PHYSICS, ENGINEERING PHYSICS AND ASTRONOMY

Courses

The list of courses offered in any academic session can be found on the Physics departmental web page (http://www.physics.queensu.ca/).
NOTE: PHYS 840, PHYS 841, PHYS 842, PHYS 843, PHYS 844, PHYS 846, PHYS 848, PHYS 849 and PHYS 861 are six week modules (1.5 credit units). All other courses are 3.0 credit units, except PHYS 899 and PHYS 999 (6.0 credit units).

APSC 896 Engineering Leadership
The course is designed to develop a range of leadership skills essential for engineering professional practice. Students will explore their own leadership abilities and develop their competencies in areas such as managing conflict, team dynamics and developing others. The course content will be presented through lectures, case studies, panel discussions and other active learning activities. Fall. P. Hungler

PHYS 813 Galactic Astronomy
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.

PHYS 814 Extragalactic Astronomy
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.
EXCLUSION: PHYS 434

PHYS 815 Stellar Structure and Evolution
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.
EXCLUSION: PHYS 435

PHYS 817 Astronomical Dynamics
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.

PHYS 823 Gravitation and Cosmology
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/ENPH 414.)
EXCLUSION: PHYS/ENPH 414.

PHYS 825 Advanced Quantum Theory
A 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, relativistic quantum mechanics and the Dirac equation, quantum information and quantum computing.
PREREQUISITE: PHYS/ENPH 345 or equivalent

PHYS 831 Electromagnetic Theory
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.
PREREQUISITE: ENPH 431, PHYS 432 or equivalent

PHYS 832 Classical Electrodynamics
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.

PHYS 840 Astronomical Instrumentation
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.

PHYS 841 Experimental Methods for Particle Astrophysics
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.

PHYS 842 Formation of Structure in the Universe
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.

PHYS 843 High Energy Astroparticle Physics
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.

PHYS 844 Neutrino Physics and Astrophysics
An introduction to neutrino physics and astrophysics. Topics include neutrino mass and mixing; solar neutrinos; supernova neutrinos; ultra high energy neutrino astronomy.

PHYS 845 Interstellar Medium and Star Formation
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.

PHYS 847 Planet Formation
Our understanding of the processes involved in planet formation have been revolutionized by astronomical discoveries of the Kuiper belt beyond Neptune in our Solar System and an increasingly large number of remarkably diverse planetary systems around other stars. This graduate module will summarize the observational constraints and review our theoretical understanding of the interplay of the physical processes leading to the formation of planets.
PREREQUISITE: Permission of the instructor.

PHYS 848 High Density Astrophysics
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.
PREREQUISITE: Permission of the instructor.

PHYS 849 Model Fitting and Bayesian Inference for Physics and Astronomy
This module provides an overview of model building and Bayesian probability theory as applied to problems in astrophysics and particle astrophysics. Topics include a comparison of Bayesian and frequentist probability theory, errors, and Markov chain Monte Carlo. The module will aim to provide a hands-on experience and students will be asked to carry out statistical analyses of actual data.

PHYS 850 Statistics for particle-physics and astrophysics
Statistics for particle-physics and astrophysics Introduction to graduate stats in particle physics and astronomy. Frequentist and Bayesian perspectives. Distributions. Central limit theorem. Likelihoods. Parameter estimation. Goodness of fit. Hypothesis testing. Priors. Monte-Carlo techniques. Machine learning. Applications may include rare-event searches, and star and galaxy clustering.
PREREQUISITE: Permission from the course coordinator
EXCLUSION: PHYS 849

PHYS 858 Introduction to Medical Physics
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.
EXCLUSION: PHYS 495

PHYS 860 Micro/Nanofabrication
A multi-disciplinary graduate course on the principles of micro/nanofabrication. It aims to help students from a broad range of sciences gain perspective on techniques, tools, and strategies for the micro/nanofabrication of devices for a variety of applications. The course will feature hands-on experience at NanoFabrication Kingston, the cleanroom and nanofabrication facility at Queen's.
PREREQUISITE: Permission of the instructor

PHYS 861 Physics of the Early Universe
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.

PHYS 862 The Early Universe and Multimessenger Astrophysics

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

PHYS 870 Statistical Mechanics
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.

PHYS 879 High Performance Computational Physics
A double-numbered course to teach students how to use the tools of high-- performance 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

PHYS 880 Elements of Solid State Physics I
The structural, electronic, optical and transport properties of solids. (Offered jointly with PHYS/ENPH 480.)
EXCLUSION: PHYS/ENPH 480

PHYS 881 Elements of Solid State Physics II
A continuation of PHYS 880. Topics include the vibrational, magnetic, and superconducting properties of solids.
PREREQUISITE: PHYS 880 or equivalent.

PHYS 883 Photonics Problem Solving
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.

PHYS 884 Nonlinear Optics
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

PHYS 885 Quantum Nanophotonics
Quantum Optics describes the behavior of quanta of light – photons – 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

PHYS 891 Nuclear and Particle Physics
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
EXCLUSION: PHYS/ENPH 490

PHYS 892 Particle Physics
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.

PHYS 893 Plasma Physics
An introduction to plasma physics. The motions of single particles under the influence of various fields is considered first, followed by a fluid description of plasma. Topics also include plasma properties, waves in plasma, equilibrium and stability. PREREQUISITE: Permission from the course instructor

PHYS 899 Master's Thesis Research

PHYS 901 Graduate Student Seminar Series
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.

PHYS 904 Science Leadership and Management
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. Required for PhD Students in Physics, Engineering Physics & Astronomy.
EXCLUSION: CHEM 904

PHYS 913 Current Topics in Astronomical Research
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.

PHYS 914 Current Topics in Astrophysical Research
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.

PHYS 921 Quantum Field Theory
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.
PREREQUISITE: PHYS 825 or equivalent.

PHYS 923 Many-body Quantum Theory
Hartree-Fock Theory. Second quantization, perturbation methods and diagrammatic representations. Density matrix, Green functions and canonical transformations. Applications to atomic, molecular, and nuclear structure and to condensed matter physics.
PREREQUISITE: PHYS 825 or equivalent.

PHYS 958 Current Topics in Medical Physics
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.
PREREQUISITE: PHYS 858 or equivalent.

PHYS 982 Advanced Topics in Condensed Matter Physics

Topics in condensed matter physics of current interest. Examples of such topics are: surface physics, magnetotransport properties, polymers and disordered solids, low temperature physics.
PREREQUISITE: PHYS 880 and PHYS 881 or equivalent.

PHYS 983 Advanced Solid State Theory

Topics include pseudopotential theory of metals, band theory of ordered and disordered solids, linear response theory, density functional theory, field theories of phase transitions.
PREREQUISITE: PHYS 825, PHYS 880 and PHYS 881 or equivalent.

PHYS 994 Current Topics In Nuclear and Particle Physics

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.

PHYS 995 Advanced Topics in Sub-Atomic Theory
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.
PREREQUISITE: PHYS 825 and PHYS 891 or PHYS 892.

PHYS 999 Ph.D. Thesis Research