COURSES FOR PHYSICS AND ASTRONOMY

Astronomy Courses

AY521 Theoretical Astrophysics
Hours 3

This course provides a broad introduction to the theoretical foundations of astrophysical phenomena, demonstrating how fundamental phenomenology arises from physical laws. Several broad domains of astrophysics are covered, including planetary and stellar orbits, radiation, radiative transfer, ionization, star and planet formation, stellar evolution, binary stars, special and general relativity (including black holes), galactic structure and dynamics (including dark matter), active galaxies, spacetime structure, formation of large scale matter structure, and cosmology (including the accelerating expansion of the Universe, dark energy, and Grand Unification of forces in the early Universe).

AY533 Observational Techniques
Hours 3

Theoretical and practical aspects of modern astronomical observational techniques. Photometry, spectroscopy, interferometry, and optical and radio data reduction and image processing.

AY550 Stars & Stellar Evolution
Hours 3

This course is intended to facilitate a fairly complete understanding of stars, including their structure, evolution (formation, stages of burning, end states), synthesis of elements, and the physical processes involved in each of these, as well as introduce the modern computational modeling techniques used to apply stellar physics to stars. For astronomy students, this course will provide the background necessary to understand the underlying principles of stellar processes and modelling as they are used both in ongoing research into stellar physics and phenomena and in support of other areas of astronomical research where stellar populations, products and processes are important. In a broader context, relevant for any physics student, this course will discuss how understanding the physical principles in fluid dynamics, high-density materials, heat transfer, plasma physics, nuclear structure, and nuclear processes are assembled into our modern understanding of how stellar objects behave, and how the study of stars pushes the frontier of understanding in these areas of physics.

AY580 Cosmology
Hours 3

This course surveys the evolution of the universe, including discussion of general relativity, the Standard Big Bang Cosmology, cosmological inflation, the cosmic microwave background, large scale structure, baryogenesis, dark matter and dark energy.

AY582 Selected Topics in Astronomy
SP

Hours 1-3

This course may deal with any astronomy topic not covered by existing courses. The course title is added at the time the course is taught. Repeat credit is allowed for different course titles.

Special Topics Course

AY590 Research Techniques
Hours 3

This course provides graduate students with domain-specific skills and knowledge in their research specialty. This training is expected to be undertaken in the context of active engagement by the student in an ongoing or semester-long research project. Alternatively, if formal preparation beyond the available courses is necessary for a student's success within their specialty, such formal preparation (reading, assignments, etc) will be performed under the direction and supervision of the instructor. Any combination of active research and additional specialty formal preparation may be specified by the instructor, as is necessary to advance the student's knowledge and skill toward that necessary to plan and perform successful research in their specialty.

Prerequisite(s): Permission of instructor is required. Core courses must be completed before taking this Research Techniques course.

AY597 Astrophysics Seminar
Hours 1

Required of all full-time physics graduate students specializing in astronomy each semester in residence. Students must attend weekly seminars and make one oral presentation.

AY620 Extragalactic Astronomy
Hours 3

This course surveys the observational and physical aspects of galaxies, clusters of galaxies, active galaxies, quasars, and astrophysical cosmology. The cosmic distance scale and galaxy evolution will be addressed. On successful completion of this course, a student will be prepared to understand the relevant research literature and be ready to embark on independent research in these topics.

AY630 Stellar and Galactic Dynamics
Hours 3

The subject of this course is the dynamics of collisionless objects (stars and dark matter) within self-gravitating systems, i.e. within galaxies and star clusters. The course is primarily theoretical, but there will be considerable discussion of the connections to observations. The approach will combine rigorous mathematical analysis with computational experiments.

AY640 Radiation Processes in Astrophysics
Hours 3

This course covers radiative transfer, blackbody radiation, and non-relativistic and relativistic electromagnetic radiation processes, including bremsstrahlung, synchrotron and Compton radiation, as well as atomic and molecular transitions.

AY682 Selected Topics in Astronomy
SP

Hours 1-3

This course may deal with any astronomy topic not covered by existing courses. The course title is added at the time the course is taught. Repeat credit is allowed for different course titles.

Special Topics Course

Physics Courses

PH501 Classical Dynamics
Hours 3

Variational principles and Lagrange's equations; two-body central-force problems; kinematics of rigid-body motion; rigid-body equations of motion; special relativity; Hamilton's equations of motion; and canonical transformations.

PH505 Physics For Science Teachers
Hours 3

Selected topics in contemporary physics for high school and post-secondary science teachers.

