Physics (PHYJ) - Joint Courses

Physics - Joint (PHYJ) Courses

With the exception of PHYS 5701 (PHY 5170) and PHYS 5302 (PHY 8132), 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.

PHYJ 5001 [0.5 credit] (PHY 5130)
Experimental Characterization Techniques in Materials Science, Physics, Chemistry, and Mineralogy

Survey of experimental techniques used in materials science, condensed matter physics, solid state chemistry, and mineralogy to characterize materials and solid substances. Diffraction. Spectroscopy. Microscopy and imaging. Other analytic techniques.
Prerequisite(s): permission of the Department.

PHYJ 5003 [0.5 credit] (PHY 5342)
Computer Simulations in Physics
Advanced numerical methods to study large scale problems in the natural sciences; molecular dynamics, Langevin dynamics, Brownian dynamics methods. The use of different thermodynamic ensembles to compute experimentally relevant physical properties, and work with non-equilibrium situations. Methods to handle very large problems on parallel computers.
Prerequisite(s): PHY 3355 (PHY 3755), PHY 3370 (PHY 3770) and familiarity with FORTRAN, Pascal or C.

PHYJ 5004 [0.5 credit] (PHY 5340)
Computational Physics: Deterministic Methods
Deterministic numerical methods in physics. Interpolation methods. Numerical solutions of Newton's, Maxwell's and Schrödinger's equations. Molecular dynamics. Non-linear dynamics. Numerical solutions of partial differential equations in physics. Finite elements. This course cannot be combined for credit with PHY 4340 (PHY 4740).

PHYJ 5005 [0.5 credit] (PHY 5341)
Computational Physics: Stochastic Methods
Interpolation, regression and modeling. Random number generation. Monte Carlo methods. Simulations in thermo-statistics. Fractals, percolation, cellular automation. Stochastic methods. This course cannot be combined for credit with PHY 4341 (PHY 4741).

PHYJ 5006 [0.5 credit] (PHY 5362)
Computational Methods in Material Sciences
Introduction to modern computational techniques used in material science research. Classical molecular dynamics, classical and quantum Monte Carlo methods, plane-wave based electronic band structure calculations, Carr-Parrinello quantum molecular dynamics. Applications to condensed matter systems: basic simulation techniques, force-field based methods, first-principles quantum mechanical methods.
Prerequisite(s): permission of the Department.

PHYJ 5102 [0.5 credit] (PHY 5361)
Nonlinear Dynamics in the Natural Sciences
Differential and difference equations, Fourier series and data analysis, stability analysis, Poincaré maps, local bifurcations, routes to chaos and statistical properties of strange attractors. Applications of these concepts to specific problems in condensed matter physics, molecular physics, fluid mechanics, dissipative structures, and evolutionary systems.
Prerequisite(s): permission of the Department.

PHYJ 5192 [0.25 credit] (PHY8192)
Selected Topics in Physics
Topics of current interest in Physics. Variable content year to year. Compulsory Components: LEC.
Prerequisite(s): Permission of the Department.

PHYJ 5310 [0.5 credit] (PHY 5310)
Advanced Optics and Photonics
Introduction to laser physics: optical resonators, light-matter interaction, basic operation of lasers, coherence, light control and manipulation, beam optics, Fourier optics. Guided wave optics: light propagation, allowed modes, dispersion.
Prerequisite(s): permission of the Department.

PHYJ 5311 [0.5 credit] (PHY 5311)
Quantum Optics I
Classical and semi-classical light-matter interaction; gauges and energy conservation; two level systems in the resonant, under-resonant and over-resonant limit; time-dependent perturbation theory and Fermi's golden rule; semi-classical laser theory; Landau Zener tunnelling and multi-photon transitions; tunnel ionization and multi-photon ionization.
Prerequisite(s): permission of the Department.

PHYJ 5312 [0.5 credit] (PHY 5312)
Quantum Optics II
Quantum light-matter interaction; quantization of the light field and of Schrodinger equation; number states and coherent states; photon emission and absorption; two-photon decay; photoelectric effect; Lamb shift, line-width and renormalization; Casimir effect; multi-photon processes; density operator; quantum theory of decay; quantum laser theory.
Prerequisite(s): permission of the Department.

