DEPARTMENT OF PHYSICS AND ENGINEERING

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
The Department of Physics and Engineering offers two undergraduate degree programs:
- B.S. in Physics: 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.
- 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.

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 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/.

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 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.

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
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 (bmitchelle@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

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 biomaterials. 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.
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 a prerequisite of PHY 170 and a prerequisite or corequisite of 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.
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 320. Biostatistics for Engineers. 3 Credits.
This course introduces students to biostatistics, covering the basic methods utilized to statistically analyze and present data using R programming language. Students will apply statistical analysis on datasets derived from biomedical engineering studies. Topics include random variables and probability distributions, estimation and confidence intervals, hypothesis testing and statistical inference, one-way ANOVA, two-way ANOVA, one-way repeated-measures ANOVA, and non-parametric tests.
Pre / Co requisites: BME 320 requires prerequisites of BME 110 and BIO 265.
Typically offered in Fall.

BME 325. Biomedical Engineering Laboratory II. 2 Credits.
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 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 410. Senior Design I. 3 Credits.
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 poster/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. 3 Credits.
This is the continuation of BME 410. This course provides students the opportunity to work on real-world, open-ended, and possibly 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 reports are required at the beginning of BME 410 and in the middle of the two semesters, respectively. A final report and poster/oral presentations are required at the end of BME 420.
Pre / Co requisites: BME 420 requires a prerequisite of BME 410 or permission of the instructor.
Typically offered in 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 (GMP) guidelines and regulations. Topics include: introduction to the FDA and other regulatory agencies, current Good Manufacturing Practices (GMP), 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 Spring.

BME 455. Bioprocess Engineering. 3 Credits.
This course covers the fundamental principles and applications of bioprocessing. Engineering principles applied to processes involving recombinant protein production are introduced. Emphasis is placed on the engineering aspects of quantitative bioprocess analysis. Topics include bioprocessing, recombinant DNA technology, material balances, mass transfer, bioreactions, and bioreactor engineering.
Pre / Co requisites: BME 455 requires a prerequisite of BME 345.
Typically offered in Fall.

BME 460. Biomedical Device Design. 3 Credits.
This is a required 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.

BME 465. Cell and Tissue Engineering. 3 Credits.
This course provides insight into current topics in cell and tissue engineering. Lectures will be supplemented with discussions of current and seminal research topics. Topics include: stem cells/induced pluripotent stem cells and their use in tissue engineering applications, biomaterials and their uses in tissue engineering, and bioreactors for modeling physiologically relevant systems.
Pre / Co requisites: BME 465 requires a prerequisite of BME 335 or permission of the instructor.
Typically offered in Spring.

BME 470. Artificial Organs and Cryobiology Fundamentals. 3 Credits.
This course will introduce students to the multidisciplinary knowledge (in thermodynamics, heat and mass transfer, physical chemistry, biology) and methodologies which are required to study cryobiology and artificial organs. It will also provide cryobiology fundamentals, including a cell's response to low temperature, osmotic behavior, and membrane transport at low temperature and activation energy, mechanisms of cryoprotection, and the fundamentals of kidneys and hemodialysis, including type of kidney diseases, different treatments, and kinetic modeling in hemodialysis.
Pre / Co requisites: BME 470 requires a prerequisite of BME 345 or permission of the instructor.
Typically offered in Spring.

NSC
NSC 200. Tools of Nanoscience. 3 Credits.
This survey course introduces students to the major concepts and techniques of nanoscience through lectures and demonstrations. This survey is intended to be phenomenological and conceptual, setting the stage for the exploration of experimental nanoscience. Students will be introduced to why nanoscale objects are different, how to make them, how to characterize them, and how to visualize them.
Pre / Co requisites: NSC 200 requires a prerequisite of SCI 111.
Typically offered in Spring.

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.

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: Science Distributive Requirement.
Typically offered in 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.
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.
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.
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 PHY 161.
Gen Ed Attribute: Science Distributive Requirement.
Typically offered in Fall & Spring.

PHY 180. Physics II. 4 Credits.
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 130 or PHY 170, CHE 103, and one of MAT 143, MAT 145, or MAT 161; and a corequisite of PHY 140 or PHY 180.
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 275. Computational Physics. 3 Credits.
This is an introductory course on the basic ideas and programming skills of computational physics, with a seven-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 275 requires a prerequisite of MAT 162 and a corequisite of PHY 180.
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.
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 275.
Typically offered in Fall & Spring.

PHY 330. Electronics I. 3 Credits.
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 275, 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 275, 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 275 and PHY 240.
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 275.
Typically offered in Fall.

PHY 420. Quantum Mechanics I. 3 Credits.
An introductory course in quantum mechanics. Topics covered include the Schrödinger equation, stationary states, time evolution, position and momentum space wave functions, bound states, scattering states, spin and orbital angular momentum, hydrogenic atoms, and entanglement. Additional topics may include perturbation theory, conserved quantities, particle statistics, and quantum information.
Pre / Co requisites: PHY 420 requires a prerequisite of PHY 240 and a corequisite of 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 a prerequisite of PHY 430. Typically offered in Spring.

PHY 455. Advanced Physics Lab: Experimental Methods & Scientific Communication. 3 Credits.
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.

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.
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 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. Distance education offering may be available. Typically offered in Fall & Spring.