An introduction to some of the exciting ideas, developments, problems, and experiments of modern day physics.

PHSX 201N. Physics by Inquiry. 3 Credits. (3 Lec, 1 Lab) F,S
PREREQUISITE: High School Algebra. A practical approach to a broad array of fundamental topics in physics for non-science majors taught by analyzing things that are used and observed in everyday life. Classroom demonstrations will provide the opportunity for in-class analysis, discussions, and hands-on activities. Physics principals will be used to scrutinize issues such as energy and recycling from economic and environmental perspectives. The latest technology in transportation, electronics, and energy production will be analyzed. The connection between basic research in physics and modern technology will be examined. Students will not receive credit if they have passed PHSX 205, PHSX 220, or PHSX 240.

PHSX 200. Research Programs in Physics. 1 Credit. (1 Lec) F
PREREQUISITE: High School Algebra. An introduction to some of the exciting ideas, developments, problems, and experiments of modern day physics.
PHSX 425. Electricity and Magnetism II. 3 Credits. (3 Lec) F
PREREQUISITE: (PHSX 343 and PHSX 423) or Graduate Standing. Propagation of electromagnetic waves, radiation, and general wave phenomena.

PHSX 427. Advanced Optics. 3 Credits. (3 Lec) S
Alternate Even Years PREREQUISITE: (PHSX 224; M 274 or M 284) or Graduate Standing. Emphasis is on new developments in optics triggered by the laser. Provides a good foundation in wave optics, nonlinear optics, integrated optics, and spectroscopy.

PHSX 435. Astrophysics. 3 Credits. (3 Lec) S
Alternate Odd Years PREREQUISITE: PHSX 222 or PHSX 242 or Graduate Standing. A survey covering basic problems in modern astrophysics such as stellar structure and evolution, solar physics, compact objects, quasars, and cosmology.

PHSX 437. Laser Applications. 3 Credits. (3 Lec) S
Alternate Odd Years PREREQUISITE: PHSX 244 or PHSX 242 or Graduate Standing. A survey of laser types and properties and applications for scientists and engineers who wish to use lasers in research or technology. Many demonstrations will be used to illustrate the principles.

PHSX 441. Solid State Physics. 3 Credits. (3 Lec) S
Alternate Odd Years PREREQUISITE: PHSX 224 or graduate standing. A treatment of the classification and electronic structure of solids. Properties of conductors, superconductors, insulators, and semiconductors will be discussed. This course is strongly recommended for students intending to study physics in graduate school.

PHSX 442. Novel Materials for Physics/Engineering. 3 Credits. (3 Lec) On Demand PREREQUISITE: Knowledge of introductory solid state physics; PHSX 441 or Graduate Standing or consent of instructor. Provides basic physical knowledge of advanced natural/artificial materials of current interest (including ferroelectrics, superconductors, nanotubes, superlattices, photonic materials, materials with giant magnetoresistance and negative susceptibilities, molecular magnets, biomaterials, etc.).

PHSX 444. Advanced Physics Lab. 4 Credits. (2 Lec. 2 Lab; 8 cr max) F,S (May not duplicate F or S semesters, 4 cr F, 4 cr S only) PREREQUISITE: PHSX 262 and PHSX 343. COREQUISITE: PHSX 461. Introduction to methods, instrumentation, and data acquisition techniques used in modern physics research. Different experiments are offered in the two semesters. For students desiring a strong experimental exposure, taking both courses is recommended. Experiments in the fall semester are typically in the optical area and include interferometers, fiber optics, spectral measurement, polarization, and laser optics. Experiments in spring semester are typically in solid state physics and particle spectroscopy. Co-convened with PHSX 516.

PHSX 446. Thermodynamics & Statistical Mechanics. 3 Credits. (3 Lec) S PREREQUISITE: PHSX 301 or Graduate Standing. Statistical physics and thermodynamics and their applications to physical phenomena. This course is strongly recommended for students intending to study physics in graduate school and is a required course for the professional option.

PHSX 451. Elementary Particle Physics. 3 Credits. (3 Lec) S Alternate Odd Years PREREQUISITE: PHSX 343 or Graduate Standing. A survey of elementary particle physics, beginning with an historical viewpoint and leading up to today's remarkably successful "Standard Model" of quarks, leptons, and gauge bosons.

