

PHYSICS

The Departments of Physics at the Universities of Guelph and Waterloo offers MSc and PhD degrees in the following fields:

- Astrophysics and Gravitation
- Atomic, Molecular and Optical Physics
- Biophysics
- Chemical Physics
- Condensed Matter and Material Physics
- Industrial and Applied Physics
- Subatomic Physics
- Quantum Computing

The University of Guelph and the University of Waterloo have a joint program in which graduate courses are taught by instructors from both universities. Students are registered at the university their advisor is located. A student comes under the general regulations of the university at which he or she is registered, and the degree is granted by that university.

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Graduate Faculty Other University

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Graduate Faculty Other University

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MSc Program

The MSc program is offered in the following fields:

1. astrophysics and gravitation;
2. atomic, molecular and optical physics;
3. biophysics;
4. chemical physics;
5. condensed matter and material physics;
6. industrial and applied physics;
7. subatomic physics; and
8. quantum computing.

Admission Requirements

Application for admission should be made as early as possible using on-line application methods described on the web-site <https://www.physics.uoguelph.ca/graduate-studies/graduate-studies-in-physics/how-to-apply> (<https://www.physics.uoguelph.ca/graduate-studies/graduate-studies-in-physics/how-to-apply/>). Successful applicants are encouraged to start their graduate studies in May or September, but a January starting date is possible. Program offices should be consulted for admission deadlines.

The admission requirements are as follows:

- An honours BSc degree in physics (or equivalent) with at least a B standing (75%) from a recognized university.
- Three letters of reference, two of which normally are from academic sources.
- Proof of competency in English (for applicants whose prior education was in a language other than English). See the University regulations on English Language Proficiency Certification.
- GRE Physics Subject Test score for all applicants who have completed their post-secondary education outside of Canada.

Successful applicants are encouraged to start their graduate studies in May or September, but a January starting date is possible. Academic transcripts and other supporting documents should be forwarded as soon as they become available. Admission to the program cannot be granted until all requirements have been met and all documents submitted.

Applications are considered by the Admissions Committee. It should be noted that students will normally be admitted only if an advisor can be found to oversee their research. Since there are a limited number of openings each year, applicants are advised to state alternative areas

of research on the preference form supplied (see web-site <https://www.physics.uoguelph.ca/graduate-studies/graduate-studies-in-physics/how-to-apply> (<https://www.physics.uoguelph.ca/graduate-studies/graduate-studies-in-physics/how-to-apply/>)).

Program Requirements

Students enrol in one of two study options:

1. thesis, or
2. course work and major research project.

Thesis

Four one-term courses (at least 2.0 course credits) acceptable for graduate credit and a thesis based on original research are required. The subject of research must be approved by the candidate's advisory committee and the thesis must be read and approved by the advisory committee. One of the four courses may be an undergraduate course approved by the student's advisory committee and the Graduate Program Coordinator. If it is a physics course, it must be at the fourth-year level.

For all students one of the courses must include at least one of the following:

Code	Title	Credits
PHYS*7010	Quantum Mechanics I	0.50
PHYS*7030	Quantum Field Theory	0.50
PHYS*7040	Statistical Physics I	0.50
PHYS*7060	Electromagnetic Theory	0.50
PHYS*7810	Fundamentals of Astrophysics	0.50

An MSc student in this program who shows a particular aptitude for research and has a superior record in fourth-year undergraduate and three one-term graduate courses may be permitted, upon recommendation of the advisor and with the approval of the coordinating committee, to transfer into the PhD program without completing an MSc thesis.

An average of at least 70% must be obtained in the required courses. A minimum grade of 65% is required for a pass in each course. No more than two courses, of the first four taken, can have a grade of less than 70%. If a student does not meet these minimum grade requirements, or receives a failing grade in any course, they may be required to withdraw from the program.

