

PHYSICS (PHYS)

PHYS P10 Fundamental Concepts in Physics for Teachers Units: 3.00

A course relevant to those interested in teaching. Activity-based learning of fundamental physics topics typically taught in elementary and secondary schools. Topics include: motion, forces, energy, heat, electricity and magnetism, and light. Students will be required to teach a one-hour enrichment class, once a week for 10 weeks, to Grade 7 or 8 students in a local school.

NOTE This course may not be included in any Plan in Physics other than a Minor.

Offering Faculty: Faculty of Arts and Science

PHYS P20 Physicists in the Nuclear Age Units: 3.00

For those interested in the impact of science on our century. Modern physics, especially nuclear physics, will be introduced by emphasizing the personalities, thoughts and writings of key scientists such as Bohr, Einstein and Rutherford and the ways in which they related to and shaped their political, scientific and social environments. Enrolment is limited.

NOTE Also offered online. Consult Arts and Science Online.

Offering Faculty: Faculty of Arts and Science

PHYS P22 Physics Frontiers: From Colliding Black Holes to Disruptive Technologies Units: 3.00

A descriptive course exploring concepts in physics at the frontiers of active research. Bypassing jargon and mathematical complexities, students will focus on the big questions at the extremes of our understanding of the universe around us. Designed for non-scientists who want to learn how we try to understand our fantastic, physic natural world.

LEARNING HOURS 114 (24L;24Pc;36O;18Oc;12P)

Offering Faculty: Faculty of Arts and Science

PHYS 104 Fundamental Physics Units: 6.00

Mechanics, including systems of particles and rigid body motion; gravitation; fluids; electricity and magnetism; oscillatory motion and waves; topics in modern physics. The material is presented at a more fundamental level appropriate for students who are seeking a deeper appreciation of physics, and who may be considering a concentration in Physics.

LEARNING HOURS 240 (72L;36Lb;36T;96P).

Requirements: Prerequisite None. Corequisite (MATH 120 or MATH 121 or [MATH 123 and MATH 124]). Exclusion PHYS 106; PHYS 117; PHYS 118. Recommended 4U Physics.

Offering Faculty: Faculty of Arts and Science

PHYS 106 General Physics Units: 6.00

Mechanics, including systems of particles and rigid body motion; fluids; electricity and magnetism; oscillatory motion and waves; heat, light and sound; topics in modern physics. Aspects of physics useful for further work in other sciences will be emphasized.

NOTE Also offered at the Bader International Study Centre. Learning Hours may vary.

LEARNING HOURS 240 (72L;36Lb;36T;96P).

Requirements: Prerequisite None. Corequisite (MATH 120 or MATH 121 or [MATH 123 and MATH 124]). Exclusion PHYS 104; PHYS 117; PHYS 118. Recommended 4U Physics.

Offering Faculty: Faculty of Arts and Science

PHYS 117 Introductory Physics Units: 6.00

An algebra-based course dealing with basic physics concepts, including dynamics, fluids, waves, electromagnetism, and basic optics. Emphasis is based on the development of problem-solving skills through the use of Mastery based course delivery. PHYS 117 includes a required lab component.

NOTE Manual: estimated cost \$15 to \$25 per manual.

Requirements: Prerequisite None. Exclusion PHYS 104; PHYS 106; PHYS 118. Recommended 4U Physics.

Course Equivalencies: PHYS117/PHYS117B

Offering Faculty: Faculty of Arts and Science

PHYS 118 Basic Physics Units: 6.00

An algebra-based course dealing with basic Physics concepts, including dynamics, fluids, waves, electromagnetism, and basic optics. Emphasis is placed on the development of problem-solving skills through the use of Mastery based course delivery.

NOTE Only offered online. Consult Arts and Science Online. LEARNING HOURS 228 (132O;96P).

Requirements: Prerequisite None. Exclusion PHYS 104; PHYS 106; PHYS 117. Recommended 4U Physics.

Offering Faculty: Faculty of Arts and Science

PHYS 119 Introductory Physics Laboratory Units: 1.50

This is the laboratory portion of PHYS 117, offered for students who completed the online PHYS 118 Basic Physics course, but would like a laboratory experience. A laboratory class in mechanics, electricity, waves and optics. This course runs 8 experiments through the fall and winter terms.

Requirements: Prerequisite PHYS 118. Exclusion PHYS 104; PHYS 106; PHYS 117.

Offering Faculty: Faculty of Arts and Science

**PHYS 206 Dynamics Units: 3.00**

An introductory course in classical dynamics of particles, of rigid bodies and of fluids that sets the foundation for more advanced work. Topics include kinematics of particles and of rigid bodies, central forces, kinetics of systems of particles, planar and three dimensional dynamics of rigid bodies and an introduction to fluid mechanics.

Requirements: Prerequisite ([PHYS 104 or PHYS 106] and [MATH 120 or MATH 121]) or permission of the Department. Recommended A minimum grade of a C in PHYS 104 or PHYS 106.

