PHSX - Physics

PHSX 103IN The Physics of How Things Work: 3 Credits (3 Lec)
PREREQUISITE: High School Algebra. (Sp) 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 111CS The World of Quantum Physics: 3 Credits (3 Lec)
PREREQUISITE: Level 400 math placement. Non-science students will be introduced to quantum physics by exploring its intellectual development and its applications in technology. This course will explore quantum physics, its philosophical implications, and its impact on society, human life, and the world's economy. Important quantum physics experiments will be executed in the classroom by the instructor; students, in groups of 3-4, will analyzed the experiments, and explore the implications in instructor-guided class discussions. This portion will occupy 50% of the class time. Classroom lectures will occupy the remaining time. A term paper will require students to independently research an historical figure with a significant role in the development of quantum physics

PHSX 200 Research Programs in Physics: 1 Credits (1 Lec)
(Sp) An introduction to some of the exciting ideas, developments, problems, and experiments of modern day physics.

PHSX 201IN Physics by Inquiry: 3 Credits (3 Lab)
(F, Sp) An in-depth exploration of basic physics principles. Scientific model building and proportional reasoning skills will be developed in the context of properties of matter, observational astronomy, and DC electric circuits. For pre-service elementary teachers.

PHSX 205 College Physics I: 4 Credits (3 Lec, 1 Lab)
PREREQUISITE: High school trigonometry or M 121Q or (Math Level 4 or Higher). (F, Sp) First semester of sequence. Topics include kinematics and dynamics of linear and rotational motion; work and energy; impulse and momentum; and fluids. Students will not receive credit if they have passed PHSX 220 or PHSX 240. Common exams

PHSX 207 College Physics II: 4 Credits (3 Lec, 1 Lab)
PREREQUISITE: PHSX 205 or PHSX 220 or PHSX 240. (F, Sp, Su) Second semester of sequence. Topics include simple harmonic motion; electric forces and fields; dc electric circuits; magnetic forces and fields; and magnetic induction and motors. Students will not receive credit if they have passed PHSX 222 or PHSX 242. Common exams

PHSX 220 Physics I with Calculus: 4 Credits (3 Lec, 1 Lab)
COREQUISITE: M 171Q or M 181Q. (F, Sp, Su) First semester of a three-semester sequence primarily for engineering and physical science students. Covers topics in mechanics (such as motion, Newton's laws, conservation laws, work, energy, systems of particles, and rotational motion) and in mechanical waves (such as oscillations, wave motion, sound, and superposition). Common exams

PHSX 222 Physics II with Calculus: 4 Credits (3 Lec, 1 Lab)
PREREQUISITE: PHSX 220 or PHSX 240; M 171Q or M 181Q
COREQUISITE: M 172 or M 182. (F, Sp, Su) Covers topics in electricity and magnetism (such as Coulomb's law, Gauss' law, electric fields, electric potential, dc circuits, magnetic fields, Faraday's law, ac circuits, and Maxwell's equations) and optics (such as light, geometrical optics, and physical optics). Common exams
.

PHSX 224 Physics III: 4 Credits (3 Lec, 1 Lab)
PREREQUISITE: PHSX 222 or PHSX 242; M 172 or M 182. (F, Sp) Covers topics in thermodynamics (such as temperature, heat, laws of thermodynamics, and the kinetic theory of gases) and modern physics (such as relativity; models of the atom; quantum mechanics; and atomic, molecular, solid state, nuclear, and particle physics)

PHSX 240 Honors Gen & Mod Phys I: 4 Credits (3 Lec, 1 Lab)
PREREQUISITE: Restricted to Physics majors or Honors students or consent of instructor
COREQUISITE: M 171Q or M 181Q. (F) The honors equivalent of PHSX 220. The concepts are discussed in more depth and the range of applications is greater. Common final only
.

PHSX 242 Honors Gen & Mod Phys II: 4 Credits (3 Lec, 1 Lab)
PREREQUISITE: PHSX 220 or PHSX 240; M 171Q or M 181Q
COREQUISITE: M 172 or M 182. (Sp) Restricted to Physics majors or Honors students or consent of instructor. The honors section of PHSX 222. The concepts are discussed in more depth and the range of applications is greater
.

