2013-2014 Graduate Calendar

The information published in this Graduate Calendar outlines the rules, regulations, curricula, programs and fees for the 2013-2014 academic years, including the Summer Semester 2013, Fall Semester 2013 and the Winter Semester 2014.

For your convenience the Graduate Calendar is available in PDF format.

If you wish to link to the Graduate Calendar please refer to the Linking Guidelines.

The University is a full member of:

- The Association of Universities and Colleges of Canada

Contact Information:

University of Guelph
Guelph, Ontario, Canada
N1G 2W1

519-824-4120

Revision Information:

Date	Description
May 6, 2013	Initial Publication
August 19, 2013	Revision
September 20, 2013	Revision
November 1, 2013	Revision
December 1, 2013	Revision
March 7, 2014	Revision
May 13, 2014	Updates for AODA Compliance

Disclaimer

The Office of Graduate Studies has attempted to ensure the accuracy of this on-line Graduate Calendar. However, the publication of information in this document does not bind the university to the provision of courses, programs, schedules of studies, fees, or facilities as listed herein.

Limitations

The University of Guelph reserves the right to change without notice any information contained in this calendar, including any rule or regulation pertaining to the standards for admission to, the requirements for the continuation of study in, and the requirements for the granting of degrees or diplomas in any or all of its programs.

The university will not be liable for any interruption in, or cancellation of, any academic activities as set forth in this calendar and related information where such interruption is caused by fire, strike, lock-out, inability to procure materials or trades, restrictive laws or governmental regulations, actions taken by the faculty, staff or students of the university or by others, civil unrest or disobedience, Public Health Emergencies, or any other cause of any kind beyond the reasonable control of the university.

The University of Guelph reaffirms section 1 of the Ontario Human Rights Code, 1981, which prohibits discrimination on the grounds of race, ancestry, place of origin, colour, ethnic origin, citizenship, creed, sex, sexual orientation, handicap, age, marital status or family status.

The university encourages applications from women, aboriginal peoples, visible minorities, persons with disabilities, and members of other under-represented groups.

Introduction

Collection, Use and Disclosure of Personal Information

Personal information is collected under the authority of the University of Guelph Act (1964), and in accordance with Ontario's Freedom of Information and Protection of Privacy Act (FIPPA) http://www.e-laws.gov.on.ca/DBLaws/Statutes/English/90f31_e.htm. This information is used by University officials in order to carry out their authorized academic and administrative responsibilities and also to establish a relationship for alumni and development purposes. Certain personal information is disclosed to external agencies, including the Ontario Universities Application Centre, the Ministry of Training, Colleges and Universities, and Statistics Canada, for statistical and planning purposes, and is disclosed to other individuals or organizations in accordance with the Office of Registrarial Services Departmental Policy on the Release of Student Information. For details on the use and disclosure of this information call the Office of Registrarial Services at the University at (519) 824-4120 or see http://www.uoguelph.ca/registrar/registrar/index.cfm?index.

Statistics Canada - Notification of Disclosure

For further information, please see Statistics Canada's web site at http://www.statcan.gc.ca and Section XIV Statistics Canada.

Address for University Communication

Depending on the nature and timing of the communication, the University may use one of these addresses to communicate with students. Students are, therefore, responsible for checking all of the following on a regular basis:

Email Address

The University issued email address is considered an official means of communication with the student and will be used for correspondence from the University. Students are responsible for monitoring their University-issued email account regularly.

Home Address

Students are responsible for maintaining a current mailing address with the University. Address changes can be made, in writing, through the Office of Graduate Studies.

Name Changes

The University of Guelph is committed to the integrity of its student records, therefore, each student is required to provide either on application for admission or on personal data forms required for registration, his/her complete, legal name. Any requests to change a name, by means of alteration, deletion, substitution or addition, must be accompanied by appropriate supporting documentation.

Student Confidentiality and Release of Student Information Policy Excerpt

The University undertakes to protect the privacy of each student and the confidentiality of his or her record. To this end the University shall refuse to disclose personal information to any person other than the individual to whom the information relates where disclosure would constitute an unjustified invasion of the personal privacy of that person or of any other individual. All members of the University community must respect the confidential nature of the student information which they acquire in the course of their work.

Complete policy at http://www.uoguelph.ca/policies.

Table of Contents

Physics

The Departments of Physics at the Universities of Guelph and Waterloo offer a joint program leading to MSc and PhD degrees. The Guelph-Waterloo Physics Institute consists of members from both university departments and is administered by a joint co-ordinating committee. Students interested in graduate work in physics at either university should consult the application requirements and the on-line application procedures available from the web-site http://gwp.on.ca. Students are ultimately registered at the university at which 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.