PHYJ 5322 [0.5 credit] (PHY 5322)
Biological Physics
Biological phenomena studied using techniques of physics. Key components of cells. Physical concepts relevant to cellular phenomena: Brownian dynamics, fluids, suspensions, entropy driven phenomena, chemical forces and self-assembly. Biological molecules. Enzymes. Molecular motors. Nerve impulses.
Precludes additional credit for PHY 4322.

PHYJ 5330 [0.5 credit] (PHY 5330)
Fibre Optics Communications
Optical fibres: description, modes, losses. optical transmitters: light-emitting diodes, semiconducting lasers. Optical receivers: design, noise, sensitivity, degradation, performance. System design and performance. Optical amplifiers: dispersion management, pre-compensation schemes, post-compensation techniques, dispersion compensating fibres, optical filters, fibre Bragg gratings, soliton generation, long-haul lightwave systems, high-capacity systems.
Precludes additional credit for ELG 5103.

PHYJ 5331 [0.5 credit] (PHY 5331)
Fiber Optics Fundamentals and Applications
Fiber optics fundamentals, Mach-Zehnder, Michelson, Fabry-Perot, Sagnac-based interferometers and phase detections, intensity of wavelength modulated sensors. Principles of Rayleigh, Raman and Brillouin scattering and scattering in fibers. Principles of self-phase and cross phase modulation and four-wave mixing. Birefringence and polarization-based instrumentation.

PHYJ 5332 [0.5 credit]
Nonlinear Optics
Nonlinear optical susceptibility; wave equation description of nonlinear optics processes: second harmonic generation, intensity dependent refractive index, sum- and frequency-generation, parametric amplification; quantum mechanical theory of nonlinear optics; Brillouin and Raman scattering; the electro-optic effect; nonlinear fibre optics and solitons.

PHYJ 5364 [0.5 credit] (PHY 5364)
Nanotechnology and Modern Methods in Biophysics
Modern experimental techniques and nanotechnology used in biophysics. Topics include biosensors, microfluidics, single molecule techniques, DNA sequencing technologies, microfabrication, nanoscale electrokinetics, atomic force microscopy, fluorescence and confocal microscopy, cell chips, etc. Course includes several hands-on experiments.
Includes: Experiential Learning Activity

PHYJ 5388 [0.5 credit] (PHY 5388)
Photons and Atoms
Atomic, molecular structure and transitions, semi-classical light-matter interaction; two level systems; time-dependent perturbation theory, Fermi's golden rule; optical Bloch equations; coherent control; optical interactions with three-level systems, electromagnetically induced transparency; optical forces; laser cooling; Bose-Einstein condensation; atom optics and interferometers; quantization of light.

PHYJ 5389 [0.5 credit] (PHY 5389)
Quantum Theory of Light
Quantum cryptography; entanglement; density operators; Bell's inequalities; quantization of light field; Lam shift; Casimir effect; vacuum; quantum optical states; Photon, homodyne detectors; quasi-probability functions; beam splitters; classical, quantum coherence; Hanbury Brown and Twiss effect, Hong-Ou-Mandel interference; quantum nonlinear optics, light-matter interaction, open systems.

PHYJ 5390 [0.5 credit] (PHY 5390)
Seminar in Quantum Science and Technology
This course will reflect the interdisciplinary nature of the rapidly advancing field of quantum science and technology. The wide-range of topics include: foundations of quantum mechanics and quantum information, quantum materials, quantum communication, quantum sensing and metrology, quantum computing and simulations.

PHYJ 5391 [0.5 credit] (PHY 5391)
Quantum Materials, Nanostructures and Devices
The course covers the electronic and optical properties of semiconductor nanostructures (quantum wells, wires and dots), topological insulators, 2D crystals, discussing single particle properties, many-electron description, response functions and computational tools. Application in single electron transistors, lasers, solar cells, Majorana quantum circuits will be covered.