PHSX 461. Quantum Mechanics I. 3 Credits. (3 Lec) F PREREQUISITE: PHSX 343 and PHSX 320; or Graduate Standing. The wave function, the Schrödinger equation in 1-D, formalism and Dirac notation, and 3-D effects including the hydrogen atom.

PHSX 462. Quantum Mechanics II. 3 Credits. (3 Lec) PREREQUISITE: PHSX 461 or Graduate Standing. Identical particles, time independent perturbation theory, time dependent perturbation theory, and the variational principle.

PHSX 490R. Undergraduate Research. 1-3 Credits. (1-3 Ind; 6 cr max) F,S,Su PREREQUISITE: Junior or senior standing and consent form with approved research plan signed by instructor/research advisor and academic advisor. Directed undergraduate research/creative activity, which may culminate in a research paper, journal article, or undergraduate thesis. Course will address responsible conduct of research. Typically only 1 credit per semester. May be repeated.

PHSX 491. Special Topics. 1-4 Credits. (1-4 Lec; 12 cr max) On Demand Max 12 cr. PREREQUISITE: Course prerequisites as determined for each offering. Courses not required in any curriculum for which there is a particular one-time need, or given on a trial basis to determine acceptability and demand before requesting a regular course number.

PHSX 492. Independent Study. 1-3 Credits. (1 Ind; 6 cr max) PREREQUISITE: Junior or senior standing, consent of instructor and approval of department head. Max 6 cr. Directed study on an individual basis.

PHSX 494. Seminar/Workshop. 1 Credit. (1 Sem; 4 cr max) PREREQUISITE: Junior or senior standing and as determined for each offering. Max 4 cr. Topics offered at the upper division level which are not covered in regular courses. Students participate in preparing and presenting discussion material. Co-convened with PHSX 594.

PHSX 497. Conceptual Physics for Teachers. 3 Credits. (3 Lec) Su PREREQUISITE: Since the course is intended for teachers, most participants will have graduate standing, however, some pre-service teachers and other science educators may also take the course as seniors in an undergraduate program. This course is designed for teachers who are covering some of the basic ideas of physics in their classrooms. At the conceptual level, the course describes the world around us. The everyday; how a ball moves when it is thrown, the forces you feel on a roller-coaster, what happens when you turn on a light switch; and the esoteric: time and space from the perspective of Einstein's relativity, atoms and nuclei. Conceptual Physics includes the topics of motion, force, energy, electricity, magnetism, waves, light, and the intriguing concepts of modern physics - relativity, atoms, and nuclei.

PHSX 499. Senior Capstone Seminar. 1 Credit. (1 Sem) S PREREQUISITE: Senior standing, completion of a senior project, and 2 credits of PHSX 490R. Senior capstone course. Participation in this course requires the completion of a senior project that integrates the student's knowledge and skills acquired during the undergraduate curriculum. Students will be required to complete: i) an APS-style abstract, ii) an APS-style 10-minute oral presentation, iii) a poster session, and iv) a written research report, based on their research/creative activity.


PHSX 511. Astronomy for Teachers. 3 Credits. (3 Rct) F,S,Su PREREQUISITE:Graduate standing; Currently certified middle and high school teachers with one year of teaching experience. This is an online, distance education course primarily intended for science educators. Topics include: the laws of gravity and orbital dynamics, a survey of the solar system, stars and stellar evolution, galaxies, and Big Bang cosmology.

PHSX 512. General Relativity Online. 3 Credits. (3 Lec) S alternate years, to be offered every years. PREREQUISITE: PHSX 222 or PHSX 242; M 182Q; PHSX 405; Bachelor's degree and one year teaching experience. This online course addresses the theory of general relativity, which underlies our understanding of gravity and the large-scale structure of the cosmos. Designed for practicing high school physics teachers. Assignments and discussions use electronic computer conferencing and simulation software.