Offering Faculty: Faculty of Arts and Science

PHYS 212 Vibrations and Waves Units: 3.00

Fundamentals of free, damped and forced vibrations with applications to various mechanical systems. Coupled oscillations and normal modes. Classical wave equation, standing and travelling waves. Continuum mechanics of solid bodies; elasticity theory with applications. Introduction to optics: image formation and optical instruments.
LEARNING HOURS 120 (24L;24T;72P).

Requirements: Prerequisite PHYS 206.

Offering Faculty: Faculty of Arts and Science

PHYS 213 Computational Methods in Physics Units: 3.00

Computing environments, algorithms, techniques and programming for solving physics problems. Numerical methods. Code development. Possible topics to be covered include numerical differentiation and integration, root finding and optimization problems, solution of linear systems of equations, Monte Carlo simulation, and symbolic computation.

LEARNING HOURS 120 (24L;24T;72P)

EQUIVALENCY PHYS 313/3.0.

Requirements: Prerequisite (PHYS 104 or PHYS 106) and (MATH 120 or MATH 121). Exclusion MATH 272; PHYS 313.

Offering Faculty: Faculty of Arts and Science

PHYS 216 Introduction to Astrophysics Units: 3.00

Broad overview of basic laws of gravitation, radiation, and relativity: history and evolution of modern astronomy; ground and space-based astronomy; the physics and evolution of stars; the milky way; galaxies in the universe; and cosmology. This course also uses the on-campus observatory at an introductory level.

Requirements: Prerequisite ([PHYS 104 or PHYS 106] and [MATH 120 or MATH 121]) or permission of the Department.

Course Equivalencies: PHYS115, PHYS216

Offering Faculty: Faculty of Arts and Science

PHYS 235 Eng. Electricity & Magnetism Units: 4.00

Requirements: (PHYS113 AND MATH227) OR (PHYS113 AND PHYS114) OR (MATH280 AND PHYS114) OR (MATH280 AND PHYS113) OR (APSC111 AND APSC112) OR (APSC111 AND MATH227) OR (MATH280 AND APSC112) OR (MATH280 AND APSC111)

Offering Term: W

Offering Faculty: Fac of Engineering Appl Sci

PHYS 239 Electromagnetism Units: 3.00

The experimental basis and mathematical description of electrostatics, magnetostatics and electromagnetic induction, together with a discussion of the properties of dielectrics and ferromagnetics, are presented. Both the integral and vector forms of Maxwell's equations are deduced.

Requirements: Prerequisite (PHYS 104 or PHYS 106) and (MATH 221 or MATH 227 or MATH 280). Recommended A minimum grade of a C in PHYS 104 or PHYS 106.

Offering Faculty: Faculty of Arts and Science

PHYS 242 Relativity and Quanta Units: 3.00

Evidence for relativistic effects. Kinematics and dynamics in special relativity, space-time diagrams, applications. Evidence for quanta, spectra, Bohr atom. Introduction to the Schroedinger equation.

Requirements: Prerequisite PHYS 104 or PHYS 106.

Recommended A minimum grade of a C in PHYS 104 or PHYS 106.

Offering Faculty: Faculty of Arts and Science

PHYS 250 Foundations of Experimental Physics Units: 3.00

Laboratory and lecture course that presents techniques and skills that are the foundations of experimental physics. Topics include statistical analysis of data, uncertainties in measurement, propagation of errors, software for data analysis, graphing and reporting. Students will be exposed to techniques in the measurement of electric, magnetic, thermal and mechanical properties. Laboratories also illustrate some principles of quantum physics, mechanics, electromagnetism and thermodynamics learned in other physics courses. Some exposure to computerized data acquisition is included.
LEARNING HOURS 132 (24L;36Lb;72P).

Requirements: Prerequisite PHYS 104 or PHYS 106.

Offering Faculty: Faculty of Arts and Science

PHYS 260 The Physics of Light and Colour Units: 3.00

Students will develop an appreciation for the physical and chemical processes that control light and colours. Students will learn the basic principles of light emission and propagation, image formation, the workings of optical devices and detectors, colour theory and colour perception, colour in art, colour in nature, and colours in astronomy.
LEARNING HOURS 108 (36L;72P).

Requirements: Prerequisite PHYS 104 or PHYS 106 or PHYS 117 or PHYS 118 or BIOL 102 or BIOL 103 or CHEM 112 or GEOL 102 or GEOL 104 or GEOL 106 or GEOL 107 or PSYC 100.

Offering Faculty: Faculty of Arts and Science

PHYS 315 Physical Processes in Astrophysics Units: 3.00

This course relates observable quantities to the physical properties of astronomical sources thereby deciphering the varied nature of the cosmos. Basic physical processes in astrophysics are discussed and applied to diverse systems including planets, stars, the interstellar medium and distant galaxies. Topics include radiative transfer and the perturbation of the signal by instruments, the atmosphere, and the interstellar medium. The main astrophysical emission processes, both continuum and line, are also presented. An observing project will be carried out during the term.
LEARNING HOURS 120 (36L;84P).

Requirements: Prerequisite (PHYS 216 and PHYS 242) or permission of the Department.