PHYJ 5392 [0.5 credit] (PHY 5392)
Introduction to Nanoscience
Nanoscience with photons (ray and wave optics), nanoscience with charged particles (light matter interaction, SEM, TEM), nanoscience with physical probes.

PHYJ 5401 [0.5 credit] (PHY 5100)
Solid State Physics I
Periodic structures, Lattice waves. Electron states. Static properties of solids. Electron-electron interaction. Dynamics of electrons. Transport properties. Optical properties.
Prerequisite(s): permission of the Department.

PHYJ 5402 [0.5 credit] (PHY 5110)
Solid State Physics II
Elements of group theory. Band structure, tight binding and other approximations, Hartree-Fock theory. Measuring the Fermi surface. Boltzmann equation and semiconductors. Diamagnetism, paramagnetism and magnetic ordering. Superconductivity.
Prerequisite(s): permission of the Department.

PHYJ 5403 [0.5 credit] (PHY 5151)
Type I and II Superconductors
Flux flow and flux cutting phenomena. Clem general critical state model. Flux quantization, Abrikosov vortex model and Ginzburg-Landau theory. Superconducting tunnelling junctions (Giaevar and Josephson types).
Prerequisite(s): PHY 4370 or permission of the Department.

PHYJ 5404 [0.5 credit] (PHY 6371)
Topics in Mössbauer Spectroscopy
Recoilless emission/absorption, anisotropic Debye-Waller factors, second order Doppler shifts. Mössbauer lineshape theory with static and dynamic hyperfine interactions. Distributions of static hyperfine parameters. Physics of the hyperfine parameters: origin of the hyperfine field, calculations of electric field gradients. Applications of Mössbauer spectroscopy.
Prerequisite(s): permission of the Department.

PHYJ 5407 [0.5 credit] (PHY 5380)
Semiconductor Physics I
Brillouin zones and band theory. E-k diagram, effective mass tensors, etc. Electrical properties of semiconductors. Conduction, hall effect, magneto-resistance. Scattering processes. Multivalley models and non-parabolic bands.
Prerequisite(s): PHY 4380 or permission of the Department.

PHYJ 5408 [0.5 credit] (PHY 5381, PHY 5781)
Semiconductor Physics II: Optical Properties
Optical constants and dispersion theory. Optical absorption, reflection and band structure. Absorption at band edge and excitons. Lattice, defect and free carrier absorption, Magneto-optics. Photo-electronic properties, luminescence, detector theory. Experimental methods.
Prerequisite(s): PHY 4380 or permission of the Department.

PHYJ 5409 [0.5 credit] (PHY 5951)
Low Temperature Physics II
Helium 3 and Helium 4 cryostats. Dilution refrigerators. Theory and techniques of adiabatic demagnetization. Thermometry at low temperatures. Problems of thermal equilibrium and of thermal isolation. Properties of matter at very low temperature.
Prerequisite(s): PHY 4355 or permission of the Department.

PHYJ 5501 [0.5 credit]
Charged Particle Dynamics

PHYJ 5502 [0.5 credit] (PHY 5740)
Physique Numérique I
Méthodes numériques déterministes en physique. Techniques d'interpolation. Solutions numérique des équations de Newton, de Maxwell et de Schrödinger. Dynamique moléculaire. Dynamique non-linéaire. Solutions numériques des équations aux dérivées partielles en physique. Éléments finis.
Prerequisite(s): permission of the Department.

PHYJ 5503 [0.5 credit] (PHY 5741)
Physique Numérique II
Interpolation, régression et modeler. Nombres aléatoires. Techniques de Monte-Carlo. Simulations thermo-statistiques. Percolation, fractales, et automisation cellulaire. Méthodes numériques stochastiques.
Prerequisite(s): permission of the Department.

PHYJ 5504 [0.5 credit] (PHY 5387)
Physics of Materials
Microscopic characteristics related to physical properties of materials. Materials families: metals and alloys, ceramics, polymers and plastics, composites, layered materials, ionic solids, molecular solids, etc. Specific materials groups. Equilibrium phase diagrams and their relation to microstructure and kinetics. Experimental methods of characterization. Interactions and reactions.
Prerequisite(s): PHY 4382 or equivalent. Cannot be combined with PHY 4387.