PH511 Biophysics
Hours 3

Physics of biological systems: proteins, lipids, nucleic acids, supramolecular structures, and molecular motors; structure, function, energetics, thermodynamics, bionanotechnology. Emphasis on systems that are best understood in physical and molecular detail.

PH512 Physics Pedagogy
Hours 1

This is a course in teaching methodologies for introductory physics, based on recent results from physics education research.

Prerequisite(s): None

PH523 Relativity
Hours 3

Special relativity, equivalence principle, tensor analysis, gravitational effects, curvature, Einstein's field equations, action principle, classic tests of Einstein's theory.

PH531 Electromagnetic Theory
Hours 3

Electric and magnetic fields, Green's functions, and Maxwell's equations.

PH532 Electromagnetic Theory
Hours 3

Electromagnetic waves, relativity, and selected topics.

Prerequisite(s): PH 531

PH534 Digtl Elect Comp Interfc
Hours 3

Theory and practical application of digital integrated circuits, including gates, flip flops, counters, latches, and displays. Computer data acquisition and control using LabView, A/D and D/A fundamentals. Digital communications.

PH541 Quantum Mechanics
Hours 3

Solution of the Schroedinger equation, matrix methods, angular momentum, and approximation methods.

PH542 Quantum Mechanics
Hours 3

Time-dependent perturbation theory, scattering theory, radiation, identical particles, and spin.

Prerequisite(s): PH 541

PH551 Machine Learning
Hours 3

The course will cover a mixture of foundational and applied machine learning topics related to practical applications in analysis of large scientific data. Students will learn the theory behind various machine learning algorithms and tools and will learn how to apply them to real-world problems. This course will introduce the fundamentals of machine learning and classification theory based on statistical learning and describe classes of popular algorithms in depth: decision and rule-based methods (decision trees and rules, bagging and boosting, random forests), deep learning-based models (fully connected, convolutional, recurrent, recursive, Bayesian, geometric deep learning and graph neural networks) as well as other machine learning algorithms. The lectures will be augmented by active learning techniques to promote greater and deeper student engagement. There will be various in-class activities and small-group discussions and problem solving to allow students to build and reinforce connections with fellow students.

Prerequisite(s): Some familiarity object-oriented programming languages (eg. Python, C++) or numerical computing environments would be useful for completion of the practical exercises.

PH561 Nuclear Particle Physics
Hours 3

Structure and properties of nuclear and subnuclear matter; conservation laws; scattering and decay processes; and fundamental interactions.

PH571 Statistical Physics
Hours 3

Ensembles, partition function, quantum statistics, Bose and Fermi systems, phase transitions and critical phenomena, and applications.

PH581 Solid State Physics
Hours 3

Structure of simple crystals; thermal, electrical, and magnetic properties of solids; the free-electron model and the band approximation; and semiconductors.

PH582 Topics Physics & Astronomy
SP

Hours 1-3

May deal with any physics or astronomy topic not covered by existing courses. The course title is added at the time the course is taught. Repeat credit is allowed for different course titles.

Special Topics Course

PH585 Magnetism: Fundamentals and Applications
Hours 3

PH585 is the first course of series of graduate level courses on magnetism (PH585, PH586 - Advanced Magnetism: Magnetic Materials, Phenomena and Devices), magnetic phenomena, magnetic materials with examples of magnetic devices for physical science and engineering students. The course is based on a combination of physical principles (materials physics, condensed mater, physics of magnetism) and examples their applications. Lecture examples, lecture and home work problems throughout the course will be based on applications (see list of applications in the topics list) with emphasize on impact of fundamental magnetism for advances in particular technology.

PH586 Advanced Magnetism: Phenomena, Materials, Devices
Hours 3

PH586 a graduate level course in magnetism, magnetic phenomena, magnetic materials with examples of magnetic devices for physical science and engineering students. The course is based on a combination of physical principles (condensed mater and physics of magnetism) and examples their applications to magnetization process and magneto-transport phenomena. The course material will include the following topics: • Review Principles of Magnetism: Fundamental Magnetic Properties • Magnetic domains and domain walls • Thermal Effects • Micromagnetics • Magnetization Processes • Landau-Lifshitz-Gilbert Equation • Hard and Soft Magnetic Materials , Permanent magnet applications • Overview of modern magnetic recording: magnetic recording media • Ferromagnetic Resonance • Interlayer and Interfacial Exchange and Exchange Bias • Review Principles of Electronic structure and Electronic transport • Magneto-transport Phenomena • Anisotropic Magnetoresistance • Giant Magnetoresistance • Tunneling Magnetoresistance • Overview of MagntoElectronic devices : HDD reader, MRAM • Special topics may be included, such as critical phenomena (Ising/Heisenberg model), magnetic and non-magnetic neutron scattering, or principles of VSM magnetometry, spin polarized electron characterization techniques.