Administrative Staff

Graduate teaching and research in physics at the University of Guelph are operated through the Guelph-Waterloo Physics Institute.

Director of the Institute
Brian McNamara (Waterloo - (519) 888-4567, Ext. 38170)
mcnamara@uwaterloo.ca

Associate Director of the Institute
Paul Garrett (Guelph, 220 MacNaughton, Ext. 52192)
pgarrett@physics.uoguelph.ca

Assistant to the Director
Linda Stadig (Waterloo (519) 888-4567, Ext. 37598, Ext. Guelph (519) 824-4120 Ext. 52263)
gwp@sciborg.uwaterloo.ca

Interim Chair
Leonid Brown (211 MacNaughton, Ext. 53991)
lebrown@physics.uoguelph.ca

Graduate Coordinator
Paul Garrett (220 MacNaughton, Ext. 52192)
pgarrett@physics.uoguelph.ca

Graduate Secretary
Reggi Vallillee (209 MacNaughton, Ext. 52262)
rv@physics.uoguelph.ca

Graduate Faculty

Leonid S. Brown
MSc, PhD Moscow State - Professor

James H. Davis
BS, BA Moorehead State College, PhD Manitoba - Professor

John R. Dutcher
BSc Dalhousie, MSc British Columbia, PhD Simon Fraser - Professor

Paul E. Garrett
BSc Queen's, MSc, PhD McMaster - Professor, Graduate Coordinator, and Associate Director GWPI

Ralf Gellert
Dipl Phys, PhD Darmstadt - Associate Professor

De-Tong Jiang
BSc Jilin, PhD Simon Fraser - Associate Professor

Stefan W. Kycia
BSc McGill; MS Pennsylvania; PhD Iowa - Associate Professor

Vladimir Ladizhansky
BS Moscow Institute of Physics and Technology; MS, PhD Weizmann Institute of Science (Rehovot, Israel) - Associate Professor

Elisabeth J. Nicol
BSc Mount Allison, MSc, PhD McMaster - Professor

Joanne M. O'Meara
BSc, PhD McMaster - Associate Professor

Eric Poisson
BSc Laval, MSc, PhD Alberta - Professor and Chair

Xiao-Rong Qin
BSc, MSc Tsinghua (Beijing), PhD Simon Fraser - Associate Professor

Carl E. Svensson
BSc, PhD McMaster - Professor

Robert Wickham
BSc Toronto, PhD Chicago - Associate Professor

Martin Williams
PhD Imperial College, London - Assistant Professor and Undergraduate Coordinator

Graduate Faculty from the University of Waterloo

Niayesh Afshordi
BA Iran, BSc Providence, PhD Princeton - Assistant Professor

Michael Balogh
BSc McMaster, PhD Victoria - Associate Professor

Jonathan Baugh
BS Tennesee, PhD North Carolina - Assistant Professor

Peter F. Bernath
BSc Waterloo, PhD M.I.T. - Professor

Kostadinka Bizheva
BS, MS Plovdiv, MS, PhD Tufts - Associate Professor

Avery Broderick
BS Stoney Brook, PhD CalTech - Assistant Professor

Anton Burkov
BS, MS Plovdiv, MS, PhD Tufts - Assistant Professor

Melanie C. Campbell
BSc Toronto, MSc Waterloo, PhD Australian National, FAAO - Professor

Z.Y. 'Jeff' Chen
BSc Fuden, PhD Maryland - Professor and Chair of the Department of Physics and Astronomy

Andrew M. Childs
BS Cal Tech, PhD MIT - Assistant Professor

David Cory
BA, PhD Case Western Reserve - Professor

Walter W. Duley
BEng McGill, DIC, PhD Imperial College, DSc London - Professor

Joseph Emerson
MSc, PhD British Columbia - Assistant Professor

Michael Fich
BSc Waterloo, MSc, PhD California - Professor

James Forrest
BSc Simon Fraser, MSc, PhD Guelph - Professor and Associate Dean of Research, Faculty of Science

Michel Gingras
BSc, MSc Laval, PhD British Columbia - Professor

Bae-Yeun Ha
BSc, MS Korea, PhD Maryland - Associate Professor

Gretchen L. Harris
BA Mount Holyoke College, MA Wesleyan, PhD Toronto - Associate Professor

David G. Hawthorn
BSc McMaster, PhD Toronto - Assistant Professor

Thorsten Hesjedal
BSc Universitat Stuttgart, MSc Eberhard-Karls-Universitaet Tuebingen, PhD Humboldt Universitaet - Associate Professor

