DEPARTMENT OF PHYSICS AND ENGINEERING

College of the Sciences and Mathematics

Overview

367 The Sciences & Engineering Center and The Commons
610-436-2497
Department of Physics and Engineering (http://www.wcupa.edu/physics/)
Matthew Waite (mwaite@wcupa.edu), *Chairperson*
Bob Thornton (rthornton@wcupa.edu), *Assistant Chairperson*
Zhongping Huang (zhuang2@wcupa.edu), *Director - Biomedical Engineering*

The Department of Physics and Engineering offers three undergraduate degree programs:

- The **B.S. in Physics** is designed as preparation for graduate school or careers in government or industry. The curriculum includes a strong foundation in mathematics and the humanities. A wide choice of electives in the program provides the flexibility to develop a minor in a related area of interest.
- The **B.S. in Physics/B.S. in Engineering** is a cooperative, dual-degree, five-year engineering program with The Pennsylvania State University at University Park, Philadelphia University, Columbia University, and Case Western Reserve University.
- The **B.S. in Biomedical Engineering** is designed to prepare students to successfully enter the biomedical industry and professional careers with a solid background in engineering, life science, chemistry, physics, and mathematics. Students will learn to apply the theories and methods of engineering to innovative technical solutions for medical disease diagnosis, treatment and prevention, and ultimately, to human health. The BME program at WCU provides hands-on experiences that will ensure that graduates will be able to be productive from their first day on the job. It also offers the academic preparation for continuing on to medical, dental, and law schools. The Biomedical Engineering program is housed in The Sciences & Engineering Center and The Commons building, the University's largest and most cutting-edge facility, which opened in the fall of 2021. The innovative 175,000 square-foot facility offers advanced laboratories, modern academic program space, and state-of-the-art simulation.

Scholarships/Awards

Physics

The **Robert M. Brown Endowed Scholarship for Physics** was established in 1997 by Mr. Robert M. Brown. Partial tuition scholarships are awarded annually on a competitive basis to students in the physics program.

The **Dr. Michael F. Martens Award** was established by a bequest of the estate of Dr. Martens, a faculty member of the Department of Physics and Engineering. Dr. Martens was a long-time member of the Lions Club of West Chester, which administers the funds for the award. The award is for achievement in Physics. Awards are determined by the department's faculty.

Other awards include the **Benjamin Faber Award** in physics and mathematics, awarded to an exemplary non-traditional physics or mathematics major; the **Dr. Gary Pascuzzo Scholarship**, which is given to one or more students in SCI 102 who are engaged in and excel in the course and who show promise to transfer the knowledge gained in the course to their own classroom; and the **Dr. Russell K. Rickert Award for Undergraduate Student Research**, which recognizes up to two students who have demonstrated a sustained and significant commitment to undergraduate research. Awards shared with other departments at WCU include the **Richard '59, M '69 and Jeanette Merion Scholarship**, which is awarded to a sophomore, junior, or senior physics, chemistry, or biology major for academic excellence, with preference given to a ROTC participant; the **Diane and Roger Casagrande Scholarship** for students in pre-engineering or communication studies; and the **Yarosewick Family Scholarship**, which supports a fourth-year science major pursuing a B.S.Ed. who has a GPA of at least a 3.2 (in physics, chemistry, biology and earth/space science).

These awards are granted annually at an induction ceremony for new members of the West Chester University chapter of Sigma Pi Sigma, the national physics honor society.

The physics programs can also be found on the Internet: http://www.wcupa.edu/physics (http://www.wcupa.edu/physics/).

Biomedical Engineering

The **Lei and Song Li Scholarship for Biomedical Engineering** was established in 2019 to help establish and support the development of the biomedical engineering program at West Chester University. The scholarship will be annually awarded on a competitive basis to two rising sophomores and two rising seniors in the BME program. Dr. Li is the founder and chairman of Frontage Holdings, the parent company of Frontage Laboratories, a contract research organization specializing in R&D product development services with operations in both the U.S. and China. Frontage Labs is headquartered in Exton, PA.