PH590 Research Techniques
Hours 3

This course provides graduate students with domain-specific skills and knowledge in their research specialty. This training is expected to be undertaken in the context of active engagement by the student in an ongoing or semester-long research project. Alternatively, if formal preparation beyond the available courses is necessary for a student's success within their specialty, such formal preparation (reading, assignments, etc) will be performed under the direction and supervision of the instructor. Any combination of active research and additional specialty formal preparation may be specified by the instructor, as is necessary to advance the student's knowledge and skill toward that necessary to plan and perform successful research in their specialty.

Prerequisite(s): Permission of instructor is required. Core courses must be completed before taking this Research Techniques course.

PH591 Advanced Laboratory
Hours 3

Experimental work in modern physics at an advanced level.

PH592 Precision Timing: Quantum Metrology and Applications
Hours 3

Advanced topics in precision timing and quantum metrology, including the noise types, statistical analyses methods and tools for precision systems; microwave and optical atomic clocks principles and basics of frequency combs; and, ubiquitous ground and space applications of precision timing in our everyday lives, including the precise time and frequency transfer methods. The lectures will be augmented by active learning techniques to promote an involved student participation and develop ability for deeper understanding of the aspects in precision timing. Multiple in-class activities and small-group discussions will be adopted.

Prerequisite(s): Permission of Instructor is required. Prerequisite topics: student is expected to have a working knowledge of fundamental mathematical concepts including Calculus, statistical analysis, probability distributions, and random variables [MATH 125, MATH 126, MATH 355, MATH 227]. Basic physics knowledge of electricity and magnetism with calculus, modern physics, and quantum mechanics [PH 105, PH 106, PH 255, PH 441, PH 541] and knowledge of the fundamental electrical engineering is desirable [ECE 225, ECE 340, ECE 370, ECE 408, ECE 440 & ECE 462]. Student should also have the ability to effectively complete written assignments in English, and familiarity with the use of MATLAB and/or Python as an analysis tool.

PH595 Independent Study
SP

Hours 3

No description available

.
Special Topics Course

PH597 Physics Seminar
Hours 1

Required of all full-time physics graduate students each semester in residence. (Students specializing in astronomy must take AY 597.) Students are required to attend at least 10 department colloquia and/or specialty research seminars. Students in their second year and beyond are required to give one oral research presentation.

PH598 Non-Thesis Research
Hours 1-9

No description available

.

PH599 Thesis Research
Hours 1-9

No description available

.

PH641 Relativistic Quantum Mechanics
Hours 3

The Dirac equation, Lorentz covariance, free-particle solutions of the Dirac equation, Foldy-Wouthuysen transformation, propagator theory, and applications to quantum electrodynamics.

Prerequisite(s): PH 542

PH642 Quantum Field Theory
Hours 3

Classical field theory, quantization of free fields, interacting fields, the scattering matrix, Feynman rules and diagrams, evaluation of integrals and divergences, and electroweak and strong interactions. Offered according to demand.

Prerequisite(s): PH 641

PH661 High Energy Physics
Hours 3

Gauge invariance, non-Abelian gauge theories, hidden symmetries, electroweak interactions of leptons and quarks, strong interactions among quarks, string theories, and phenomenology of high-energy interactions. Offered according to demand.

Prerequisite(s): PH 642

PH662 High Energy Physics II
Hours 3

This course will review physics beyond the Standard Model, Grand Unified Theories, Supersymmetric Theories, Superstrings, and Exact Solutions in Quantum Field Theory.

Prerequisite(s): PH 661

PH681 Adv Solid State Physics
Hours 3

Computational methods in solid-state physics are explored in more detail than in PH 581. Band structure calculations, Green's functions, density-functional methods, superconductivity, and disordered materials. Offered according to demand.

Prerequisite(s): PH 581

PH682 Selected Topics Physics
SP

Hours 1-6

May deal with any physics topic not covered by existing courses. The course title is added at the time each course is taught. Repeat credit is allowed for different course titles.

Special Topics Course

PH698 Non-Dissertat Research
Hours 1-9

Because this is non-dissertation research, students may repeat this course each semester for up to 18 credit hours.

PH699 Dissertation Research
Hours 1-12

No description available

.