PHSX 256 Solving Problems with Python: 3 Credits (3 Lec)
PREREQUISITE: PHSX 220 or 240; or PHSX 205 and M 161Q or M 165Q or M 171Q or M181Q. (Sp) Introduction to the Python programming language and computational problem solving with emphasis on realistic problems in the physical sciences. Recommended for students in all STEM fields

PHSX 261 Laboratory Electronics I: 3 Credits (2 Lec, 1 Lab)
PREREQUISITE: PHSX 222 OR PHSX 242. (F) Laboratory electronic measurements and analysis, and design of basic linear circuits

PHSX 262 Laboratory Electronics II: 2 Credits (1 Lec, 1 Lab)
PREREQUISITE: PHSX 261. (Sp) Analysis and design of basic digital circuits and advanced laboratory electronic measurements

PHSX 290R Undergraduate Research: 1-3 Credits (1-3 Other)
PREREQUISITE: Consent of instructor and approval of department head. Directed undergraduate research. Course will address responsible conduct of research
Repeatable up to 3 credits.

PHSX 291 Special Topics: 1-4 Credits ()
PREREQUISITE: None required but some may be determined necessary by each offering department. 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
Repeatable up to 12 credits.

PHSX 292 Independent Study: 1-3 Credits (1-3 Other)
PREREQUISITE: Consent of instructor and approval of department head. Directed study on an individual basis
Repeatable up to 6 credits.

PHSX 301 Mathematical Methods in the Physical Sciences: 3 Credits (3 Lec)
PREREQUISITE: M 273 or M 283 ; PHSX 222 or PHSX 242
COREQUISITE: M 274 or M 284. (F, Sp) Survey of the most important mathematical techniques used in the physical sciences: power series, complex variables, linear algebra, vector calculus, Fourier analysis, series solutions of ordinary differential equations, and partial differential equations. Applications to specific problems in the various disciplines of the physical sciences are emphasized
.

PHSX 305RN Art and Science of Holography: 3 Credits (2 Lec, 1 Lab)
PREREQUISITE: M105Q or M121Q or equivalent math placement test; and Junior standing or instructor permission. (Sp) Beginner's course on creating holograms. Pictorial and geometric interpretations of lasers, interference, coherence, film, and holography enable students with limited science and M backgrounds to create their own holographic masterpieces. Lab techniques and documenting the creative process are emphasized

PHSX 317 Instrument Building for Scientists: 1 Credits (1 Lab)
(F, Sp, Su) Junior standing required. Introduction to design, and fabrication of parts for laboratory experiments. Hands-on training in the safe use of band saw, drill press, milling machine, lathe, and CNC machinery use. Completion will allow students controlled access to machine shop.

PHSX 320 Classical Mechanics: 3 Credits (3 Lec)
PREREQUISITE: PHSX 301; PHSX 220 or PHSX 240. (F) Principles of Newtonian and Lagrangian mechanics including single particle motion, systems of particles, rigid body motion, moving coordinate systems, and small oscillations

PHSX 331 Methods of Computational Physics: 2 Credits (1 Lec, 1 Other)
PREREQUISITE: PHSX 301. (F) Introduction to the use of computational methods in physics. Emphasis will be placed on common methods of casting problems into forms amenable to numerical solution and for displaying numerical results. (1 cr. Lecture, 1cr. Recitation)

PHSX 343 Modern Physics: 3 Credits (3 Lec)
PREREQUISITE: PHSX 224, PHSX 301, and M 284 or M 274. (F) Waves in classical physics and quantum mechanics: complex representation, amplitude mechanics, and interference; Special relativity: postulates, Lorentz transformations, applications in nuclear and particle physics; Quantum mechanics: interpretation of key experiments, Schrodinger equation, particles in potentials, spin, the atom; Introduction to nuclear and particle physics

PHSX 423 Electricity and Magnetism I: 3 Credits (3 Lec)
PREREQUISITE: PHSX 343 or Graduate Standing. (Sp) Electrostatic and magnetostatic fields due to simple charge and current distributions, forces on charges and currents due to those fields, basic analog circuits, conductivity and resistivity, and Maxwell's Equations as applied to electromagnetic induction and waves

PHSX 425 Electricity and Magnetism II: 3 Credits (3 Lec)
PREREQUISITE: PHSX 423 or Graduate Standing. (F) Electrostatic and magnetostatic fields and potentials in matter, electromagnetic conservation laws, propagation of electromagnetic waves in materials, potentials due to dynamic charge distributions, and electromagnetic radiation. This course is strongly recommended for students intending to study physics in graduate school

PHSX 427 Advanced Optics: 3 Credits (3 Lec)
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)
PREREQUISITE: (PHSX 320; PHSX 343; 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)
PREREQUISITE: PHSX 222 OR PHSX 242. () 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)
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 444 Advanced Physics Lab: 4 Credits (2 Lec, 2 Lab)
PREREQUISITE: PHSX 262 and PHSX 343
COREQUISITE: PHSX 461. (F, Sp) 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
.
Repeatable up to 8 credits.

