Same as CHEM 4200/5200] (Fall)

PHYSICS 4210/5210. Nanotechnology — 3 hrs.
Study of nanoscale materials and processes, with emphasis on the current and potential future applications of materials with distinctive properties due to their nanometer scale dimensions; nanoporous materials; discussion of the broader implications of nanotechnology in areas such as government policy, occupational safety and medical technology. Prerequisite(s): CHEM 1110 and CHEM 1120 (or CHEM 1130); PHYSICS 1511 or PHYSICS 1701; PHYSICS 1512 or PHYSICS 1702; junior standing. [Same as CHEM 4210/5210] (Odd Springs)

Introduction to the theory and applications of analog and digital electronics utilizing the Digital Electronics curriculum from the nationally certified Project Lead The Way (PLTW) curriculum. Especially intended for science and technology K-12 education majors to become certified PLTW teachers of this course. Prerequisite(s): PHYSICS 1511 or PHYSICS 1400 or PHYSICS 1701; junior standing. [Same as TECH 4290/5290] (Spring)

PHYSICS 4300/5300. Introduction to Electronics — 4 hrs.
Introduction to DC and AC circuits; electrical measurements, circuit theory and circuit simulation; analog and digital circuits; energy generation and efficiency. Discussion, 2 periods; lab, 4 periods. Prerequisite(s): PHYSICS 1512 or PHYSICS 1702; MATH 1421; junior standing. (Fall)

Introduction to computer interfacing, instrument control, and data acquisition. Utilization of industry standard software and microcontrollers to acquire and process data, process signals, and perform feedback control of physical systems. Prerequisite(s): PHYSICS 1511 and PHYSICS 1512, or PHYSICS 1701 and PHYSICS 1702; junior standing. (Odd Springs)

PHYSICS 4450/5450. Laboratory Projects — 1-3 hrs.
Experimental activities to meet individual needs and interests not normally included in other courses. Maximum of 3 hours may be applied to a physics major or minor. Prerequisite(s): junior standing; consent of department. (Fall and Spring)

Vectors and kinematics; force and motion; work and energy; Lagrange's equations; gravity; oscillations; rigid-body motion; and accelerated reference frames. Prerequisite(s): MATH 1420; MATH 1421; PHYSICS 1701; PHYSICS 1702; PHYSICS 2300; PHYSICS 2700; junior standing. Prerequisite(s) or corequisite(s): MATH 2422. (Fall)

Basic physical principles underlying a variety of current global energy sources. The science and technology of energy generation from fossil fuels, the sun, wind, and atomic nuclei. Energy storage mechanisms will also be discussed. Prerequisite(s): PHYSICS 1511 or PHYSICS 1701; PHYSICS 1512 or PHYSICS 1702; or departmental consent. (Odd Falls)

PHYSICS 4700/5700. Electrodynamics — 4 hrs.
General principles of Classical Electrodynamics: Electrostatics, Electric Current, Electric and Magnetic Fields in Vacuum, Electromagnetic Induction, Maxwell's equations and electromagnetic waves, Electric and Magnetic Fields in Matter, Types of Materials (Dielectrics, Conductors, Magnetic Materials). Phenomena will be explored through theoretical investigations supplemented with computational simulations and experiments. Prerequisite(s): MATH 2422; PHYSICS 2300; PHYSICS 2700; junior standing. (Odd Falls)

Structural, thermal, and electronic properties of materials; applications to modern devices. Discussion, 2 periods; lab, 2 periods. Prerequisite(s): PHYSICS 4100/5100; PHYSICS 4110/5110; junior standing. (Even Falls)

PHYSICS 4800/5800. Quantum Mechanics — 4 hrs.
Solution of Schrodinger equation for several systems: spin and angular momentum; identical particles; perturbation theory; WKB approximation; and scattering. Prerequisite(s): PHYSICS 2700; PHYSICS 4100/5100; PHYSICS 4600/5600; junior standing. (Even Springs)

PHYSICS 4860/5860. Computational Physics — 3 hrs.
Computer simulations and numerical solutions of behaviors of important physical systems, emphasizing those that are very difficult or impossible to analyze by traditional means, for example, nonlinear oscillators or phase transitions in the Ising Model. Discussion, 2 periods; lab, 2 periods. Prerequisite(s): PHYSICS 2300;
PHYSICS 2700; PHYSICS 4100/5100; PHYSICS 4600/5600; junior standing. (Spring)

PHYSICS 4900/5900. Thermodynamics and Statistical Mechanics — 4 hrs.
General principles of classical thermodynamics and applications (e.g., to first-order phase transitions); general principles of statistical mechanics and applications (e.g., to the classical ideal gas). Prerequisite(s): PHYSICS 2300; PHYSICS 2700; PHYSICS 4100/5100; junior standing. (Spring)

PHYSICS 4950/5950. Readings in Physics — 1-3 hrs.
Readings/problems in areas of physics (or related interdisciplinary areas) not normally covered in other courses. Maximum of 3 hours may be applied to a physics major or minor. Prerequisite(s): junior standing; consent of department. (Variable)

PHYSICS 4990. Senior Thesis — 1 hr.
Senior Thesis. Open only to students pursuing the B.S. Physics Honors Research Emphasis or the B.A. Physics-Teaching Honors Research Emphasis. Prerequisite(s): consent of the department head. (Fall, Spring, Summer)

PHYSICS 6100. Modeling and Simulation of Physical Systems — 3 hrs.
Computer simulation and visualization of physical systems. Students will code, debug, and run basic simulations in C++ as well as more sophisticated simulations with other tools, including parallel computing. Prerequisite(s): CS 1160 and PHYSICS 4860/5860, or MATH 3440/5440 and CS 1160, or consent of instructor. (Variable)

PHYSICS 6299. Research.
Prerequisite(s): consent of department. (Variable)

Introduction to computer interfacing, instrument control, and data acquisition. Discussion of digital signal processing and utilization of industry-standard software platforms in laboratory activities. Prerequisite(s): PHYSICS 2300; PHYSICS 4300/5300. (Variable)

PHYSICS 6500. Special Problems in Physics — 1-6 hrs.
Credit determined at registration. Problems selected according to needs of students. Prerequisite(s): consent of department. (Variable)