The **West Pharmaceutical Services Biomedical Engineering Scholarship** was established in 2019 when the BME program welcomed their first cohort of students. This scholarship will be awarded to three incoming freshmen to the BME program. The scholarship will be based primarily on merit. West is a leading global manufacturer in the design and production of technologically advanced, high-quality, integrated containment and delivery systems for injectable medicines. They are a trusted partner to the world's top pharmaceutical and biotechnology companies—working by their side to improve patient health.

Cooperative Physics/Engineering Programs

The Department of Physics and Engineering offers multiple 3+2 Physics-Engineering Programs. These are dual-degree programs in which a student typically spends three years at West Chester and two years at one of our partner institutions, after which a student holds a B.S. in Physics from West Chester University and a bachelor's degree in engineering from the partner institution. Currently, WCU has agreements with Penn State University (main campus), Thomas Jefferson University, Columbia University, and Case Western Reserve University.

Admission to one of the affiliate engineering institutions is contingent upon a recommendation from the Department of Physics and Engineering and the student having maintained the overall average for the specific engineering program. Check with an advisor in Physics for updates on program availability and GPA requirements. Transfer students and students who have completed a bachelor's degree are not eligible for the Penn State program.

Programs

Majors

- B.S. in Biomedical Engineering (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/physics-engineering/biomedical-engineering-bs/)
- B.S. in Physics (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/physics-engineering/physics-bs/)
- B.S. in Physics/B.S. in Engineering (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/physics-engineering/physics-bs-engineering-bs/)

Minor

- Physics (http://catalog.wcupa.edu/undergraduate/sciences-mathematics/physics-engineering/physics-minor/)

Policies

- See undergraduate admissions information. (http://catalog.wcupa.edu/general-information/admissions-enrollment/undergraduate-admissions/)
- See academic policies. (http://catalog.wcupa.edu/undergraduate/academic-policies-procedures/)

All undergraduate students are held to the academic policies and procedures outlined in the undergraduate catalog. Students are encouraged to review departmental handbooks for program tips, suggested course sequences, and explanations of procedures. When applicable, additional policies for specific department programs may be listed below.

Admission Policy for the Department of Physics and Engineering

For admission to the physics program, most students should have completed, in addition to the general University requirements, one year each of high school chemistry and physics, and a minimum of three years of mathematics, including algebra and trigonometry, and be prepared to start calculus. Any student with a deficiency must complete WRT 120 and MAT 161 with grades of C- or better to be admitted to the program.

Admission Policy for the Biomedical Engineering Program

Freshmen Admission Requirements

In addition to West Chester University's admission requirement, students should have met the following minimum requirements to be accepted into the Biomedical Engineering program:

Students who provide SAT scores:

1. Three years high school mathematics, including Algebra I, Algebra II/trigonometry, geometry and pre-calculus.
2. One year each of high school biology and physics or chemistry.
3. An SAT Math score of 530 or better
4. An SAT Comprehensive (Math + Critical Reading) score of 1050 (or ACT® Composite score of 22) or better.

Students who don't provide SAT scores:

1. Three years high school mathematics, including Algebra I, Algebra II/trigonometry, geometry and pre-calculus.
2. One year each of high school biology and physics or chemistry.
3. Student should have an average GPA of 3.0 in these classes.
4. Overall high school GPA should be greater than 3.3.

Transfer Student Requirements

Transfer applicants who attended another accredited institution of higher education are subject to the "general requirements for admission of transfers" of West Chester University. In addition, transfer students from two-year and four-year U.S. accredited institutions must have a minimum cumulative GPA of 2.2 out of 4.0 and must have completed with a grade of "C" or better in at least one calculus course and one science course in chemistry, physics, or biology that are approved for transfer credit toward degree requirements in the Biomedical Engineering program.

West Chester students who are enrolled in other majors, including the Exploratory Studies program, are required to meet the following requirements by the end of their first semester for transfer into the Biomedical Engineering program:

1. Completion of MAT 131 (Pre-Calculus) or MAT 161 (Calculus I) with grade of "C" or better;
2. Completion of CHE 103 with grades of "C" or better
3. Earn a cumulative GPA of 2.2 or higher.