PHSX 446 Thermodynamics & Statistical Mechanics: 3 Credits (3 Lec)
PREREQUISITE: PHSX 301 and PHSX 224 and PHSX 343, or Graduate Standing. (Sp) 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)
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)
PREREQUISITE: PHSX 343 and PHSX 320. (F) The wave function, the Schrodinger 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. (Sp) Identical particles, time independent perturbation theory, time dependent perturbation theory, and the variational principle

PHSX 490R Undergraduate Research: 1-3 Credits (1-3 Other)
PREREQUISITE: Junior or senior standing and consent form with approved research plan signed by instructor/ research advisor and academic advisor. (F, Sp) 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
Repeatable up to 6 credits.

PHSX 491 Special Topics: 1-4 Credits (1-4 Lec)
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
Repeatable up to 12 credits.

PHSX 492 Independent Study: 1-3 Credits (1 Other)
PREREQUISITE: Junior or senior standing, consent of instructor and approval of department head. (F, Sp) Max 6 cr. Directed study on an individual basis
Repeatable up to 6 credits.

PHSX 494 Seminar/Workshop: 1-4 Credits ()
PREREQUISITE: Junior or senior standing and as determined for each offering. (F, Sp) 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
Repeatable up to 4 credits.

PHSX 499R Senior Capstone Seminar: 1 Credits (1 Other)
PREREQUISITE: PHSX 490R and Senior Standing. (Sp, Su) 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 501 Mathematical Methods and Their Applications in Classical Mechanics: 3 Credits (3 Lec)
PREREQUISITE: PHSX 320 or graduate standing. (F) This course covers Lagrangian and Hamiltonian mechanics, small oscillations, strings and continua, and fluids. Relevant mathematical methods will include multivariate Taylor expansions, linear algebra, Sturm-Liouville theory, and Fourier theory

PHSX 506 Quantum Mechanics I: 3 Credits (3 Lec)
PREREQUISITE: PHSX 462 or graduate standing. (F) The graduate Quantum Mechanics-1 course covers foundational principles of quantum mechanics, with deeper emphasis on the more general and more formal structure of quantum physics. The main equations are developed from few underlying physical and mathematical concepts

PHSX 507 Quantum Mechanics II: 3 Credits (3 Lec)
PREREQUISITE: PHSX 506. (Sp) The graduate Quantum Mechanics-2 course covers applications of quantum formalism developed in QM-1. A more detailed description of angular momentum addition and applications to more complex systems. Time-dependent perturbations and transitions between quantum states. Application to radiation and scattering problems. Quantum mechanics in relativistic case

PHSX 511 Astronomy for Teachers: 3 Credits (3 Other)
(F) This is an online, distance educaLon course primarily intended for science educators. Topics include: exploring the nature of light and matter, a survey of the solar system, stars and stellar formation and evolution, galaxies, Big Bang cosmology and observational astronomy. Offered Fall.

PHSX 512 General Relativity Online: 3 Credits (3 Lec)
PREREQUISITE: PHSX 222 or PHSX 242 or M 182 or PHSX 405 or equivalent. (Sp) 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. It is recommended that students take PHSX 343 or PSXH 405 or equivalent before taking this course. Offered Spring

PHSX 513 Quantum Mechanics Online: 3 Credits (3 Lec)
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. Offered summer.

PHSX 514 Comparative Planetology Online: 3 Credits (3 Lec)
(Su) 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)
PREREQUISITE: Graduate standing. Topics in astrophysics, condensed matter physics, optics, mathematical physics, or particle physics are presented as needed to supplement the curriculum
Repeatable up to 6 credits.

PHSX 516 Experimental Physics: 3 Credits (2 Lec, 1 Lab)
PREREQUISITE: (PHSX 261, PHSX 423, and PHSX 461) or graduate standing. (F, Sp) 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
Repeatable up to 6 credits.