Course Work and Major Research Project (MRP)

Seven one-term courses (0.50 unit weight) acceptable for graduate credit, plus a project course summarized in a report, are required. The project must be approved by the candidate's advisor and the report read and approved by the advisor and one other faculty member. At least four of the seven courses must be physics graduate level courses.

Two of the seven courses may be upper level undergraduate courses approved by the student's advisory committee and the Graduate Program Coordinator. If it is a physics course, it must be at the fourth-year level. This program is recommended for those planning careers requiring a broad non-specialized knowledge of physics (for example, high school teaching).

PhD Program

The PhD program is research-based and offered in the fields of:

1. astrophysics and gravitation;
2. atomic, molecular and optical physics;
3. biophysics;
4. chemical physics;
5. condensed matter and material physics;
6. industrial and applied physics;
7. subatomic physics; and
8. quantum computing.

Admission Requirements

There are three pathways for admission to the PhD program:

1. An MSc degree in physics from an approved university or college with at least a B standing (75%) is normally required for entrance into the PhD program. Other requirements are the same as those described above for the MSc program (see web-site <https://www.physics.uoguelph.ca/graduate-studies/graduate-studies-in-physics/how-to-apply> (<https://www.physics.uoguelph.ca/graduate-studies/graduate-studies-in-physics/how-to-apply/>)).
2. Students with an undergraduate degree in Physics may apply for admission directly to the PhD program. Successful applicants will have an outstanding academic record, breadth of knowledge in physics, previous research experience, and strong letters of recommendation.
3. Students wishing to be considered for transfer to a PhD program prior to completion of the MSc program must request the transfer up to 3 full-time terms after initial registration and have an excellent academic record as well as a strong aptitude for research.

Program Requirements

Three cores courses or their equivalent must be completed by end of the first year of the PhD program. This requirement may be satisfied, in full or in part, by courses taken during the M.Sc. The core courses for the program are:

Code	Title	Credits
PHYS*7010	Quantum Mechanics I	0.50
PHYS*7030	Quantum Field Theory	0.50
PHYS*7040	Statistical Physics I	0.50
PHYS*7060	Electromagnetic Theory	0.50
PHYS*7670	Introduction to Quantum Information Processing	0.50
PHYS*7810	Fundamentals of Astrophysics	0.50

One of the core courses must include PHYS*7010 Quantum Mechanics I, PHYS*7040 Statistical Physics I, or PHYS*7060 Electromagnetic Theory. Exception: Biophysics students within the Physics PhD program are required to take only one core course by the completion of the first year of the program, which must include one of PHYS*7010 Quantum Mechanics I, PHYS*7040 Statistical Physics I, or PHYS*7060 Electromagnetic Theory.

A minimum of two one-term courses are required to be taken for the PhD degree, which may include or be in addition to the core courses required as specified above. One of the required courses may be an undergraduate course outside the student's main field of study and must be approved by the student's advisory committee and the Graduate Program Coordinator. No undergraduate course in physics may be taken for credit. No courses taken for MSc credit may be used to satisfy the minimum course requirement. However, courses taken during the MSc

program and in excess of those required for the MSc program will be allowed for PhD credit. The extra courses must be identified prior to admission to the PhD program.

An average of at least 70% must be obtained in the required courses. A minimum grade of 65% is required for a pass in each course. No more than two courses, of the first four taken, can have a grade of less than 70%. If a student does not meet these minimum grade requirements, or receives a failing grade in any course, they may be required to withdraw from the program.

Students who transfer to the PhD, or who enter the PhD directly, will need to complete the course work requirements of both the MSc and PhD degrees, a total of six one-term graduate courses. Three of the core courses including one of PHYS*7010 Quantum Mechanics I, PHYS*7040 Statistical Physics I or PHYS*7060 Electromagnetic Theory will have been taken by the end of the first year of the PhD program.

Interdepartmental Programs Biophysics

The Department of Physics participates in the MSc/PhD programs in biophysics. Please consult the Biophysics (calendar.uoguelph.ca/graduate-calendar/graduate-programs/biophysics/) listing for a detailed description of the graduate programs offered by the Biophysics Interdepartmental Group.