PHYJ 5505 [0.5 credit] (PHY 5355)
Statistical Mechanics
Ensemble theory. Interacting classical and quantum systems. Phase transitions and critical phenomena. Fluctuations and linear response theory. Kinetic equations.

Prerequisite(s): PHY 4370 and PHY 3355 or permission of the Department.

PHYJ 5506 [0.5 credit] (PHY 5742)
Simulations numériques en physique
Un cours ayant but d'étudier des méthodes numériques avancées employées dans les problèmes à grande échelle dans les sciences naturelles. Emploi d'ensembles thermo-dynamiques différents, calculs de propriétés physiques expérimentalement pertinentes, et extension aux situations hors d'équilibre. Techniques pour ordinateurs parallèles.
Prerequisite(s): permission of the Department.

PHYJ 5507 [0.5 credit] (PHY 5922)
Advanced Magnetism
Study of some experimental and theoretical aspects of magnetic phenomena found in ferro-, ferri-, antiferro-magnetic and spin glass materials. Topics of current interest in magnetism.
Prerequisite(s): PHY 4385 and permission of the Department.

PHYJ 5508 [0.5 credit] (PHY 5320)
Introduction to the Physics of Macromolecules
Chemistry of macromolecules and polymers; random walks and the static properties of polymers; experimental methods; the Rouse model and single chain dynamics; polymer melts and viscoelasticity; the Flory-Huggins theory; the reptation theory; computer simulation algorithms; biopolymers and copolymers.
Prerequisite(s): permission of the Department.

PHYJ 5509 [0.5 credit] (PHY 5347)
Physics, Chemistry and Characterization of Mineral Systems
The materials science of mineral systems such as the network and layered silicates. In-depth study of the relations between mineralogically relevant variables such as: atomic structure, crystal chemistry, site populations, valence state populations, crystallization conditions. Interpretation and basic understanding of characterization tools.
Prerequisite(s): permission of the Department.

PHYJ 5603 [0.5 credit]
Ion Collisions in Solids

PHYJ 5703 [0.5 credit] (PHY 6170)
Advanced Quantum Mechanics II
Systems of identical particles and many-body theory. Lattice and impurity scattering. Quantum processes in a magnetic field. Radiative and non-radiative transitions. Introduction to relativistic quantum mechanics.
Prerequisite(s): PHY 5170 and permission of the Department.

PHYJ 5722 [0.5 credit] (PHY 5722)
Physique Biologique
Application des méthodes de la physique à l'etude des phénomènes biologiques. Composantes principales d'une cellule. Concepts physiques pertinents aux phénomènes cellulaires : dynamique brownienne, liquides, suspensions, phénomènes d'origine entropique, forces chimiques et auto-assemblage. Molécules biologiques. Enzymes. Moteurs moléculaires. Impulsions nerveuses.
Precludes additional credit for PHY 4722.
Offert également, avec des exigences différentes, sous la cote PHY 4722.

PHYJ 6406 [0.5 credit] (PHY 6382)
Physics of Semiconductor Superlattices
Fundamental physics of two-dimensional quantized semiconductor structures. Electronic and optical properties of superlattices and quantum wells. Optical and electronic applications. This course is intended for students registered for the Ph.D. in semiconductor physics research.
Prerequisite(s): advanced undergraduate or graduate course in solid state physics and permission of the Department.

PHYJ 6407 [0.5 credit] (PHY 6782)
Physique des super-réseaux à semi-conducteurs
Physique fondamentale des structures quantiques bi-dimensionnelles à semiconducteurs. Propriétés électroniques et optiques des super-réseaux et puits quantiques. Applications à l'électronique et à l'optique. Ce cours est destiné aux étudiants et aux étudiantes inscrits au doctorat en physique des semiconducteurs.
Prerequisite(s): permission of the Department.