PHSX 519 Mathematical Methods and Their Applications in Electromagnetic Theory: 3 Credits (3 Lec)
PREREQUISITE: PHSX 425 or graduate standing. (Sp) This course covers electro- and magnetostatics, fields in matter, induction, Maxwell's equations, and waves. Relevant mathematical methods will include PDE solutions to boundary value problems in three coordinate systems, Green's functions, and complex variables

PHSX 520 Electromagnetic Theory II: 3 Credits (3 Lec)
PREREQUISITE: PHSX 519. (F) The second part of Electromagnetism course covers electromagnetic waves, their radiation and propagation (including media), and Special relativity

PHSX 523 General Relativity I: 3 Credits (3 Lec)
PREREQUISITE: PHSX 519. (F) 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)
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)
PREREQUISITE: PHSX 523. () Current topics in general relativity will be explored

PHSX 531 Nonlinear Optics/Laser Spectroscopy: 3 Credits (3 Lec)
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)
PREREQUISITE: PHSX 446 or graduate standing. (Sp) 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)
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)
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)
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)
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)
PREREQUISITE: PHSX 501 and PHSX 519
COREQUISITE: PHSX 520. (F) 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)
PREREQUISITE: M 349, M 472, and PHSX 320 or graduate standing. mathematical methods which find application in physics. (F) Differential equations, contour integration, special functions, integral transforms, boundary value problems, and Green's functions

PHSX 567 Mathematical Physics II: 3 Credits (3 Lec)
PREREQUISITE: PHSX 566. () Theory of computational techniques, and applications such as numerical integration, differential equations, Monte Carlo methods, and fast Fourier transforms
Repeatable up to 3 credits.

PHSX 571 Electric Circuits and Magnetism for Teachers: 3 Credits (2 Lec, 1 Lab)
(Su) This 3-credit graduate course is designed for practicing teachers who are teaching or planning 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. Students will engage with each concept using guided inquiry home experiments and online simulation labs, quizzes, and peer discussion. Offered Summer.

PHSX 572 Space Science for Elementary Teachers: 1 Credits (1 Lec)
(Fall, odd years.) 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. Offered odd Fall semesters.

PHSX 573 The Science of Sound for Teachers: 2 Credits (2 Lec)
(Sp) 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. Offered Spring.

PHSX 574 World of Motion & Force for Elem/MS Teachers: 2 Credits (2 Lec)
(Su) In this 7-week, 2-credit course for elementary/MS teachers we will focus on the core ideas of measurement, motion, and forces as they appear in modern inquiry-oriented science education. Its broad purpose is to introduce elementary and middle school teachers to core ideas about motion and forces, as they relate to inquiry-oriented science curricular materials. The course aims to help teachers use modern curricular materials more effectively by increasing their understanding of the physics concepts. Offered Summer.

PHSX 576 World of Force for Teachers: 1 Credits (1 Lec)
(Su) 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. Offered Summer.

PHSX 577 Physics of Renewable Energy for Teachers: 3 Credits (3 Lec)
PREREQUISITE: Graduate standing; science educator; interest in science. (Su) Wind turbines are an example of circular motion, nuclear power is derived from fission, and solar energy is from energy stored in electromagnetic waves. With each renewable energy source, introductory physics concepts can be found. These sources can be used as a means of student engagement in the classroom. During this online course, participants will complete a series of online units centered on bringing the physics of renewable energy sources into a high school physics classroom. While doing so students will develop an understanding of the underlying physics associated with renewable energy sources. As this course is intended for classroom

PHSX 579 Special Relativity for Teachers: 3 Credits (3 Other)
(F) An introduction to the concepts and applications of Special Relativity. Designed for practicing high school teachers seeking context, background, tools, and methods to enrich their professional knowledge and abilities. Assignments and discussions use computer conferencing and online graphing/calculating software. Offered Fall.

PHSX 580 Conceptual Physics for Teachers: 3 Credits (3 Lec)
(Su) This course is designed for middle and high school teachers who are covering some of the basic ideas of physics in their classrooms. At the conceptual level, the course investigates many of the fundamental concepts of physics and their relevance to the world around you. Topics include measurement, motion, force, momentum, energy, power, gravitation, torque, rotational motion, simple harmonic motion, mechanical waves, and sound. Offered Summer. On-Line Only.

PHSX 582 Astrobiology for Teachers Online: 3 Credits (3 Lec)
(Sp) 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. Offered Spring.

PHSX 584 Physics by Inquiry: Light & Color for Teachers: 2 Credits (2 Lab)
(Summer, even years.) An in-depth and hands-on exploration of basic physics principles. The course will begin with a careful investigation of light and reflection of light, leading to an understanding of colored light, pigments, and how the two interact with one another. For middle school and high school science teachers. Offered in summers of even years.

PHSX 585 Physics by Inquiry: Electric Circuits: 3 Credits (1 Lec, 2 Lab)
() An in-depth and hands-on exploration of basic physics principles. Scientific model building and proportional reasoning skills will be developed in the context of dc electric circuits and phases of the moon. For middle school and high school science teachers. Offered Summer.