Courses

Unless otherwise indicated, courses are offered on an alternate year basis and as requested.

PHYS*6010 PSI Quantum Field Theory I Unspecified [0.50]

Canonical quantization of fields, perturbation theory, derivation of Feynman diagrams, applications in particle and condensed matter theory, renormalization in ϕ^4 .

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6020 PSI Statistical Physics Unspecified [0.50]

A brief review of ensembles and quantum gases, Ising model, Landau theory of phase transitions, order parameters, topology, classical solutions.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6030 PSI Quantum Field Theory II Unspecified [0.50]

Feynman Path Integral, abelian and nonabelian gauge theories and their quantization, spontaneous symmetry breaking, nonperturbative techniques: lattice field theory, Wilsonian renormalization.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6040 PSI Relativity Unspecified [0.50]

Special relativity, foundations of general relativity, Riemannian geometry, Einstein's equations, FRW and Schwarzschild geometries and their properties.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6050 PSI Quantum Theory Unspecified [0.50]

Schrodinger equation: free particle, harmonic oscillator, simple time-dependent problems, Heisenberg picture and connection with classical physics. Entanglement and non-locality. Pure and mixed states, quantum correlators, measurement theory and interpretation.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6060 PSI Information and Data Analysis Unspecified [0.50]

Probability, entropy, Bayesian inference and information theory. Maximum likelihood methods, common probability distributions, applications to real data including Monte Carlo methods.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6070 PSI Dynamical Systems Unspecified [0.50]

Maps, flows, stability, fixed points, attractors, chaos, bifurcations, ergodicity, approach to chaos. Hamiltonian systems, Liouville, measure, Poincare theorem, integrable systems with examples.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6080 PSI Computation Unspecified [0.50]

Common algorithms for ode and pde solving, with numerical analysis. Common tasks in linear algebra. Focus on how to write a good code, test it, and obtain a reliable result. Parallel programming.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6210 PSI Cosmology Unspecified [0.25]

FRW metric, Hubble expansion, dark energy, dark matter, CMB, Thermodynamic history of early universe. Growth of perturbations, CDM model of structure formation and comparison to observations, cosmic microwave background anisotropies, inflation and observational tests.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6220 PSI Standard Model Unspecified [0.25]

Application of Yang-Mills theory to particle physics, QCD and its tests in the perturbative regime, theory of weak interactions, precision tests of electroweak theory, CKM matrix and flavour physics, open questions.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6230 PSI String Theory Unspecified [0.25]

Superstring spectrum in 10d Minkowski, as well as simple toroidal and orbifold compactifications. T-duality, D-branes, tree amplitudes. Construct some simple unified models of particle physics. Motivate the 10- 11-dimensional supergravities. Simple supergravity solutions and use these to explore some aspects of adS/CFT duality.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6240 PSI Mathematical Physics Topics Unspecified [0.25]

Differential forms, de Rham cohomology, differential topology and characteristic classes, monopoles and instantons, Kahler manifolds, Dirac equations, zero modes and index theorems.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6350 PSI Quantum Information Review Unspecified [0.25]

Review of selected topics in Quantum Information.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6360 PSI Gravitational Physics Review Unspecified [0.25]

Review of selected topics in Gravitational Physics.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6370 PSI Condensed Matter Theory Unspecified [0.25]

Review of selected topics in Condensed Matter Theory.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6380 PSI Quantum Gravity Unspecified [0.25]

Review of selected topics in Quantum Gravity.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6390 PSI Foundations of Quantum Theory Unspecified [0.25]

Review of selected topics in Foundations of Quantum Theory.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6410 PSI Explorations in Quantum Information Unspecified [0.25]

Review of selected topics in Quantum Information.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6420 PSI Explorations in Gravitational Physics Unspecified [0.25]