Graduation Requirements for the Biomedical Engineering Program

The minimum credits requirement for graduation with a degree of Bachelor of Science in Biomedical Engineering is 126. In addition to the University graduation requirement of a cumulative GPA of 2.0 or above, the Biomedical Engineering students must earn a cumulative Tech GPA of 2.2 or above, and earn a C+ or above in 300-level and above BME courses for graduation. The Tech GPA is calculated based on all engineering courses, mathematics, and science courses attempted at West Chester University.

Transfer Policy for the Department of Physics and Engineering

Transfer students must take a minimum of six credits at West Chester at the 250 level or above. A 2.0 GPA or better must be maintained for all physics courses.

Advanced Placement Policy for the Department of Physics and Engineering

Visit the Registrar's website (https://www.wcupa.edu/registrar/testCredit.aspx) for information on how course credit for success on AP exams in physics is awarded.

Faculty

Professors

Kevin B. Aptowicz (kaptowicz@wcupa.edu) (2005)
B.S., Columbia University; M.S., University of Colorado; Ph.D., Yale University

Zhongping Huang (zhuang2@wcupa.edu) (2018)
Director, Biomedical Engineering
B.S., M.S., Zhejiang University; Ph.D., University of Kentucky

Anil Kumar Kandalam (akandalam@wcupa.edu) (2012)
B.Sc., Osmania University; M.Sc., University of Hyderabad; Ph.D., Michigan Technological University

Robert J. Thornton (rthornton@wcupa.edu) (2008)
Assistant Chairperson, Physics and Engineering
B.S., Lehigh University; Ph.D., University of Hawaii

Associate Professors

Tianran Chen (tchen@wcupa.edu) (2014)
B.S., Zhejiang University; Ph.D., University of Minnesota

Brandon Mitchell (bmitchell@wcupa.edu) (2016)
B.S., SUNY Fredonia; M.S., Ph.D., Lehigh University

Ian A. Morrison (imorrison@wcupa.edu) (2016)
A.B., Bowdoin College; M.S., Ph.D., University of California, Santa Barbara

Shawn Pfeil (spfeil@wcupa.edu) (2012)
B.S., University of California, San Diego; M.A., Ph.D., University of California, Santa Barbara

Jeffrey Sudol (jsudol@wcupa.edu) (2007)
B.A., Macalester College; Ph.D., University of Wyoming

Matthew M. Waite (mwaite@wcupa.edu) (2001)
Chairperson, Physics and Engineering
B.A., Gettysburg College; Ph.D., University of Delaware

Assistant Professors

Jesse Placone (jplacone@wcupa.edu) (2019)
B.S., Ph.D., Johns Hopkins University

Nicole L. Ramo (nramo@wcupa.edu) (2021)
B.S., Kettering University; Ph.D., Colorado State University

Courses

BME

BME 110. Introduction to Biomedical Engineering. 3 Credits.
Introduction to the development of biomedical engineering or bioengineering using fundamental concepts and tools from physics, mechanical, chemical, electrical engineering and biology. Topics may include: biomaterials; biomechanics; bioinstrumentation; biotransport and artificial organs; cell and tissue engineering; systems and signals; biochemical engineering; bioelectric phenomenon; and biomeasurements. Additional topics include developing engineering tools for use in advanced courses and problem-solving skills.
Consent: Permission of the Department required to add.
Typically offered in Fall.

BME 120. Introduction to Computer Aided Engineering Design. 3 Credits.
LEC (1), LAB (3)
This course introduces students to the modern computational tools used for engineering design and analysis. Topics include: the principles of SolidWorks, simple and advanced part modeling approaches, assembly modeling, drawing, configurations/design tables and surface modeling, the applications of SolidWorks in manufacturing processes, mechanical systems, and engineering analysis.
Typically offered in Spring.

BME 199. Transfer Credits. 1-10 Credits.
Transfer Credits.
Repeatable for Credit.

BME 220. Statics. 3 Credits.
This course covers the application of the principles of mechanics to engineering problems of equilibrium. Topics include resultants, equilibrium, friction, center of gravity, internal forces, analysis of structures, and moment of inertia.
Pre / Co requisites: BME 220 requires prerequisites of PHY 170 and MAT 162.
Typically offered in Fall.