Offering Faculty: Faculty of Arts and Science

PHYS 316 Methods in Mathematical Physics I Units: 3.00

Methods of mathematics important for physicists. Complex arithmetic, series expansions and approximations of functions, Fourier series and transforms, vector spaces and eigenvalue problems, ordinary differential equations and Green's functions.

LEARNING HOURS 120 (36L;12T;72P).

Requirements: Prerequisite (MATH 221 or MATH 227 or MATH 280) and (MATH 225 or MATH 231 or MATH 232). Exclusion MATH 334; MATH 338; PHYS 312.

Offering Faculty: Faculty of Arts and Science

PHYS 317 Methods in Mathematical Physics II Units: 3.00

A continuation of PHYS 316. Partial differential equations, functions of a complex variable and contour integration, and special topics such as probability and statistics, group theory and non-linear dynamics.

LEARNING HOURS 120 (36L;12T;72P).

Requirements: Prerequisite PHYS 316. Exclusion MATH 228; MATH 326; MATH 338; PHYS 312.

Offering Faculty: Faculty of Arts and Science

PHYS 321 Advanced Mechanics Units: 3.00

An introduction to the equations of mechanics using the Lagrange formalism and to the calculus of variations leading to Hamilton's principle. The concepts developed in this course are applied to problems ranging from purely theoretical constructs to practical applications. Links to quantum mechanics and extensions to continuous systems are developed.

Requirements: Prerequisite PHYS 212 and (MATH 221 or MATH 227 or MATH 280) and (MATH 225 or MATH 231 or MATH 232).

Offering Faculty: Faculty of Arts and Science

PHYS 334 Electronics for Physicists Units: 3.00

The design of electronic circuits and systems, using commonly available devices and integrated circuits. The properties of linear circuits are discussed with particular reference to the applications of feedback; operational amplifiers are introduced as fundamental building blocks. Digital circuits are examined and the properties of the commonly available I.C. types are studied; their use in measurement, control and signal analysis is outlined. Laboratory work is closely linked with lectures and provides practical experience in the subjects covered in lectures.

Requirements: Prerequisite PHYS 239.

Course Equivalencies: PHYS333, PHYS334

Offering Faculty: Faculty of Arts and Science

PHYS 335 Semiconductor Physics Units: 3.00

An examination of the basic phenomena of semiconductor physics and their application in diodes, transistors, optical detectors, and lasers. The laboratory illustrates the use of semiconductor devices in electronic circuits. (0/10/2/28/8)~
COURSE DELETED IN 2008/09 ~

Requirements: PHYS231 OR PHYS235 OR PHYS239

Course Equivalencies: PHYS335, PHYS380

Offering Faculty: Faculty of Arts and Science

PHYS 336 Solid State Devices Units: 3.25

This course deals with the fundamental concepts of solid state materials and the principles of operation of modern electronic and optoelectronic devices. Topics in materials include crystal structure, energy bands, carrier processes and junctions. Topics in device operation include p-n junction diodes, bipolar junction transistors, field-effect junction transistors, metal-oxide-semiconductor field-effect transistors, and double heterojunction lasers.(0/18/0/21/0)

Requirements: (ELEC252 AND ELEC280) OR (ELEC252 AND PHYS231)

Offering Faculty: Faculty of Arts and Science



PHYS 344 Introduction to Quantum Mechanics Units: 3.00

Matter waves. Postulates of wave mechanics. Stationary states and one-dimensional potentials. Particle tunneling and scattering states. Introduction to matrix mechanics and Dirac notation. Quantized angular momentum, and the H atom.

Requirements: Prerequisite PHYS 212 and PHYS 242 and (MATH 221 or MATH 280) and (MATH 225 or MATH 231 or MATH 232). Equivalency PHYS 343.

Course Equivalencies: PHYS343, PHYS344

Offering Faculty: Faculty of Arts and Science

PHYS 345 Quantum Physics of Atoms, Nuclei and Particles Units: 3.00

Spin. Addition of angular momentum. Many electron atoms and the periodic table. Introduction to perturbation theory and Fermi's golden rule. Time dependent perturbations, including stimulated emission. Introduction to nuclear and particle physics.

Requirements: Prerequisite PHYS 344. Equivalency PHYS 424.

Course Equivalencies: PHYS345, PHYS424

Offering Faculty: Faculty of Arts and Science

PHYS 350 General Laboratory Units: 6.00

Experiments in heat, optics, electron physics, quantum physics, and radioactivity are performed. A substantial part of the course is an experimental project during the Winter Term. A topic for the experimental physics, or observational astronomy project will be assigned after discussion with the student.

LEARNING HOURS 222 (72Lb;60;144P).

Requirements: Prerequisite PHYS 239 and PHYS 242 and PHYS 250.

Offering Faculty: Faculty of Arts and Science

PHYS 352 Measurement Experiment Design Units: 3.00

Measurement of a variety of quantities with particular reference to techniques used in current physics and engineering practice, including optics, X-rays in crystallography and analysis, vacuum practice, nuclear techniques, signal-to-noise enhancement, the use of digital computers for instrumentation purposes, and the statistical analysis of data.