PHSX 513. Quantum Mechanics Online. 3 Credits. (3 Lec) Su alternate years, to be offered every years. PREREQUISITE: Graduate standing; Currently certified high school teachers with one year of teaching experience; an introductory physics course; and a working knowledge of elementary differential and integral calculus. This online course addresses the key ideas behind quantum mechanical observations and devices, including the fundamental behavior of electrons and photons. Designed for practicing high school physics teachers. Assignments and discussions use electronic computer conferencing and simulation software.
PHSX 514. Comparative Planetology Online. 3 Credits. (3 Lec) S
PREREQUISITE: Bachelor's degree, professional teaching certificate, and at least one year of K-12 teaching experience. Because the use of technology is integral to the course, some familiarity with using technology in the classroom is required. Establishing a Virtual Presence in the Solar System has been developed and tested as an Internet-delivered course for off-campus students. Its audience consists of practicing elementary and secondary teachers who have experience in teaching general science but have little, if any, formal course work in astronomy. Its goal is to help graduate-level teachers learn solar system astronomy concepts to integrate the new National Science Education Standards and NASA resources into existing instructional strategies. Course participants learn advanced solar system concepts, utilize WWW-resources, communicate with research scientists using the Internet, analyze digital images using image processing software, and organize materials for use in K-12 classroom environments.

PHSX 515. Advanced Topics In Physics. 3 Credits. (3 Lec; 6 cr max) On Demand
Max 6 cr. PREREQUISITE: Graduate standing. Topics in astrophysics, condensed matter physics, optics, mathematical physics, or particle physics are presented as needed to supplement the curriculum.

PHSX 516. Experimental Physics. 3 Credits. (2 Lec. 1 Lab; 6 cr max) F,S
PREREQUISITE: (PHSX 261, PHSX 423, and PHSX 461) or graduate standing. Experiments chosen from laser optics and atomic, solid-state, and nuclear physics are carried out in depth to introduce the graduate student to methods, instrumentation, and data acquisition techniques useful for experimental thesis projects. Co-convened with PHSX 444.

PHSX 519. Electromagnetic Theory I. 3 Credits. (3 Lec) S
PREREQUISITE: PHSX 425 or graduate standing. Electro- and magnetostatics, conservation laws and covariance of Maxwell's equations, and dynamics of relativistic particles and fields.

PHSX 520. Electromagnetic Theory II. 3 Credits. (3 Lec) F

PHSX 523. General Relativity I. 3 Credits. (3 Lec) F, alternate years, to be offered even years.
PREREQUISITE: PHSX 519. Tensor calculus, differential geometry, and an introduction to Einstein's theory of gravity. The Schwarzschild solution and black hole physics.

PHSX 524. General Relativity II. 3 Credits. (3 Lec) S, alternate years, to be offered odd years.
PREREQUISITE: PHSX 523. Advanced topics in gravitation theory such as singularities, cosmological models, and gravitational waves.

PHSX 525. Current Topics in General Relativity. 3 Credits. (3 Lec) S
PREREQUISITE: PHSX 523. Current topics in general relativity will be explored.

PHSX 531. Nonlinear Optics/Laser Spectroscopy. 3 Credits. (3 Lec) F, alternate years, to be offered odd years.
PREREQUISITE: PHSX 507. Two-level atoms in laser fields and applications to nonlinear optics such as photon echoes, second harmonic generation, and stimulated Raman scattering. Atomic and molecular energy level structure, linear and nonlinear spectroscopy, and applications to gaseous and solid state laser materials.

PHSX 535. Statistical Mechanics. 3 Credits. (3 Lec) S
PREREQUISITE: PHSX 446 or graduate standing. Basic concepts of equilibrium statistical mechanics, with application to classical and quantum systems, will be presented as well as theories of phase transitions in fluid, magnetic, and other systems.

PHSX 544. Condensed Matter Physics I. 3 Credits. (3 Lec) F, alternate years, to be offered even years.
PREREQUISITE: PHSX 446 or graduate standing, and PHSX 507. Crystal structure and the reciprocal lattice. Quantum theory of electrons and phonons.

PHSX 545. Condensed Matter Physics II. 3 Credits. (3 Lec) S, alternate years, to be offered odd years.
PREREQUISITE: PHSX 544. Applications to the transport, optical, dielectric, and magnetic properties of metals, semiconductors, and insulators.

PHSX 555. Quantum Field Theory. 3 Credits. (3 Lec) S
PREREQUISITE: PHSX 507. Techniques of canonical and path integral quantization of fields; renormalization theory. Quantum electrodynamics; gauge theories of the fundamental interactions.