Robert Hill
BSc, PhD Bristol - Associate Professor

Michael Hudson
BSc Montreal, PhD Cambridge - Associate Professor and Associate Dean of Science (Computing), Faculty of Science

Stefan H.J. Idziak
BSc McGill, PhD Pennsylvania - Associate Professor

Thomas Jennewein
MSc Innsbruck, PhD Vienna - Associate Professor

Lyndon Jones
BSc Cardiff, PhD Birmingham - Associate Professor

Achim Kempf
BSc Heidelberg, PhD Munich - Associate Professor

Holger Kleinke
BSc, MSc Münster, PhD Mainz - Professor

Jan Kycia
BSc McGill, MSc Pennsylvania, PhD Northwestern - Associate Professor

Raymond Laflamme
BSc Laval, PhD Cambridge - Professor

Yuri Leonenko
MSc Novosibirsk, PhD Russia - Assistant Professor

Zoya Leonenko
MSc, PhD Novosibirsk - Associate Professor

Tong K. Leung
BSc, PhD British Columbia - Associate Professor

Wing-Ki Liu
BSc, MSc, PhD Illinois - Professor

Qing-Bin Lu
BSc, MSc Fuzhou, China, PhD Newcastle - Associate Professor

Adrian Lupascu
BSc, MSc Bucharest (Romania), PhD Netherlands - Assistant Professor

Norbert L Lütkenhaus
MSc München, PhD Scotland, Habilitation Germany - Associate Professor

Brian McNamara
BS Villanova, MA, PhD Virginia - Professor and Director of the Institute

Robert B. Mann
BSc McMaster, MSc, PhD Toronto - Professor

James Martin
BSc, MSc, PhD Waterloo - Associate Professor

Brian McNamara
BS Villanova, MA, PhD Virginia - Professor, GWPI Director

Roger Melko
BSc, MSc Waterloo, MA, PhD UC Santa Barbara - Assistant Professor

Michele Mosca
BMath Waterloo, MSc, DPhil Oxford - Professor

Linda F. Nazar
BSc British Columbia, PhD Toronto - Professor

Hartwig Peemoeller
BSc Winnipeg, MSc Victoria, PhD Waterloo - Professor

Marco Piani
MSc, PhD Trieste Italy - Assistant Professor

Kevin Resch
BSc Queen's, MSc, PhD Toronto - Assistant Professor

Joseph Sanderson
BSc, PhD London - Associate Professor

Guenter A. Scholz
BSc Simon Fraser, MSc McMaster, PhD Simon Fraser - Associate Professor

Donna Strickland
BEng McMaster, PhD Rochester - Associate Professor and Associate Chair

James Taylor
BSc, MSc Toronto, PhD Victoria - Assistant Professor

Russell Thompson
BSc Ottawa, MSc Regina, PhD Western Ontario - Assistant Professor

Paul S. Wesson
BSc London, PhD Cambridge, FRAS London - Professor

Frank Wilhelm-Mauch
BSc Vordiplom, MSc (Dipl.-Phys.), PhD Karlsruhe (Germany) - Professor

David Yevick
AB Harvard, MA, PhD Princeton, Docuent Lund - Professor

MSc Program

The MSc programs provide for emphasis on astrophysics and gravitation, atomic, molecular and optical physics, biophysics, chemical physics, condensed matter and material physics, industrial and applied physics, subatomic physics, and quantum computing.

Three options are available for the MSc degree:

- A research-based option in which the student is required to complete four one-semester courses (at least 2.0 course credits) and a thesis.
- A course-work option in which the student is required to complete eight one-semester courses (at least 4.0 course credits), one of which must be a research project course that includes a report.
- A co-operative option in which the student spends two semesters working in a government or industrial laboratory. The student is required to complete four one-semester courses (at least 2.0 course credits) and a thesis.

Admission Requirements

Application for admission should be made as early as possible using on-line application methods described on the web-site http://gwp.on.ca/application/index.html. 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 http://gwp.on.ca/).

MSc Co-operative Option

In addition to the admission requirements described above, admission to the co-op option is restricted to Canadian citizens and permanent residents.

Degree Requirements

Research-Based MSc Option

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 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 Quantum Mechanics 1 (PHYS*7010), Introduction to Quantum Field Theory (PHYS*7030), Statistical Physics 1 (PHYS*7040), Electromagnetic Theory (PHYS*7060), and Fundamentals of Astrophysics (PHYS*7810). 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 co-ordinating 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, he/she may be required to withdraw from the program.