Review of selected topics in Gravitational Physics.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6430 PSI Explorations in Condensed Matter Theory Unspecified [0.25]

Review of selected topics in Condensed Matter Theory.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6440 PSI Explorations in Quantum Gravity Unspecified [0.25]

Review of selected topics in Quantum Gravity.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6450 PSI Explorations in Foundations of Quantum Theory Unspecified [0.25]

Review of selected topics in Foundations of Quantum Theory.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6460 PSI Explorations in Particle Physics Unspecified [0.25]

Review of selected topics in Particle Physics.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6470 PSI Explorations in String Theory Unspecified [0.25]

Review of selected topics in String Theory.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6480 PSI Explorations in Complex Systems Unspecified [0.25]

Review of selected topics in Complex Systems.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*6490 PSI Explorations in Cosmology Unspecified [0.25]

Review of selected topics in Cosmology.

Department(s): Department of Physics

Location(s): Waterloo Campus

PHYS*7010 Quantum Mechanics I Unspecified [0.50]

Review of formalism of nonrelativistic quantum mechanics including symmetries and invariance. Approximation methods and scattering theory. Elementary quantum theory of radiation. Introduction to one-particle relativistic wave equations.

Offering(s): Annually

Department(s): Department of Physics

Location(s): Guelph

PHYS*7020 Quantum Mechanics II Unspecified [0.50]

Concepts of relativistic quantum mechanics, elementary quantum field theory, and Feynman diagrams. Application to many-particle systems.

Prerequisite(s): PHYS*7010

Department(s): Department of Physics

Location(s): Guelph

PHYS*7030 Quantum Field Theory Unspecified [0.50]

Review of relativistic quantum mechanics and classical field theory. Quantization of free quantum fields (the particle interpretation of field quanta). Canonical quantization of interacting fields (Feynman rules). Application of the formalism of interacting quantum fields to lowest-order quantum electrodynamic processes. Radiative corrections and renormalization.

Prerequisite(s): PHYS*7010

Department(s): Department of Physics

Location(s): Guelph

PHYS*7040 Statistical Physics I Unspecified [0.50]

Statistical basis of thermodynamics; microcanonical, canonical and grand canonical ensembles; quantum statistical mechanics, theory of the density matrix; fluctuations, noise, irreversible thermodynamics; transport theory; application to gases, liquids, solids.

Offering(s): Annually

Department(s): Department of Physics

Location(s): Guelph

PHYS*7050 Statistical Physics II Unspecified [0.50]

Phase transitions. Fluctuation phenomena. Kubo's theory of time correlation functions for transport and spectral properties; applications selected from a variety of topics including linearized hydrodynamics of normal and superfluids, molecular liquids, liquid crystals, surface phenomena, theory of the dielectric constant, etc.

Prerequisite(s): PHYS*7040

Department(s): Department of Physics

Location(s): Guelph

PHYS*7060 Electromagnetic Theory Unspecified [0.50]

Solutions to Maxwell's equations; radiation theory, normal modes; multipole expansion; Kirchhoff's diffraction theory; radiating point charge; optical theorem. Special relativity; transformation laws for the electromagnetic field; line broadening. Dispersion; Kramers-Kronig relations. Magnetohydrodynamics and plasmas.

Offering(s): Annually

Department(s): Department of Physics

Location(s): Guelph

PHYS*7080 Applications of Group Theory Unspecified [0.50]

Introduction to group theory; symmetry, the group concept, representation theory, character theory. Applications to molecular vibrations, the solid state, quantum mechanics and crystal field theory.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7090 Green's Function Method Unspecified [0.50]

Review of essential quantum field theory. Zero and finite temperature. Green's functions. Applications.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7100 Atomic Physics Unspecified [0.50]

Emphasis on atomic structure and spectroscopy. Review of angular momentum, rotations, Wigner-Eckart theorem, n-j symbols. Energy levels in complex atoms, Hartree-Fock theory, radiative-transitions and inner-shell processes. Further topics selected with class interest in mind, at least one of which is to be taken from current literature.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7120 Special Topics in Theoretical Physics Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7130 Molecular Physics Unspecified [0.50]

Angular momentum and the rotation of molecules; introduction to group theory with application to molecular vibrations; principles of molecular spectroscopy; spectra of isolated molecules; intermolecular interactions and their effects on molecular spectra; selected additional topics (e.g., electronic structure of molecules, experimental spectroscopic techniques, neutron scattering, correlation functions, collision induced absorption, extension of group theory to molecular crystals, normal coordinate analysis, etc.).