PHSX 586 Physics by Inquiry: Heat & Temperature for Teachers: 2 Credits (2 Lab)
(Summer, odd years.) Physics 586 is one-week long and entirely laboratory based. Instead of absorbing facts from a lecture, the students make observations and build scientific models to account for their observations. The course emphasizes the development of basic concepts and reasoning skills, and efforts are made to actively engage students in the learning process. Staffto-student ratio is of necessity high and interactions with staff are through Socratic dialog: the instructors do not give answers but help the students to find their own. Available computer technology is utilized as appropriate. The course will explore the differences between the concepts of heat and temperature. This will include a study of heat capacity, specific heat, phase change, and heat transfer. The curriculum used will be the Physics by Inquiry modules developed by the Physics Education Group at University of Washington. This curriculum is based on two decades of research on student misconceptions. Each activity is designed to elicit those misconceptions known to block learning, and to allow the student to confront and resolve the difficulties. Students are often presented with several opportunities to confront the same misconception in increasingly rich contexts to ensure that they are completely free of the misconception. This teaching approach has a three-fold advantage when used with future teachers: 1) They come away from the class with a clear understanding of the physics based on their own experience; 2) They acquire an awareness of those difficulties with which their future students are likely to be struggling; 3) Most importantly, they acquire a self-confidence in their ability to do science, to face unknown situations and find their own answers. Their teaching will be free of references to higher authority. Offered in summers of odd years.

PHSX 587 Physics by Inquiry: Geometric Optics for Teachers: 2 Credits (2 Lab)
(Summers, even years.) Optics will be divided into two separate, one-week long courses (each 2 credits) and entirely laboratory based. One week will be Geometrics and the other will be Light and Color, with the courses running back-to-back. Separate course numbers are pending. Instead of absorbing facts from a lecture, the students make observations and build scientific models to account for their observations. The course emphasizes the development of basic concepts and reasoning skills, and efforts are made to actively engage students in the learning process. Staff-to-student ratio is of necessity high and interactions with staff are through Socratic dialog: the instructors do not give answers but help the students to find their own. Available computer technology is utilized as appropriate. The course will begin with a careful investigation of geometrical optics, leading to an understanding of light, mirrors, images, lenses, prisms, and refraction. This will be followed by an exploration of light and color, leading to an understanding of light and shadow, light sources, pinhole cameras, pigments, and colored light. The curriculum used will be the Physics by Inquiry modules developed by the Physics Education Group at University of Washington. This curriculum is based on two decades of research on student misconceptions. Each activity is designed to elicit those misconceptions known to block learning, and to allow the student to confront and resolve the difficulties. Offered summers of even years.

PHSX 589 Graduate Consultation: 3 Credits (3 Other)
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 Other)
PREREQUISITE: Master's standing
Repeatable up to 99 credits.

PHSX 591 Special Topics: 1-4 Credits (4 Lec)
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
Repeatable up to 12 credits.

PHSX 592 Independent Study: 1-3 Credits (1-3 Other)
PREREQUISITE: Graduate standing, consent of instructor, approval of department head and Dean of Graduate Studies. Directed research and study on an individual basis
Repeatable up to 6 credits.

PHSX 594 Seminar: 1 Credits (1 Other)
PREREQUISITE: Graduate standing or seniors by petition. (F, Sp) 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
Repeatable up to 8 credits.

PHSX 595 Teaching Mechanics Using Research-based Curriculum: 2 Credits (1 Lec, 1 Lab)
() 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. Offered Summer.

PHSX 596 Teaching Electricity & Magnetism for Teachers: 2 Credits (1 Lec, 1 Lab)
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. Offered Summer.

PHSX 597 Physics of Renewable Energy for Teachers: 3 Credits (2 Lec, 1 Other)
Renewable energy sources, such as wind, nuclear and solar, are rich in introductory physics concepts. During this online course, participants will complete a series of units centered on bringing the physics of renewable energy sources into a high school physics classroom. Course time will be devoted to creating classroom materials appropriate for secondary science classrooms which are consistent with Next Generation Science Standards. Energy sources covered will include power derived from fossil fuels, solar, wind, nuclear, geothermal, hydro, biomass and water waves. World energy consumption, sustainability, energy storage and end users will also be covered. Offered Summer.

PHSX 689 Doctoral Reading & Research: 3-5 Credits (3 Other)
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
Repeatable up to 15 credits.

PHSX 690 Doctoral Thesis: 1-10 Credits (1 Other)
PREREQUISITE: Doctoral standing
Repeatable up to 99 credits.