Requirements: PHYS 239 PHYS344

Offering Faculty: Faculty of Arts and Science

PHYS 372 Thermodynamics Units: 3.00

Temperature, equations of state, internal energy, first and second laws, entropy and response functions. Application to heat engines and refrigerators. Free energies, Legendre transformations, changes of phase. Introduction to the Boltzmann factor and statistical mechanics.

Requirements: PHYS242

Offering Faculty: Faculty of Arts and Science

PHYS 380 Electrical & Optical Properties Units: 3.00

An introduction to the electrical and optical properties of insulators, semiconductors and metals. Introduction to Fermi-Dirac statistics, crystal and band theory and electron transport. Topics covered include the physics behind diodes, field effect and bipolar junction transistors, and electro-optical discrete devices.

Requirements: (PHYS231 AND PHYS344) OR (PHYS239 AND PHYS344)

Course Equivalencies: PHYS335, PHYS380

Offering Faculty: Faculty of Arts and Science

PHYS 414 Introduction to General Relativity Units: 3.00

Einstein's theory of gravity is developed from fundamental principles to a level which enables the student to read some of the current literature. Includes an introduction to computer algebra, an essential element of a modern introduction to Einstein's theory.

Requirements: Prerequisite PHYS 321 and (PHYS 312 or PHYS 317 or MATH 334).

Offering Faculty: Faculty of Arts and Science

PHYS 432 Electromagnetic Theory Units: 3.00

Electromagnetic theory and applications. Topics include: Maxwell's equations, gauge theory, relativistic transformations of Maxwell's equations, properties of waves in free space, dielectrics, conductors and ionized media, reflection and refraction at the surfaces of various media, propagation in metallic and dielectric waveguides, radiation of electromagnetic waves from charged particles and antennae.

Requirements: Prerequisite PHYS 239 and (MATH 221 or MATH 280) and (MATH 225 or MATH 231 or MATH 232). Equivalency PHYS 332.

Course Equivalencies: PHYS332, PHYS432

Offering Faculty: Faculty of Arts and Science

PHYS 434 Extragalactic Astronomy Units: 3.00

Requirements: PHYS315

Offering Faculty: Faculty of Arts and Science

PHYS 435 Stellar Structure and Evolution Units: 3.00

This course provides a detailed account of the formation, structure, evolution and endpoints of stars. Topics include the HR diagram, nuclear energy generation, radiative transport and stellar model building, supernovae, white dwarfs, neutron stars, pulsars and black holes.

Requirements: Prerequisite PHYS 315.

Offering Faculty: Faculty of Arts and Science

PHYS 444 Advanced Quantum Physics Units: 3.00

This course covers perturbation theory, scattering theory and the addition of angular momentum. Special topics may include: many-electron systems, path integral formulation of quantum mechanics, entanglement and quantum computing, quantum optics.

Requirements: Prerequisite PHYS 345. Equivalency PHYS 426.

Course Equivalencies: PHYS426, PHYS444

Offering Faculty: Faculty of Arts and Science

PHYS 450 Adv Physics Lab & Proj Units: 6.00

This course provides advanced physics and engineering physics students with experience in a wide range of modern experimental techniques. Experiments encompass measurements in applied physics, quantum solid state physics, low temperature physics, nuclear physics and optics. The course has set experiments in the Fall Term and group projects in the Winter Term.

Requirements: (PHYS350 AND PHYS343) OR (PHYS343 AND PHYS350) OR (PHYS350 AND CHEM331) OR (PHYS343 AND PHYS351) OR (PHYS342 AND PHYS343) OR (PHYS344 AND PHYS350) OR (PHYS342 AND PHYS351) OR (PHYS350 AND CHEM313) OR (PHYS344 AND PHYS351) OR (PHYS350 AND CHEM313)

Offering Faculty: Faculty of Arts and Science

PHYS 453 Advanced Physics Laboratory Units: 3.00

Advanced physics laboratory course providing students with experience in a range of experimental techniques and analysis. A selection of experiments are performed from fields including nuclear physics, applied physics, fluid mechanics, solid state physics, low-temperature physics and optics.

LEARNING HOURS 132 (76Lb;60P)

Requirements: (PHYS350 AND PHYS343) OR (PHYS350 AND CHEM331) OR (PHYS350 AND PHYS343) OR (PHYS350 AND CHEM313) OR (PHYS350 AND CHEM313) OR (PHYS343 AND PHYS351) OR (PHYS344 AND PHYS350) OR (PHYS344 AND PHYS351)

Offering Faculty: Faculty of Arts and Science

PHYS 454 Advanced Physics Design Project Units: 3.00

Groups of students in physics and engineering physics undertake a large design project of their choice that reflects and further develops their knowledge of physics. The students then build a prototype of their design to demonstrate the feasibility of the project within the design constraints.

Requirements: Prerequisite PHYS 350.

Offering Faculty: Faculty of Arts and Science

PHYS 460 Laser Optics Units: 3.00

Topics and applications in modern physical optics, culminating with the development of the laser and its current applications. Topics include: Gaussian beam propagation, optical resonators, Fourier optics, fiber optics, holography, light-matter interaction using classical and semi-classical models, and the basic theory and types of lasers.

Requirements: Prerequisite PHYS 239 and (PHYS 344 or CHEM 313). Corequisite PHYS 432.