PHSX 560. Astrophysics. 3 Credits. (3 Lec) F, alternate years, to be offered even years.
PREREQUISITE: PHSX 425, PHSX 462, PHSX 446, and PHYS 435, or graduate standing. The purpose of this course is to prepare graduate students for thesis-level research in astrophysics, solar physics or related fields. Topics covered include: fluid mechanics, hydrodynamics, plasma physics, radiation processes and stability of equilibrium states.

PHSX 565. Astrophysical Plasma Physics. 3 Credits. (3 Lec) F, alternate years, to be offered odd years.
COREQUISITE: PHSX 520. An introduction to the physics of fluids and plasma relevant to astrophysical plasmas such as the solar corona. Topics covered include: magnetostatics, one-fluid (MHD) and two-fluid approaches, linear waves and instabilities, shocks, transonic flows and collisional effects.

PHSX 566. Mathematical Physics I. 3 Credits. (3 Lec) F
PREREQUISITE: M 349, M 472, and PHSX 320 or graduate standing. Mathematical methods which find application in physics. Differential equations, contour integration, special functions, integral transforms, boundary value problems, and Green's functions.

PHSX 567. Mathematical Physics II. 3 Credits. (3 Lec) S, alternate years, to be offered even years.
PREREQUISITE: PHSX 566. Theory of computational techniques, and applications such as numerical integration, differential equations, Monte Carlo methods, and fast Fourier transforms.

PHSX 571. Electric Circuits and Magnetism for Teachers. 2 Credits. (2 Lec) Su
PREREQUISITE: Graduate standing; science educator; interest in science. This 2-credit graduate course is designed for practicing teachers who are teaching or plan to teach electricity and magnetism as part of the science curricula in their classrooms. Its broad purpose is to introduce core concepts in electric circuits and magnetism. The course aims to help teachers by increasing their understanding of the underlying physics so that they may use their curricular materials more effectively.

PHSX 572. Space Science for Elementary Teachers. 1 Credit. (1 Lec) F
PREREQUISITE: Graduate standing; science educator; interest in science. During this online course, participants will complete a series of online units focusing on space science and astronomy concepts to build core knowledge that can be incorporated into the classroom. This course will be taught in a manner that will allow the participant to experience the activities they will be teaching and to learn teaching “best practices” prior to implementation in their classroom. The course is intended for elementary classroom teachers and materials will be aligned to the National Model Academic Standards in Space Science.

PHSX 573. The Science of Sound for Teachers. 2 Credits. (2 Lec) S
PREREQUISITE: Graduate standing; science educator; interest in science. The Science of Sound is a 2-unit graduate course for in-service and pre-service teachers who are interested in understanding the basic principles of Sound, and is ideal for teachers of grades 5 through 8 (although teachers of all grades are welcome!). This is a conceptual physics course, focusing on the big ideas of Sound and their application in the real-world. To accommodate working professionals, this course is offered as an online, scheduled, asynchronous experience.

PHSX 574. World of Motion for Teachers. 1 Credit. (1 Lec) Su
PREREQUISITE: Graduate standing; science educator; interest in science. In this 6-week course for teachers we will focus on the core ideas of measurement and motion, as they appear in modern inquiry-oriented science education. The course aims to help teachers use modern curricular materials more effectively by increasing their understanding of the physics concepts.

PHSX 576. World of Force for Teachers. 1 Credit. (1 Lec) Su
PREREQUISITE: Graduate standing; science educator; interest in science. This 1-credit course is designed for teachers who are exploring the concepts of forces in their classrooms. Its broad purpose is to introduce elementary and middle school teachers to core ideas about forces, as they relate to modern, inquiry-oriented science curricular materials. The course aims to help teachers use such materials more effectively by increasing their understanding of physics concepts. It is not a course in how to use a particular curriculum.

PHSX 580. Electromagnetic Theory. 3 Credits. (3 Lec) F, alternate years, to be offered even years.
PREREQUISITE: PHSX 519. Tensor calculus, differential geometry, and an introduction to Einstein's theory of gravity. The Schwarzschild solution and black hole physics.

PHSX 585. Advanced Topics in Physics. 3 Credits. (3 Lec) S, alternate years, to be offered odd years.
PREREQUISITE: PHSX 519. Advanced topics in gravitation theory such as singularities, cosmological models, and gravitational waves.