BME 230. Dynamics. 3 Credits.
This course is to present the fundamentals of particle and rigid body dynamics and to apply these fundamentals to the systematic solution of engineering problems. Topics include: work, energy, and momentum; kinetics and kinematics of a particle; planar and three-dimensional kinematics; and dynamics of rigid bodies.
Pre / Co requisites: BME 230 requires a prerequisite of BME 220.
Typically offered in Spring.

BME 310. Engineering Thermodynamics. 3 Credits.
This course introduces students to engineering thermodynamics. Topics include: basic concepts of pure substance; system parameters (temperatures, pressure, etc.); first law and second law of thermodynamics; ideal gas; and equation of the state, work, energy, enthalpy, entropy, and thermal refrigeration cycle.
Pre / Co requisites: BME 310 requires prerequisites of PHY 170, CHE 104, and MAT 162.
Typically offered in Fall.

BME 315. Biomedical Engineering Laboratory I. 2 Credits.
LEC (1), LAB (3)
This course introduces student laboratory techniques and tools in biomedical engineering measurement, as well as provides hands-on laboratory experiences. Students will perform a series of laboratory experiments. A project will be conducted at the end of the semester.
Pre / Co requisites: BME 315 requires prerequisites of BME 110 and BIO 265.
Typically offered in Fall.

BME 325. Biomedical Engineering Laboratory II. 2 Credits.
LEC (1), LAB (3)
This course is the continuation of BME 315. Students will perform a series of laboratory experiments. A project will be conducted at the end of the semester.
Pre / Co requisites: BME 325 requires prerequisites of BME 110, BME 315, and BIO 265.
Typically offered in Spring.

BME 335. Biomaterials. 3 Credits.
This course provides an introduction to the interactions between cells and the surfaces of biomaterials. Topics include: materials commonly used in biomedical applications, chemical structure of biomaterials, physical and mechanical properties of biomaterials, the biocompatibility of those materials with the biological environment, and the immune response to biomaterials.
Pre / Co requisites: BME 335 requires prerequisites of BIO 265 and CHE 104.
Typically offered in Fall.

BME 345. Biotransport Phenomena. 4 Credits.
This course provides the fundamental biomedical applications of fluid mechanics, heat, and mass transfer. Topics include: the principles and applications of biotransport fundamentals, fluid mechanics, macroscopic biotransport, 1-D steady and unsteady state transport, and general multidimensional microscopic transport.
Pre / Co requisites: BME 345 requires prerequisites of BIO 265, BME 310, and MAT 315.
Typically offered in Spring.

BME 355. Biomedical Instrumentation. 3 Credits.
This course is to study the fundamentals of instrumentation in biomedical fields. Topics include: various types of medical instruments; basic analog and digital electronics; data acquisition signal processing; and applications of instrumentation in diagnoses, medical imaging, and laboratory. Regulation and medical safety will be discussed.
Pre / Co requisites: BME 355 requires prerequisites of BIO 265, PHY 180, and MAT 315.
Typically offered in Spring.

BME 365. Biomechanics for Engineers. 3 Credits.
In this course, students acquire the basic tools used to analyze the human body as a mechanical system with examples from the tissue level to the whole-body level. Relevant concepts introduced in previous mechanics courses (e.g., BME 230) will be advanced and applied in BME-specific contexts. Topics include the following: joint kinematics and kinetics; linked segment modeling; tissue stresses and strains; and biomechanics related to injury/disease as well as treatments. Emphasis will be placed on how to effectively find, read, interpret, and synthesize the information presented in scholarly research articles to write a literature review and propose a research study.
Pre / Co requisites: BME 365 requires prerequisites of BIO 265 and BME 230.
Gen Ed Attribute: Writing Emphasis.
Distance education offering may be available.
Typically offered in Spring & Summer.

BME 401. Senior Seminar I. 1 Credit.
This course is to provide students an opportunity to learn how to prepare and make formal presentations. Students will make several presentations during the semester with a chosen topic that they are interested in.
Pre / Co requisites: BME 401 requires students to be senior-level.
Typically offered in Fall.

