

# Physics (PHYS)

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## Physics (PHYS) Courses

With the exception of PHYS 5701 Intermediate Quantum Mechanics with Applications and PHYS 5302 Classical Electrodynamics, which may be offered at either Carleton or the University of Ottawa, all PHYS courses are offered only at Carleton, and all PHYJ courses are offered only at the University of Ottawa.

### PHYS 5002 [0.5 credit] (PHY 5344)

#### Statistical Data Analysis Techniques for Physics

Computational methods used in analysis of experimental data. Introduction to probability and random variables. Monte Carlo methods for simulation of random processes. Statistical methods for parameter estimation and hypothesis tests. Confidence intervals. Multivariate data classification. Unfolding methods. Examples taken primarily from particle and medical physics.

Includes: Experiential Learning Activity

Prerequisite(s): an ability to program in Python, Java, C, or C++, and permission of the Department.

Also offered at the undergraduate level, with different requirements, as PHYS 4807, for which additional credit is precluded.

### PHYS 5101 [0.5 credit] (PHY 8111)

#### Classical Mechanics and Theory of Fields

Hamilton's principle; conservation laws; canonical transformations; Hamilton-Jacobi theory; Lagrangian formulation of classical field theory.

Prerequisite(s): permission of the Department.

### PHYS 5201 [0.5 credit]

#### Introduction to Medical Imaging Principles and Technology

Basic principles and technological implementation of x-ray, nuclear medicine, magnetic resonance imaging (MRI), and other imaging modalities used in medicine. Contrast, resolution, storage requirements for digital images. Applications outside of medicine, future trends. Precludes additional credit for BIOM 5201.

Prerequisite(s): permission of the Physics Department.

### PHYS 5202 [0.5 credit] (PHY 8122)

#### Special Topics in Molecular Spectroscopy

Topics may include: electronic spectra of diatomic and triatomic molecules and their interpretation using molecular orbital diagrams; Raman and resonance Raman spectroscopy; symmetry aspects of vibrational and electronic levels of ions and molecules in solids; the presence of weak and strong resonant laser radiation. Also listed as CHEM 5009/CHM 8150.

Prerequisite(s): permission of the Department.

### PHYS 5203 [0.5 credit] (PHY 5161)

#### Medical Radiation Physics

Interaction of electromagnetic radiation with matter. Sources: X-ray, accelerators, radionuclide. Charged particle interaction mechanisms, stopping powers, kerma, dose. Introduction to dosimetry. Units, measurements, dosimetry devices.

Prerequisite(s): permission of the Department.

### PHYS 5204 [0.5 credit] (PHY 5112)

#### Physics of Medical Imaging

Physical foundation of and recent developments in transmission X-ray imaging, computerized tomography, nuclear medicine, magnetic resonance imaging, and ultrasound, for the specialist imaging physicist. Image quality, contrast, resolution, SNR, MTF, DQE. Introduction to image processing, system performance assessment.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 5203 and one of PHYS 4203 or PHYS 5313, or permission of the Department.

### PHYS 5206 [0.5 credit] (PHY 5164)

#### Medical Radiotherapy Physics

Radiation therapy process and physics. Ion chamber dosimetry, Monte Carlo techniques of radiation transport, cavity theories, external beam therapy, brachytherapy, dosimetry protocols, detectors used in radiation therapy. Treatment planning, monitor unit calculations, intensity-modulated radiation therapy. Novel and alternate techniques.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 5203 or permission of the Department.

### PHYS 5207 [0.5 credit] (PHY 5165)

#### Radiobiology

Physics and chemistry of radiation interactions. Cell biology, DNA damage and repair, survival curves and models, radiosensitivity, oxygen effect. Linear energy transfer, relative biological effectiveness. Whole body radiation effects, radioprotectors, radiosensitizers. Hyperthermia. Molecular techniques in radiobiology. Model tumour systems.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 5203 must have been taken, or be taken concurrently, or permission of the Department.

### PHYS 5208 [0.5 credit] (PHY 5163)

#### Radiation Protection

Dose quantities, effects of radiation exposure, fetal risks, scientific basis for protection, dose limits. Background radiation, dose from internal radionuclides. Doses in radiology, incidents in radiation therapy. Shielding design, working with radioactive materials. Instruments and measurement. Radiation protection organizations.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 5203 or permission of the Department.