Department(s): Department of Physics

Location(s): Guelph

PHYS*7140 Nonlinear Optics Unspecified [0.50]

Classical and Quantum Mechanical descriptions of nonlinear susceptibility, nonlinear wave propagation, nonlinear effects such as Pockel's and Kerr effects, harmonic generation, phase conjugation and stimulated scattering processes.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7150 Nuclear Physics Unspecified [0.50]

Static properties of nuclei; alpha, beta, gamma decay; two-body systems; nuclear forces; nuclear reactions; single-particle models for spherical and deformed nuclei; shell, collective, interacting boson models.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7160 Special Topics in Subatomic and Nuclear Physics Unspecified [0.50]

Restriction(s): Instructor consent required.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7170 Intermediate and High Energy Physics Unspecified [0.50]

Strong, electromagnetic and weak interactions. Isospin, strangeness, conservation laws and symmetry principles. Leptons, hadrons, quarks and their classification, formation, interactions and decay.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7180 Special Topics in Subatomic and Nuclear Physics Unspecified [0.25]

Restriction(s): Instructor consent required.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7310 Solid State Physics I Unspecified [0.50]

Phonons, electron states, electron-electron interaction, electron-ion interaction, static properties of solids.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7320 Solid State Physics II Unspecified [0.50]

Transport properties; optical properties; magnetism; superconductivity; disordered systems.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7330 Special Topics in Theoretical Condensed Matter Physics Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7370 Special Topics in Surface Physics Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7380 Special Topics in Condensed Matter and Materials Physics Unspecified [0.25]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7450 Special Topics in Experimental Physics Unspecified [0.50]

A modular course in which each module deals with an established technique of experimental physics. Four modules will be offered during the Winter and Spring semesters, but registration and credit will be in the spring semester. Typical topics are neutron diffraction, light scattering, acoustics, molecular beams, NMR, surface analysis, etc.

Offering(s): Annually

Department(s): Department of Physics

Location(s): Guelph

PHYS*7470 Optical Electronics Unspecified [0.50]

Optoelectronic component fabrication, light propagation in linear and nonlinear media, optical fiber properties, electro-optic and acousto-optic modulation, spontaneous and stimulated emission, semiconductor lasers and detectors, noise effects in fiber systems.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7510 Clinical Applications of Physics in Medicine Unspecified [0.50]

This course provides an overview of the application of physics to medicine. The physical concepts underlying the diagnosis and treatment of disease will be explored. Topics will include general imaging principles such as resolution, intensity, and contrast; x-ray imaging and computed tomography; radioisotopes and nuclear medicine, SPECT and PET; magnetic resonance imaging; ultrasound imaging and radiation therapy. Offered in conjunction with PHYS*4070. Extra work is required of graduate students.

Restriction(s): Credit may be obtained for only one of PHYS*4070 or PHYS*7510.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7520 Molecular Biophysics Unspecified [0.50]

Physical methods of determining macromolecular structure: energetics, intramolecular and intermolecular forces, with application to lamellar structures, information storage, DNA and RNA, recognition and rejection of foreign molecules. Offered in conjunction with PHYS*4540. Extra work is required of graduate students.