BME 402. Senior Seminar II. 1 Credit.
This is the continuation of BME 401. Students will recognize and address bioethical questions through a group presentation and discussions. Topics include: security, confidentiality, privacy, and bioethical dilemmas.
Pre / Co requisites: BME 402 requires students to be senior-level.
Typically offered in Spring.

BME 410. Senior Design I. 3 Credits.
LEC (2), LAB (1)
This is a capstone design course. This course provides students the opportunity to work with real-world, open-ended, and/or interdisciplinary challenges proposed by faculty or industrial project sponsors. Students work as a small team supervised by a faculty member and/or industry advisor. Students team learn and apply principles of engineering, biology, chemistry, physics, and mathematics to solve biomedical engineering problems through the consideration of engineering solutions in global, economic, environmental, and societal contexts. The design process involves: defining functional requirements, conceptualization, design, development, construction, physical prototyping, measurement, analysis, and conclusion. An initial proposal and progress report are required at the beginning of the course as well as in the middle of these two semesters, respectively. A final report and post/oral presentations are required at the end of the second semester.
Pre / Co requisites: BME 410 requires prerequisites of BME 325, BME 345, BME 355, BME 365 or permission of the instructor.
Gen Ed Attribute: Speaking Emphasis.
Typically offered in Fall.

BME 420. Senior Design II. 1 Credit.
This is the continuation of BME 410. This course provides students the opportunity to work with real-world, open-ended, and/or interdisciplinary challenges proposed by faculty or industrial project sponsors. Students work as a small team supervised by a faculty member and/or industry advisor. Students team learn and apply principles of engineering, biology, chemistry, physics, and mathematics to solve biomedical engineering problems through the consideration of engineering solutions in global, economic, environmental, and societal contexts. The design process involves: defining functional requirements, conceptualization, design, development, construction, physical prototyping, measurement, analysis, and conclusion. An initial proposal and progress report are required at the beginning of the course and in the middle of the two semesters, respectively. A final report and post/oral presentations are required at the end of the second semester.
Pre / Co requisites: BME 420 requires students to be senior-level.
Typically offered in Fall & Spring.

BME 450. Regulatory and GMP. 3 Credits.
This course provides students knowledge of the processes in the manufacture or quality control of biotechnology products with current Good Manufacturing Practices (cGMP) guidelines and regulations. Topics include: introduction to the FDA and other regulatory agencies, current Good Manufacturing Practices (cGMP), process validation requirements and product life cycle quality management, and the application of the regulations to case studies.
Pre / Co requisites: BME 450 requires a prerequisite of BME 325 or permission of the instructor.
Typically offered in Fall.

BME 460. Introduction to Biomedical Device Design. 3 Credits.
This is an elective, project-based learning course for Biomedical Engineering (BME) majors. It introduces the engineering design process and related concepts, tools, and methodologies in the context of biomedical device design. Students will work in teams to redesign, modify, fabricate, and validate a current medical device. Topics include the engineering design process, rapid prototyping using 3D printing, finite-element analysis (FEA), and the use of standards in design evaluation (e.g., ASTM testing standards).
Pre / Co requisites: BME 460 requires prerequisites of BME 120 and BME 365.
Typically offered in Fall.

PHY

PHY 100. Elements of Physical Science. 3 Credits.
A study of motion, energy, light, and some aspects of modern physics.
Gen Ed Attribute: Science Distributive Requirement.
Distance education offering may be available.
Typically offered in Fall & Spring.

PHY 105. Structure of the Universe. 3 Credits.
A survey of phenomena and objects in the universe from the very smallest distance scales to the grandest in the cosmos. Includes a historical consideration of the developments of modern theories of the physical world.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

PHY 115. Engineering Graphics I. 1 Credit.
Use and preparation of engineering drawings. Topics include the use of instruments, linework, geometric construction, lettering, four types of projections, dimensioning, and sections.
Typically offered in Fall.

PHY 116. Engineering Graphics II. 1 Credit.
A continuation of PHY 115, to include topics such as layout, detail, and assembly drawings, developments, auxiliary drawings, various types of drafting, machine tool processes, and computer drafting.
Pre / Co requisites: PHY 116 requires prerequisite of PHY 115.
Typically offered in Spring.