**PHYS 5209 [0.5 credit] (PHY 5166)****Medical Physics Practical Measurements**

Experience with current clinical medical imaging and cancer therapy equipment, and dosimetry and biophysics instrumentation. The course requires completion of experimental projects on medical imaging, radiotherapy, dosimetry, and biophysics, conducted at local clinics and NRC laboratories.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 5203, and two of PHYS 5204, PHYS 5206, PHYS 5207, and enrollment in the medical physics graduate program, or permission of the Department.

**PHYS 5210 [0.0 credit] (PHY 5168)****Anatomy and Physiology for Medical Physicists**

An overview of human anatomy and physiology as background for the application of physics to cancer therapy and medical imaging. Anatomy as depicted by imaging technologies such as CT, MRI, and radiography will be emphasized. Graded Sat/Uns.

Prerequisite(s): enrollment in the graduate program in medical physics or permission of the Department.

**PHYS 5291 [0.5 credit] (PHY 5167)****Advanced Topics in Medical Physics**

Topics may include medical imaging physics, cancer therapy physics, medical biophysics, or radiation protection and health physics.

Prerequisite(s): PHYS 5203 plus, as appropriate to the particular advanced topic offered, at least one of PHYS 5204, PHYS 5206, PHYS 5207; or permission of the Department.

**PHYS 5302 [0.5 credit] (PHY 8132)****Classical Electrodynamics**

Covariant formulation of electrodynamics; Liénard-Wiechert potentials; radiation reaction; plasma physics; dispersion relations.

Prerequisite(s): PHYS 3308, PHYS 3802, and PHYS 3807, or equivalent courses, or permission of the Department.

**PHYS 5313 [0.5 credit]****Physical Applications of Fourier Analysis**

Fourier transform, convolution. Sampling theorem. Applications to imaging: descriptors of spatial resolution, filtering. Correlation, noise power. Discrete Fourier transform, FFT. Filtering of noisy signals. Image reconstruction in computed tomography and magnetic resonance. Laplace transform. Integral transforms, application to boundary value problems.

Also offered at the undergraduate level, with different requirements, as PHYS 4203, for which additional credit is precluded.

Lectures three hours a week.

**PHYS 5318 [0.5 credit] (PHY 5318)****Modern Optics**

Electromagnetic wave propagation; reflection, refraction; Gaussian beams; guided waves. Laser theory: stimulated emission, cavity optics, gain and bandwidth, atomic and molecular lasers. Mode locking, Q switching. Diffraction theory, coherence, Fourier optics, holography, laser applications. Optical communication systems, nonlinear effects: devices, fibre sensors, integrated optics.

Prerequisite(s): permission of the Department.

Also offered at the undergraduate level, with different requirements, as PHYS 4208, for which additional credit is precluded.

**PHYS 5401 [0.5 credit]****Astrophysics**

Stellar evolution, including stellar modeling, main sequence stars, red giants and the end states of stars such as neutron stars and black holes. Galactic structure and dynamics. Neutrino astrophysics.

Also offered at the undergraduate level, with different requirements, as PHYS 4201, for which additional credit is precluded.

**PHYS 5402 [0.5 credit]****Cosmology**

Observational evidence for the Big Bang. Cosmological space-time, expansion dynamics and contents of the universe. Physical processes in the expanding universe, inflation, nucleosynthesis, the cosmic microwave background, dark matter, and dark energy.

Also offered at the undergraduate level, with different requirements, as PHYS 4202, for which additional credit is precluded.

**PHYS 5601 [0.5 credit] (PHY 5966)****Experimental Techniques of Nuclear and Elementary Particle Physics**

The interaction of radiation and high energy particles with matter; experimental methods of detection and acceleration of particles; use of relativistic kinematics; counting statistics.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 4307 or equivalent, and PHYS 4707; or permission of the Department.

**PHYS 5602 [0.5 credit] (PHY 5967)****Physics of Elementary Particles**

Standard Model. Properties of leptons, quarks, hadrons. Fundamental interactions: photon, gluons,  $W/Z$  bosons. Higgs bosons. Conservation laws, invariance principles, quantum numbers. Decay rates and scattering cross-sections. Quantum electrodynamics and chromodynamics. Resonances. Weak interactions, CKM matrix, parity and CP violation. Neutrino masses and oscillations. Future directions.

Prerequisite(s): PHYS 4707 or permission of the Department.

Also offered at the undergraduate level, with different requirements, as PHYS 4602, for which additional credit is precluded.

**PHYS 5604 [0.5 credit] (PHY 8164)****Intermediate Nuclear Physics**

Properties of the deuteron and the neutron-proton force. Nucleon-nucleon forces, isospin and charge independence. Nuclear models. Scattering theory. Interpretation of n-p and p-p scattering experiments. Interaction of nucleons with electrons. Interaction of nuclei with radiation.