Restriction(s): Credit may be obtained for only one of PHYS*4540 or PHYS*7520

Department(s): Department of Physics

Location(s): Guelph

PHYS*7540 Special Topics in Biophysics Unspecified [0.50]

Offered on demand

Department(s): Department of Physics

Location(s): Guelph

PHYS*7570 Special Topics in Biophysics Unspecified [0.25]

Offered on demand

Department(s): Department of Physics

Location(s): Guelph

PHYS*7670 Introduction to Quantum Information Processing Fall Only [0.50]

Quantum superposition, interference, and entanglement. Postulates of Quantum Mechanics. Quantum computational complexity. Quantum Algorithms. Quantum communication and cryptography. Quantum error correction. Implementations.

Department(s): Department of Physics

Location(s): Guelph, Waterloo Campus

PHYS*7680 Special Topics in Quantum Information Processing Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph, Waterloo Campus

PHYS*7690 Special Topics in Quantum Information Processing Unspecified [0.25]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7710 Special Lecture and Reading Course Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7730 Special Topics in Physics Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7750 Interinstitution Exchange Unspecified [0.50]

At the GWPI director's discretion, a PhD or MSc student may receive credit for a term of specialized studies at another institution. Formal evaluation is required.

Restriction(s): Instructor consent required.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7760 Special Topics in Physics Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7770 Special Topics in Physics Unspecified [0.25]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7810 Fundamentals of Astrophysics Unspecified [0.50]

The fundamental astronomical data: techniques to obtain it and the shortcomings present. The classification systems. Wide- and narrow-band photometric systems. The intrinsic properties of stars: colours, luminosities, masses, radii, temperatures. Variable stars. Distance indicators. Interstellar reddening. Related topics.

Department(s): Department of Physics

Location(s): Guelph, Waterloo Campus

PHYS*7840 Advanced General Relativity Winter Only [0.50]

Review of elementary general relativity. Timelike and null geodesic congruences. Hypersurfaces and junction conditions. Lagrangian and Hamiltonian formulations of general relativity. Mass and angular momentum of a gravitating body. The laws of black-hole mechanics.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7850 Quantum Field Theory for Cosmology Unspecified [0.50]

Introduction to scalar field theory and its canonical quantization in flat and curved spacetimes. The flat space effects of Casimir and Unruh. Quantum fluctuations of scalar fields and of the metric on curved spacetimes and application to inflationary cosmology. Hawking radiation.

Prerequisite(s): PHYS*7010

Department(s): Department of Physics

Location(s): Guelph, Waterloo Campus

PHYS*7860 General Relativity for Cosmology Unspecified [0.50]

Introduction to the differential geometry of Lorentzian manifolds. The principles of general relativity. Causal structure and cosmological singularities. Cosmological space-times with Killing vector fields. Friedmann-Lemaître cosmologies, scalar vector and tensor perturbations in the linear and nonlinear regimes. De Sitter space-times and inflationary models.

Department(s): Department of Physics

Location(s): Guelph, Waterloo Campus

PHYS*7870 Cosmology Unspecified [0.50]

Friedmann-Robertson-Walker metric and dynamics; big bang thermodynamics; nucleosynthesis; recombination; perturbation theory and structure formation; anisotropies in the Cosmic Microwave Background; statistics of cosmological density and velocity fields; galaxy formation; inflation.

Department(s): Department of Physics

Location(s): Guelph

PHYS*7880 Special Topics in Astrophysics Unspecified [0.50]

Offered on demand

Department(s): Department of Physics

Location(s): Guelph

PHYS*7890 Special Topics in Astrophysics Unspecified [0.25]

Offered on demand

Department(s): Department of Physics

Location(s): Guelph

PHYS*7900 Special Topics in Gravitation and Cosmology Unspecified [0.50]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7910 Special Topics in Gravitation and Cosmology Unspecified [0.25]

Department(s): Department of Physics

Location(s): Guelph

PHYS*7970 MSc Project Unspecified [1.00]

Study of a selected topic in physics presented in the form of a written report. For students whose MSc program consists entirely of courses.

Department(s): Department of Physics

Location(s): Guelph