PHY 123. Food, Fire, and Physics: The Science of Cooking. 3 Credits.
An exploration of food and cooking from a physical science perspective. Principles of soft matter physics (e.g. phase diagram, intermolecular forces, viscosity, diffusion, self-assembly, polymer physics) are discussed and used to gain insight into food and cooking.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

PHY 125. Theology and Science: Enemies or Partners. 3 Credits.
An inquiry into the relationship of theology to the natural sciences. Team taught by both a physicist and a philosopher, the course investigates how ideas of God have been affected by advances in physics and biology.
Gen Ed Attribute for Students Admitted Prior to Fall 2020: Humanities Distributive Requirement, Science Distributive Requirement.
Gen Ed Attribute for Students Admitted Fall 2020 and After: None.
Typically offered in Spring.
Cross listed courses PHI 125, PHY 125.

PHY 130. General Physics I. 4 Credits.
LEC (3), LAB (2), DIS (1)
An introductory, noncalculus, physics course. Mechanics of solids and fluids, wave motion, heat and temperature, thermodynamics, and kinetic theory.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall, Spring & Summer.

PHY 140. General Physics II. 4 Credits.
LEC (3), LAB (2), DIS (1)
An extension of PHY 130. Electricity and magnetism, geometrical and physical optics, and modern physics.
Pre / Co requisites: PHY 140 requires a prerequisite of PHY 130.
Typically offered in Fall, Spring & Summer.

PHY 170. Physics I. 4 Credits.
LEC (3), LAB (2), DIS (1)
An introductory laboratory-based course. Includes mechanics, waves, heat, and thermodynamics. The laboratory emphasizes error analysis, the writing of technical reports, and data analysis using computers. A laboratory section must be added along with the lecture and discussion.
Pre / Co requisites: PHY 170 requires a prerequisite of MAT 161 OR a prerequisite of MAT 143 or MAT 145 and a corequisite of MAT 161.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

PHY 175. Computational Physics. 3 Credits.
This is an introductory course on the basic ideas and programming skills of computational physics, with a six-week introduction to programming given at the beginning of the course. Students will develop their own computer software to solve problems in mechanics, electrostatics, magnetism, quantum mechanics, chaos and other areas.
Pre / Co requisites: PHY 175 requires prerequisites of MAT 161, MAT 162, and PHY 170.
PHY 175 requires corequisite courses of MAT 261, MAT 311, and PHY 180.
Typically offered in Spring.

PHY 180. Physics II. 4 Credits.
LEC (3), LAB (2), DIS (1)
A continuation of PHY 170. Includes electricity and magnetism, geometrical and physical optics, electronics, and modern physics.
Pre / Co requisites: PHY 180 requires a prerequisite of PHY 170 and corequisite of MAT 162.
Typically offered in Fall & Spring.

PHY 205. Cellular and Molecular Biophysics. 3 Credits.
This course draws on concepts and tools from physics, biology, and chemistry to understand how energy is transformed into order in living systems. This will require students to consider the roles evolution, polymer physics, and chemistry have played in shaping the machinery of life. This course is aimed at students from physics, biology, and chemistry who are interested in stretching themselves beyond disciplinary boundaries.
Pre / Co requisites: PHY 205 requires prerequisites of PHY 140 or PHY 180, CHE 104, and MAT 161 or MAT 145.
Gen Ed Attribute: Interdisciplinary Requirement, Speaking Emphasis.
Typically offered in Spring.

PHY 240. Introduction to Modern Physics. 3 Credits.
An atomic view of electricity and radiation, atomic theory, special relativity theory, X-rays, radioactivity, nuclear fission, and introductory quantum mechanics.
Pre / Co requisites: PHY 240 requires prerequisites of PHY 140 or PHY 180 and MAT 162.
Typically offered in Spring.

PHY 260. Engineering Statics. 3 Credits.
Composition and resolution of forces, equivalent force systems, equilibrium of particles and rigid bodies, centroids and center of gravity, analysis of simple structures, internal forces in beams, friction, moments and products in inertia, and methods of virtual work.
Pre / Co requisites: PHY 260 requires prerequisites of PHY 130 or PHY 170 and MAT 162.
Typically offered in Spring.