Offering Faculty: Faculty of Arts and Science

PHYS 472 Statistical Mechanics Units: 3.00

Phase space, the ergodic hypothesis and ensemble theory. Canonical and grand canonical ensembles. Partition functions. Ideal quantum gases. Classical gases and the liquid-vapour transition. Introduction to techniques for interacting systems, including Monte Carlo simulations.

Requirements: Prerequisite (PHYS 213 or PHYS 313) and PHYS 344 and PHYS 372. Exclusion CHEM 412.

Offering Faculty: Faculty of Arts and Science

PHYS 479 High Performance Computational Physics Units: 3.00

This course teaches students how to use the tools of high performance computing facilities, including communications protocol for parallel computations. Students will employ these facilities and tools and use various numerical algorithms in the solution of physics problems.

LEARNING HOURS 120 (24L;24T;72P).

Requirements: Prerequisite (PHYS 213 or PHYS 313) and PHYS 344. Corequisite PHYS 432.

Offering Faculty: Faculty of Arts and Science

PHYS 480 Solid State Physics Units: 3.00

A fundamental treatment of the properties of solids. Topics include: crystal structure, X-ray and neutron scattering, the reciprocal lattice, phonons, electronic energy bands, and the thermal, magnetic, optical and transport properties of solids.

Requirements: Prerequisite PHYS 345 or CHEM 313.

Offering Faculty: Faculty of Arts and Science

PHYS 483 Nanoscience and Nanotechnology Units: 3.00

An examination of the key ideas, techniques and technologies in the fields of nanoscience and nanotechnology. Emphasis will be placed on the physics involved, measurement techniques, and technological applications. Topics covered are selected from the following: electrical and optical properties of quantum dots, quantum wires and nanotubes; quantum information technology; mesoscopic electronics; nanostructures on surfaces; and scanning-probe and optical microscopy.

Requirements: Prerequisite ([PHYS 345 or CHEM 313] and PHYS 480) or permission of the Department.

Offering Faculty: Faculty of Arts and Science



PHYS 490 Nuclear and Particle Physics Units: 3.00

A systematic introduction to nuclear and particle physics for advanced physics students. Topics include basic nuclear properties: size, mass, decay and reactions; shell model of nuclear structure; magnetic moments; gamma and beta decay; quark model of elementary particles; and strong, electromagnetic and weak interactions.

Requirements: Prerequisite PHYS 345.

Offering Faculty: Faculty of Arts and Science

PHYS 491 Physics of Nuclear Reactors Units: 3.00

The objective of this course is the understanding of the fundamental physics associated with a nuclear reactor. Topics include a brief review of basic nuclear physics, neutron interactions and cross-sections, neutron diffusion, neutron moderation, theory of reactors, changes in reactivity, control of reactors. Offered in alternate years.

NOTE Manual: estimated cost \$15 to \$25 per manual.

LEARNING HOURS 120 (36L;12T;72P).

Requirements: Prerequisite Level 3 or above and registration in a (PHYS, ASPH or MAPH Plan).

Offering Faculty: Faculty of Arts and Science

PHYS 495 Introduction to Medical Physics Units: 3.00

Topics include: the production and measurement of X-rays and charged particles for radiation therapy and nuclear medicine; interactions of radiation with matter and biological materials; interaction coefficients and radiation dosimetry; radiation safety; physics of medical imaging with examples from nuclear medicine, ultrasound and magnetic resonance imaging.

Requirements: Prerequisite Level 3 or above and registration in a (PHYS, ASPH or MAPH Plan).

Offering Faculty: Faculty of Arts and Science

PHYS 590 Research Thesis Units: 6.00

Investigation of a contemporary research topic in physics or astronomy under the supervision of a faculty member, and leading to a written thesis and an oral presentation of results.

Requirements: Prerequisite Level 4 or above and registration in a (PHYS, ASPH or MAPH Plan).

Offering Faculty: Faculty of Arts and Science

PHYS 594 Independent Study Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 750 Engineering Physics Thesis Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 810 Astrophysics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 811 Radio Astrophysics Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 812 Galactic Physics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 813 Galactic Astronomy Units: 3.00

This course describes the material content, energetics, formation and evolution of the Galaxy, and places our Galaxy in the context of galaxies, in general. Topics include the interstellar medium, stellar populations, dynamics, the Galactic center and the Galactic halo.

Offering Faculty: Faculty of Arts and Science

PHYS 814 Extragalactic Astronomy Units: 3.00

This course describes the material content, energetics and evolution of the Universe beyond our Galaxy. Topics include global properties of galaxies and clusters, the extragalactic distance scale, extragalactic radio sources, large scale structure, dark matter, and cosmology.

Offering Faculty: Faculty of Arts and Science

PHYS 815 Stellar Structure & Evolution Units: 3.00

This course provides a detailed account of the formation, structure, evolution and end-points of stars. Topics include the HR diagram, nuclear energy generation, radiative transport and stellar model building, supernovae, white dwarfs, neutron stars, pulsars and black holes.