Prerequisite(s): PHYS 4608 or permission of the Department.

**PHYS 5701 [0.5 credit] (PHY 5170)****Intermediate Quantum Mechanics with Applications**

Angular momentum and rotation operations; Wigner and Racah coefficients; several and many electron problem in atoms; variational and Hartree-Fock formalism; introduction to second quantized field theory; scattering theory.

Prerequisite(s): PHYS 4707 and PHYS 4708 or permission of the Department.

**PHYS 5702 [0.5 credit] (PHY 8172)****Relativistic Quantum Mechanics**

Relativistic wave equations. Expansion of S matrix in Feynman perturbation series. Feynman rules. An introduction to quantum electro-dynamics with some second quantization. Gauge theories. May include introduction to Standard Model.

Prerequisite(s): PHYS 5701 and permission of the Department.

**PHYS 5801 [0.5 credit] (PHY 5140)****Methods of Theoretical Physics I**

This course and PHYS 5802 are designed for students who wish to acquire a wide background of mathematical techniques. Topics can include complex variables, evaluation of integrals, approximation techniques, dispersion relations, Padé approximants, boundary value problems, Green's functions, integral equations.

**PHYS 5802 [0.5 credit] (PHY 5141)****Methods of Theoretical Physics II**

This course complements PHYS 5801. Topics include group theory, discussion of SU<sub>2</sub>, SU<sub>3</sub>, and other symmetry groups. Lorentz group.

**PHYS 5804 [0.5 credit]****Introduction to General Relativity**

Special relativity using tensor analysis. Curved spacetime with physics applications which may include the solar system, stars, black holes, and gravitational waves. Introduction to differential geometry and Einstein's field equations.

Also offered at the undergraduate level, with different requirements, as PHYS 4804., for which additional credit is precluded.

**PHYS 5900 [1.0 credit] (PHY 8290)****Selected Topics in Physics (M.Sc.)**

A student may, with the permission of the Department, take more than one selected topic, in which case each full course is counted for credit.

Prerequisite(s): permission of the Department.

**PHYS 5901 [0.5 credit] (PHY 8191)****Selected Topics in Physics (M.Sc.)**

Prerequisite(s): permission of the Department.

**PHYS 5905 [1.0 credit] (PHY 5495)****Physics in Modern Technology Work Term**

Experience for students enrolled in the physics in modern technology stream. To receive course credit, students must receive satisfactory evaluations for their work term employment. Written and oral reports describing the work term project are required.

Includes: Experiential Learning Activity

Prerequisite(s): Registration in the physics in modern technology stream of the M.Sc. program and permission of the Department.

**PHYS 5909 [2.5 credits] (PHY 7999)****M.Sc. Thesis**

Includes: Experiential Learning Activity

Prerequisite(s): permission of the Department.

**PHYS 6601 [0.5 credit] (PHY 8165)****Particle Physics Phenomenology**

This course covers much of the required knowledge for research in particle physics from both the experimental and theoretical points of view. Topics may include: standard model, parton model, quark model, hadron spectroscopy, and tests of QCD.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 5602 and PHYS 5702 or permission of the Department.

**PHYS 6602 [0.5 credit] (PHY 8166)****Advanced Topics in Particle Physics**

Phenomenology. This course will consist of a variety of seminars and short lecture courses, and will cover topics of immediate interest to the research program of the department.

Includes: Experiential Learning Activity

Prerequisite(s): PHYS 6601 or permission of the Department.

**PHYS 6701 [0.5 credit] (PHY 8173)****Quantum Field Theory**

Relativistic quantum field theory; second quantization of Bose and Fermi fields; reduction and LSZ formalism; perturbation expansion and proof of renormalizability of quantum field theories; calculations of radiative corrections and applications.

Prerequisite(s): PHYS 5701 and PHYS 5702, or permission of the Department.

**PHYS 6900 [0.5 credit] (PHY 8490)****Selected Topics in Physics (Ph.D.)**

Prerequisite(s): permission of the Department.

**PHYS 6901 [0.5 credit] (PHY 8391)**  
**Selected Topics in Physics (Ph.D.)**  
Prerequisite(s): permission of the Department.

**PHYS 6909 [8.0 credits] (PHY 9999)**  
**Ph.D. Thesis**  
Includes: Experiential Learning Activity  
Prerequisite(s): permission of the Department.