PHY 300. Mechanics. 3 Credits.
Particle kinematics, dynamics, energy, and momentum considerations; oscillations; central force motion; accelerated reference frames; rigid body mechanics; Lagrangian mechanics.
Pre / Co requisites: PHY 300 requires prerequisites of PHY 140 or PHY 180 and MAT 162.
Typically offered in Fall.

PHY 310. Intermediate Physics Lab: Experimental Methods & Scientific Communication. 3 Credits.
LEC (1), LAB (2)
A lecture and laboratory course designed to familiarize students with experimental physics and scientific communication. Students conduct experiments, analyze data, and come to evidence-based conclusions. In addition, explicit instruction occurs on writing and presenting in the discipline of physics. Students write a scientific report on an experiment and present their findings to the department.
Pre / Co requisites: PHY 310 requires prerequisites of PHY 240 and PHY 175.
Gen Ed Attribute: Speaking Emphasis, Writing Emphasis.
Typically offered in Fall & Spring.

PHY 330. Electronics I. 3 Credits.
LEC (2), LAB (2)
Emphasis is divided between theory and experiment. The course begins with a brief review of resistive and RC voltage dividers. Electronic circuits studied include basic operational amplifiers, timers, instrumentation amplifiers, logic circuits, flip flops, counters, and timers.
Pre / Co requisites: PHY 330 requires prerequisites of MAT 161 and PHY 140 or PHY 180.
Typically offered in Spring.

PHY 350. Heat and Thermodynamics. 3 Credits.
Equations of state, first and second laws of thermodynamics, ideal and real gases, entropy, and statistical mechanics.
Pre / Co requisites: PHY 350 requires prerequisites of PHY 175, PHY 240, and MAT 261.
Typically offered in Spring.

PHY 370. Mathematical Physics. 3 Credits.
Selected topics in mathematics applied to problems in physics, ordinary differential equations, vector calculus, Fourier analysis, matrix algebra, and eigenvalue problems.
Pre / Co requisites: PHY 370 requires prerequisites of PHY 175, PHY 180, MAT 261, MAT 315 or (MAT 311 and MAT 343), or instructor permission.
Typically offered in Fall.

PHY 390. Fundamentals of Astrophysics. 3 Credits.
An advanced physics course that deals with a broad range of topics in modern astrophysics. Topics include, but are not limited to, astronomical measurements, celestial mechanics, radiative transfer theory, stellar structure, and both newtonian and relativistic cosmology.
Pre / Co requisites: PHY 390 requires prerequisites of PHY 175 and PHY 240.
Typically offered in Spring.

PHY 400. Analytical Dynamics. 3 Credits.
Wave propagation, Lagrange's equations and Hamilton's principle, rigid body motion, and special relativity.
Pre / Co requisites: PHY 400 requires prerequisites of PHY 300 and MAT 343.
Typically offered in Spring.

PHY 410. Optics. 3 Credits.
Geometrical and physical optics. Reflection and refraction at surfaces, lenses, interference and diffraction, and polarization.
Pre / Co requisites: PHY 410 requires prerequisites of MAT 261, MAT 315, and PHY 175.
Typically offered in Fall.

PHY 420. Quantum Mechanics I. 3 Credits.
This course is an introductory quantum mechanics course. The following fundamental topics will be covered: the Schrodinger equation, Solutions to systems with stationary states (potential step, potential well, potential barrier, and harmonic oscillator), an abstract view of quantum mechanics (Dirac notation, Operator methods), the hydrogen atom, Angular momentum, and Spin.
Pre / Co requisites: PHY 420 requires prerequisites of PHY 240, PHY 300, and MAT 315 or MAT 343 or PHY 370.
Typically offered in Fall.

PHY 425. Quantum Mechanics II. 3 Credits.
This course is the second-semester quantum mechanics course. The following fundamental topics will be covered: Time-independent Perturbation Theory, the Variational Principle, the WKB approximation, time-dependent Perturbation Theory, and advanced topics.
Pre / Co requisites: PHY 425 requires a prerequisite of PHY 420.
Typically offered in Spring.