Offering Faculty: Faculty of Arts and Science

PHYS 817 Astronomical Dynamics Units: 3.00

Due to its long range and lack of shielding, the Newtonian gravitational force plays a major role in the dynamical evolution of astronomical systems ranging in scale from planetary systems to clusters of galaxies. In this course we examine common features across these scales as well as specific features of importance in the gravitational dynamics of the Solar System and other planetary systems, star clusters, galaxies and clusters of galaxies.

Offering Faculty: Faculty of Arts and Science

PHYS 820 Quantum Mechanics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 823 Gravitation & Cosmology Units: 3.00

Einstein's theory of gravity is developed from fundamental principles to a level which enables the student to read some of the current literature. The course includes an introduction to computer algebra, an essential element of a modern introduction to Einstein's theory. (Offered jointly with PHYS-414.)

Offering Faculty: Faculty of Arts and Science

PHYS 824 Quantum Theory I Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 825 Advanced Quantum Theory Units: 3.00

An intermediate graduate level course in quantum mechanics suitable for students from all research areas in the department. Topics include second quantization, many-particle systems and Hartree-Fock theory, symmetries and invariance in quantum theory, density matrices, quantization of the electromagnetic field, path integrals, relativistic quantum mechanics and the Dirac equation.

Offering Faculty: Faculty of Arts and Science

PHYS 830 Electrodynamics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 831 Electromagnetic Theory Units: 3.00

An advanced but non-relativistic discussion of classical electromagnetic theory intended for students in applied/engineering physics and condensed matter physics and with an emphasis on the generation and propagation of electromagnetic waves. Topics include polarization, multipoles and electromagnetic fields in macroscopic media, diffraction theory, simple radiating systems, and the propagation of waves in dispersive media and plasmas. Additional topics may include guided waves, nonlinear optics, and the optics of anisotropic media.

Offering Faculty: Faculty of Arts and Science

PHYS 832 Classical Electrodynamics Units: 3.00

An advanced course in relativistic electrodynamics, intended for students in subatomic physics and astrophysics. Topics include the covariant formulation of Maxwell's equations, relativistic motion of charged particles in electromagnetic fields and the resultant radiated fields, synchrotron radiation, Cerenkov radiation, and the inverse Compton effect are discussed. Additionally, the course may offer a brief treatment of magnetohydrodynamics. Applications to problems in astrophysics and high energy particle physics will be discussed.

Offering Faculty: Faculty of Arts and Science

PHYS 840 Astronomical Instrumentation Units: 1.50

A survey of instrumentation and techniques for astronomical ground and space-based observations. Topics include theory of measurement; imaging; interferometry and spectroscopy of electromagnetic radiation at radio, infrared, optical, and X-ray wavelengths; data analysis.

Offering Faculty: Faculty of Arts and Science

PHYS 841 Particle Astrophysics Experim. Units: 1.50

An introduction to experimental techniques employed in modern particle astrophysics experiments. Topics will include a description of the interactions of particles with matter and the detection techniques for topics of current interest, including neutrinos, dark matter, double beta decay and supernovae.

Offering Faculty: Faculty of Arts and Science

PHYS 842 Form. Of Structure In Universe Units: 1.50

A course covering modern theories of the formation of cosmological structure. Topics include the theory of gravitational instability in the linear regime; the statistics of density fields; cosmic flows; non-linear instability in the context of the cold dark matter universe; N-body simulations; comparisons of theory with the observed Universe.

Offering Faculty: Faculty of Arts and Science

PHYS 843 High Energy Astroparticle Phys Units: 1.50

A survey of astrophysical sources and mechanisms that produce high energy particles (gamma rays, neutrinos, and cosmic rays). Propagation of the particles and techniques for detecting high energy particles will be discussed.

Offering Faculty: Faculty of Arts and Science

PHYS 844 Neutrino Physics & Astrophys. Units: 1.50

An introduction to neutrino physics and astrophysics. Topics include neutrino mass and mixing; solar neutrinos; supernova neutrinos; ultra high energy neutrino astronomy.

Offering Faculty: Faculty of Arts and Science

PHYS 845 Interstellar Medium and Star Formation Units: 3.00

An overview of the physics of the interstellar medium with particular focus on molecular clouds and the process of star formation. Possible topics include: phases of the ISM, molecular cloud properties and substructure, heating and cooling processes in molecular clouds, radiative transfer, Jeans instability and fragmentation, and the regulation of star formation by magnetic fields, turbulence and feedback.

PREREQUISITE: permission of the instructor.

Offering Faculty: Faculty of Arts and Science

PHYS 846 Stellar Atmospheres Units: 1.50

This course provides an introduction to the physics of stellar atmospheres, including bulk stellar properties, concepts of local thermodynamic equilibrium, excitation and ionization equilibria, radiative energy transport, convective instability, continuous opacity, model stellar atmospheres, and stellar continua. This is followed by a development of the basic tools of quantitative spectroscopy, including concepts of line opacity and line profiles, contribution functions, hydrogen line profiles, stellar abundance determinations, and microscopic and macroscopic velocity fields. The course concludes with a discussion of special topics such as stellar magnetic fields, non-LTE, stellar winds, stellar pulsation, and stellar activity including chromospheres and coronae.