PHSX 590. Independent Study. 0-3 Credits. (1-3 Lec) F,S
PREREQUISITE: Graduate standing. The purpose of this course is to prepare graduate students for thesis-level research in astrophysics, solar physics or related fields. Topics covered include: fluid mechanics, hydrodynamics, plasma physics, radiation processes and stability of equilibrium states.

PHSX 591. Seminar in Physical Science. 1 Credit. (1 Lec) S
PREREQUISITE: Graduate standing; science educator; interest in science. The Seminar in Physical Science is offered as an online, scheduled, asynchronous experience. This is a conceptual physics course, focusing on the big ideas of Sound and their application in the real-world. To accommodate working professionals, this course is offered as an online, scheduled, asynchronous experience.
PHSX 582. Astrobiology for Teachers Online. 3 Credits. (3 Lec) F,S
PREREQUISITE: (1) a bachelor’s degree, including college level biology and college level physics or astronomy (2) two years of experience teaching science (3) must be currently certified and teaching science at the middle or high school level. Astrobiology is the study of the origin, evolution, distribution, and destiny of life in the universe. It defines itself as an interdisciplinary science at the intersection of physics, astronomy, biology, geology, and mathematics, to discover where and under what conditions life can arise and exist in the Universe. The course topics will cover the discovery of planetary systems around other stars, the nature of habitable zones around distant stars, the existence of life in extreme environments. These concepts will serve as a foundation to study possible extraterrestrial ecosystems on planets and moons like Mars and Europa.

PHSX 589. Graduate Consultation. 3 Credits. (3 Ind) F,S,Su
PREREQUISITE: Master’s standing and approval of the Dean of Graduate Studies. This course may be used only by students who have completed all of their coursework (and thesis, if on a thesis plan) but who need additional faculty or staff time or help.

PHSX 590. Master’s Thesis. 1-10 Credits. (1 Ind; max unlimited) F,S,Su
Max credits unlimited. PREREQUISITE: Master’s standing.

PHSX 591. Special Topics. 1-4 Credits. (1 Lec. 12 cr max) On Demand
Max 12 cr. PREREQUISITE: Upper division courses and others as determined for each offering. Courses not required in any curriculum for which there is a particular one time need, or given on a trial basis to determine acceptability and demand before requesting a regular course number.

PHSX 592. Independent Study. 1-3 Credits. (1-3 Ind; 6 cr max) On Demand
Max 6 cr. PREREQUISITE: Graduate standing, consent of instructor, approval of department head and Dean of Graduate Studies. Directed research and study on an individual basis.

PHSX 594. Seminar. 1 Credit. (1 Sem; 8 cr max) On Demand
Max 8 cr. PREREQUISITE: Graduate standing or seniors by petition. Course prerequisites as determined for each offering. Topics offered at the graduate level which are not covered in regular courses. Students participate in preparing and presenting discussion material.

PHSX 595. Teaching Mechanics Using Research-based Curriculum. 2 Credits. (1 Lec, 1 Lab) Su
PREREQUISITES: Teacher of science with a minimum of two years teaching experience. This course prepares participants to teach a mechanics course built around Tutorials in Introductory Physics (McDermott, et al.). This research-based curriculum was designed to be used in recitations to augment traditional lecture courses operating essentially independent of the lecture. The course will model both the student-centered tutorial instruction and the supporting active-engagement lectures for a selection of topics from the first semester of the two-semester sequence.

PHSX 596. Teaching Electricity & Magnetism for Teachers. 2 Credits. (1 Lec, 1 Lab) Su
Participants will learn how to teach an integrated course built around Tutorials in Introductory Physics (McDermott, et al.). This research-based curriculum challenges students to confront their misconceptions and build gut-level models of the key concepts of electricity and magnetism. The course will showcase both the student-centered tutorial instruction and the supporting active-engagement PowerPoint lectures. We will also review the physics education research literature that provides the foundation for these curricular materials.

PHSX 689. Doctoral Reading & Research. 3-5 Credits. (3 Ind; 15 cr max) On Demand
Max 15 cr. PREREQUISITE: Doctoral standing. This course may be used by doctoral students who are reading research publications in the field in preparation for beginning doctoral thesis research.

PHSX 690. Doctoral Thesis. 1-10 Credits. (1 Ind; max unlimited) F,S,Su
Max credits unlimited. PREREQUISITE: Doctoral standing.
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