PHY 430. Electricity and Magnetism I. 3 Credits.
Electrostatics of point charges and extended charge distributions, fields in dielectrics, and magnetic fields due to steady currents. Ampere's Law and induced emfs. Topics in electromagnetic waves as time permits.
Pre / Co requisites: PHY 430 requires prerequisites of PHY 300 and MAT 343 or PHY 370.
Typically offered in Fall.

PHY 435. Electricity and Magnetism II. 3 Credits.
This course covers the applications of Maxwell's equations. Specific topics include: conservation laws, electromagnetic waves, guided waves, gauge transformations, retarded potentials, radiation from point charges and dipoles, and transformations of the electromagnetic field.
Pre / Co requisites: PHY 435 requires prerequisites of PHY 240, PHY 370, and PHY 430.
Typically offered in Spring.

PHY 440. Microcomputer Electronics. 3 Credits.
Laboratory study of special circuits, integrated circuits, microcomputers, and microcomputer interface applications.
Pre / Co requisites: PHY 440 requires prerequisites of PHY 330 and MAT 343 or PHY 370.
Typically offered in Spring.

PHY 450. Advanced Physics Lab I. 1 Credit.
A course to familiarize students with contemporary laboratory equipment and methods.
Typically offered in Fall.

PHY 455. Advanced Physics Lab: Experimental Methods & Scientific Communication. 3 Credits.
LEC (1), LAB (2)
This course is a continuation of PHY 310, a lecture and laboratory course designed to familiarize students with modern physics laboratory equipment and practices through a series of experiments. Students write three research papers and give one research talk describing the experiments and their results in a style consistent with scientific conventions.
Pre / Co requisites: PHY 455 requires a prerequisite of PHY 310.
Gen Ed Attribute: Speaking Emphasis, Writing Emphasis.
Typically offered in Fall & Spring.

PHY 460. Advanced Physics Lab II. 1 Credit.
A continuation of PHY 450.
Typically offered in Spring.

PHY 480. Special Topics in Physics. 1-3 Credits.
Topics of special interest to be presented once or twice. Enrollment requirements to be specified by the instructor. Course may be repeated by student for credit any number of times when different topics are presented.
Typically offered in Spring.
Repeatable for Credit.

PHY 481. Special Topics with Lab. 3 Credits.
LEC (2), LAB (2)
Topics of special interest to be presented with a laboratory component. Enrollment requirements to be specified by the instructor. Course may be repeated by student for credit up to three times when different topics are presented.
Consent: Permission of the Department required to add.
Typically offered in Fall & Spring.
Repeatable for Credit.

PHY 490. Introduction to Research. 1-9 Credits.
Specific problems in consultation with the faculty adviser.
Consent: Permission of the Department required to add.
Typically offered in Fall.
Repeatable for Credit.

SCI

SCI 100. Climate Change. 3 Credits.
This course provides an introduction to the science of climate change. Core topics include albedo, the greenhouse effect, the carbon cycle, and feedback mechanisms between these phenomena. Students will study past climates, climate models, and the impacts of modern climate change. Near the end of the semester students will discuss efforts to mitigate climate change. They conclude by briefly discussing the most widely adopted climate change policies. No previous experience with these subjects is assumed.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

SCI 103. Science in the Arts: Color and Music. 3 Credits.
This class will be geared towards how science shows up in art and music. Students will initially study some basic physics principles such as force and motion, electric and magnetic fields, periodic oscillations, and wave properties. They will then introduce some biological and neuropsychological concepts as they begin to focus on light, optics and color, and the human eye. Next, students will focus on sound, sound production, sound perception, and the organization of sound into musical scales such that "music" can be constructed.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

SCI 111. Applications of Math and Reasoning in Nanoscience. 1 Credit.
This 3-week course will expose the students to basic problem-solving skills involving polynomial, rational, exponential, logarithmic, and trigonometric functions, where an emphasis will be placed on understanding function properties, models, and graphs applied to nanoscience situations. Little to no prior knowledge of physics, biology, chemistry, or engineering is assumed. There will be a hands-on component to this course that will utilize inquiry-oriented activities with Arduinos and other experimental interfaces. An example of a hands-on activity will be the synthesis and analysis of gold nanoparticles, focusing on their use in applications such as sensory probes, drug delivery, and catalysis.
Typically offered in Summer.