Offering Faculty: Faculty of Arts and Science

**PHYS 848 High Density Astrophysics Units: 1.50**

This module studies astrophysical situations in which Newtonian dynamics fails at the local scale. Topics include:

Neutron Stars: Origin, current understanding of their structure, interaction with their environment and the importance of binary pulsars in verifying the status of general relativity. Black Holes: Origin, current understanding of their uniqueness properties in the static and stationary cases, interaction with their environment and the importance of black holes in a cosmological context.

Offering Faculty: Faculty of Arts and Science

PHYS 849 Model Fitting and Bayesian Inference for Physics and Astronomy Units: 1.50

Offering Faculty: Faculty of Arts and Science

PHYS 850 Instruments & Measurements Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 854 Acoustic Wave Generation Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 858 Introduction - Medical Physics Units: 3.00

This course introduces a number of topics in the field of medical physics. Included are: the physics of radiation therapy, ultrasound imaging, magnetic resonance imaging, x-ray imaging, radioisotope imaging and image reconstruction techniques.

Offering Faculty: Faculty of Arts and Science

PHYS 860 App Science In Micro/Nano Tech Units: 3.00

A multi-disciplinary graduate course on advanced topics in microfabrication with research perspectives. It aims to help students from a broad range of Applied Sciences with special interests in micro/nano-technology to relate the physics of selected advanced topics to current opportunities and problems in their research. Instructions integrate contributions from several faculty members. An ongoing articulation of the interface between micro- and nano-scale methodologies will be maintained.

Offering Faculty: Faculty of Arts and Science

PHYS 861 Physics Of The Early Universe Units: 1.50

The history of the Universe from the Big Bang to the formation of the cosmic radiation background. Topics include shortcomings of the standard cosmological model; inflation; baryogenesis; the quark-hadron phase transition; big bang nucleosynthesis; dark matter; the epoch of last scattering.

Offering Faculty: Faculty of Arts and Science

PHYS 862 The Early Universe and Multimessenger Astrophysics Units: 3.00

A graduate course aimed at completing the cosmology curriculum of Queen's astronomy students, and providing the context and theoretical background behind the particle astrophysics research done at Queen's. Topics include inflation, nucleosynthesis, recombination, perturbation theory and linear structure formation, dark matter physics and detection, dark energy, neutrino astronomy, gravitational waves, cosmic rays and dark matter.

PREREQUISITE: Permission from the course coordinator.

EXCLUSION: PHYS-861

Offering Faculty: Faculty of Arts and Science

PHYS 870 Statistical Mechanics Units: 3.00

The principles of classical and quantum statistical mechanics with application to the theories of the gaseous, liquid, and solid states of matter. Review of thermodynamics, fundamentals. Fermi-Dirac and Bose-Einstein statistics, solids and phase transitions.

Offering Faculty: Faculty of Arts and Science

PHYS 879 High Performance Computational Physics Units: 3.00

A double-numbered course to teach students how to use the tools of highperformance computing facilities, and to have them employ these tools and various common numerical algorithms, in the solution of numerical physics projects. Offered jointly with PHYS-479.

PREREQUISITE: prior programming experience and permission from the course instructor

EXCLUSION: PHYS-479

Offering Faculty: Faculty of Arts and Science

PHYS 880 Elem. Of Solid State Physics I Units: 3.00

The structural, electronic, optical and transport properties of solids. (Offered jointly with PHYS-480*.)

Offering Faculty: Faculty of Arts and Science

PHYS 881 Solid State Physics II Units: 3.00

A continuation of PHYS-880*. Topics include the vibrational, magnetic, and superconducting properties of solids.

Offering Faculty: Faculty of Arts and Science

PHYS 883 Photonics Problem Solving Units: 3.00

Advances in photonics materials and sensing benefit from a multidisciplinary approach. Students will work at the interface of chemistry, physics and engineering in interdisciplinary teams to solve up to three problems, involving techniques such as chemical synthesis, optical characterization, device fabrication, and numerical modelling. Some projects may involve hands-on experimentation.

PREREQUISITE: Permission from the course coordinator

Offering Faculty: Faculty of Arts and Science

PHYS 884 Nonlinear Optics Units: 3.00

Nonlinear optical effects arise when the electric polarization of a medium is a nonlinear function of the light field. With the advent of new materials and more intense lasers, nonlinear optics has become important in many systems of scientific and technological interest. Topics will include an examination of nonlinear susceptibilities and nonlinear wave propagation in molecular and solid state systems.

PREREQUISITE: PHYS-432/ENPH-431 and PHYS/ENPH-345 or equivalent.

EXCLUSION: PHYS-882*

Offering Faculty: Fac of Engineering Appl Sci

PHYS 885 Quantum Nanophotonics Units: 3.00

Quantum Optics describes the behavior of quanta of light γ photons γ as they flow through our world or interact with matter. Increasingly, concepts from this field are at the core of complex experiments and emerging technologies. This course introduces the basic principles of quantum optics, the use of nanophotonics to enhance these effects, and then applies these to select topics within this growing field.

PREREQUISITE: PHYS-432/ENPH-431 and PHYS/ENPH-345 or equivalent.

EXCLUSION: PHYS-882*

Offering Faculty: Fac of Engineering Appl Sci

PHYS 890 Nuclear Physics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 891 Nuclear & Particle Physics Units: 3.00

A systematic introduction to nuclear and particle physics. Topics include basic nuclear properties; size mass, decay and reactions; shell model of nuclear structure; magnetic moments; gamma and beta decay; quark model of elementary particles; and strong, electromagnetic and weak interactions

Offering Faculty: Faculty of Arts and Science

PHYS 892 Particle Physics Units: 3.00

A course in particle physics, covering topics such as: the physics of particles; symmetries and conservation laws; quark models of hadrons; the parton model and QCD; weak interactions.

Offering Faculty: Faculty of Arts and Science

PHYS 899 Master's Thesis Research Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 901 Graduate Seminar Series Units: 0.00

A series of research seminar presented by students in the PhD programme summarizing the important issues in their research areas. Presentation of a seminar is required of every PhD student in each of their second and third years. To be offered every fall/winter; graded Pass/Fail.

Offering Faculty: Faculty of Arts and Science

PHYS 904 Science Leadership and Management Units: 3.00

The Science Leadership and Management course will be delivered over twelve 3-hour sessions to Chemistry and Physics students in either of the first two years of their PhD studies (or other graduate students with permission from the course coordinator and supervisor). The first and last four-week sessions will focus on the development and application of leadership skills, and the second four-week session will focus on the development of management skills, that are useful in scientific positions in industry and academia. To be offered every fall; graded Pass/Fail. Exclusion: CHEM-904*

Offering Faculty: School of Graduate Studies

PHYS 911 Advanced Radio Astronomy Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 912 Astronomy Seminar Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 913 Topics In Astronomical Resear. Units: 3.00

A discussion of recent problems in astronomy based on current literature. Possible topics include: radio jets in double radio sources, emission from the galactic centre and early type star formation.

Offering Faculty: Faculty of Arts and Science

PHYS 914 Topics In Astrophysical Res. Units: 3.00

A discussion of recent problems in astrophysics based on current literature. Possible topics include: clock synchronization in general relativity, gravitational bounce and the effect of gravitational radiation in very close binary systems.

Offering Faculty: Faculty of Arts and Science

PHYS 917 Astronomy & Cosmology Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 920 Advanced Quantum Theory Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 921 Quantum Field Theory Units: 3.00

Introduction to quantum field theory, with applications to particle physics, condensed matter, gravitation, and cosmology. Topics that may be covered include effective field theory, non-Abelian interactions, renormalization, anomalies, symmetry breaking, and the path integral.

Requirements: PRE_PHYS 825

Offering Faculty: Faculty of Arts and Science

PHYS 923 Many-Body Quantum Theory Units: 3.00

An investigation into different theoretical perspectives on the issue of identity and the importance of these perspectives for the politics of identity. Theories of gender, race, class, nation, and sexual orientation, from a variety of perspectives, including Marxist, feminist, postmodern, and psychoanalytic theory. (Offered jointly with POLS-456*).

Offering Faculty: Faculty of Arts and Science



PHYS 928 Many-Body Quantum Theory Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 940 Quantum Electronics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 941 Quantum Electronics I Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 942 Quantum Electronics II Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 943 Microwave Spectroscopy Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 958 Topics In Medical Physics Units: 3.00

A discussion of recent problems in medical physics based on current literature. Possible topics include: adaptive radiation therapy, Monte Carlo simulations in radiation physics, imaging in radiation therapy, image reconstruction, and radiation dose planning algorithms.

Offering Faculty: Faculty of Arts and Science

PHYS 963 Advanced Solid State Physics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 980 Adv. Solid State Physics Units: 6.00

Offering Faculty: Faculty of Arts and Science

PHYS 982 Top. In Condensed Matter Phys. Units: 3.00

Topics in condensed matter physics of current interest. Examples of such topics are: surface physics, magnetotransport properties, polymers and disordered solids, low temperature physics.

Offering Faculty: Faculty of Arts and Science

PHYS 983 Advanced Solid State Theory Units: 3.00

Topics include pseudopotential theory of metals, band theory of ordered and disordered solids, linear response theory, density functional theory, field theories of phase transitions.

Offering Faculty: Faculty of Arts and Science

PHYS 987 Solid State Physics Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 992 High Energy Physics Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 994 Topics In Subatomic Physics Units: 3.00

A discussion of selected topics of current interest in nuclear and particle physics. Possible subjects include one or more from weak interactions and neutrinos, particle astrophysics, and grand unified theories.

Offering Faculty: Faculty of Arts and Science

PHYS 995 Adv Topics/Sub-Atomic Theory Units: 3.00

A course primarily for students in theoretical physics. Various topics of current interest will be discussed, such as the interacting boson model, and investigations of the nuclear response to leptonic, pionic, and hadronic probes.

Offering Faculty: Faculty of Arts and Science

PHYS 997 Nuclear Physics Units: 3.00

Offering Faculty: Faculty of Arts and Science

PHYS 999 Ph. D. Thesis Research Units: 6.00

Offering Faculty: Faculty of Arts and Science