MSc Co-operative Option

Students enter the co-op MSc program in September. The first term of the program is spent taking two courses (for all except those in biophysics **, one of these courses must be chosen from PHYS*7010, PHYS*7030, PHYS*7040, PHYS*7060, PHYS*7670, and PHYS*7810) and performing the duties of a regular teaching assistant. During this term, the student will discuss work-term prospects with the Guelph and Waterloo personnel responsible for co-op activities and conduct interviews with potential employers. Satisfactory performance in this phase of the program allows the student to spend the next two terms working in an industrial or government laboratory. Upon completion of the work terms, the student must submit a work report as discussed below.

The student must complete a minimum of two additional graduate courses and complete a research project under the supervision of a faculty member in accordance with the regular thesis requirements of the MSc degree program, as outlined by the Faculty of Graduate Studies.

**Exception: In place of the core physics course biophysics students may choose any course approved by the student's advisory committee and the graduate coordinator.

Course-Based MSc Option

Eight one-term courses (0.50 unit weight) acceptable for graduate credit, including 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. [Exception: biophysics students taking the course-based MSc option are required to take only one of the core courses PHYS*7010, PHYS*7030, PHYS*7040, PHYS*7060, PHYS*7670, and PHYS*7810]. Two of the courses may be undergraduate courses approved by the advisor and the Graduate Advisory Committee. If they are Physics courses, they 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

Two options are available for the PhD degree:

- A research-based option in which the student is required to complete four one-semester courses (2.0 credits) and a thesis.
- A co-operative option in which the student spends two semesters working in a government or industrial laboratory. The student is required to complete four one-semester courses (2.0 credits) and a thesis.

Admission Requirements

A 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 http://gwp.on.ca/).

PhD Co-operative Option

In addition to the admission requirements described above, admission to the co-op option is restricted to Canadian citizens or permanent residents.

Degree Requirements

Four one-term courses not including any already taken for MSc credit are required; courses taken during the MSc program and in excess of those required will, however, be allowed for PhD credit. The extra courses must be identified prior to admission. The core courses for the program are Quantum Mechanics 1 (PHYS*7010), Introduction to Quantum Field Theory (PHYS*7030), Statistical Physics 1 (PHYS*7040), Electromagnetic Theory (PHYS*7060), Introduction to Quantum Information Processing (PHYS*7670), and Fundamentals of Astrophysics (PHYS*7810). By the end of the first year of the program, three of the core courses, including one of Quantum Mechanics 1 (PHYS*7010), Statistical Physics 1 (PHYS*7040) and Electromagnetic Theory (PHYS*7060) or their equivalent should be completed. (Exception: Biophysics students must have taken at least one of Quantum Mechanics 1 (PHYS*7010), Statistical Physics 1 (PHYS*7040), and Electromagnetic Theory (PHYS*7060) by the completion of the first year of the PhD program.) 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 coordinator. No undergraduate course in physics may be taken for credit.

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, he/she may be required to withdraw from the program.

PhD candidates are required to pass a Qualifying Examination normally during the first year of the program; in any case, it must be passed no later than the fifth semester in which he/she is enrolled. This is an oral examination of approximately two hours' duration before a committee that includes representation from the student's advisory committee. It is designed to test the student's knowledge of the fundamentals and applications of physics closely related to the thesis topic. An assessment of the student's ability in research will be a factor in determining the examination result. If a student has not passed the Qualifying Examination by the end of the fifth semester in which they are enrolled, he/she may be required to withdraw from the program.

PhD students must meet their advisory committee members at least once a year to present a written and oral report on their progress. Candidates must present a thesis embodying the results of original research conducted by them on an advanced topic. The thesis is defended before a committee which may also examine the student's knowledge of related material.

PhD Co-operative Option

Students normally enter the co-op PhD program in September, following completion of their MSc degree. The student first spends one or two academic terms on campus, taking a minimum of two courses per term and performing the regular duties of a teaching assistant. During this time, the student will discuss work term prospects with the Guelph and Waterloo personnel responsible for co-op activities and conduct interviews with potential employers. After satisfactory performance in the academic term(s), the student spends a full year in an industrial or government laboratory.

Students must complete all three of the core courses including one of PHYS*7010, PHYS*7040 and PHYS*7060 by the end of their first two academic terms in the program. (Exception: Biophysics students must take at least one of the three core courses.) A total of four graduate courses (2.0 credits) are required (excluding those already taken for MSc credit).

The student is required to pass a Qualifying Examination and complete, under the supervision of a faculty member, a research project on an advanced topic. A thesis embodying the results of original research conducted by the student must be presented and defended before a committee.

Interdepartmental Programs

Biophysics Interdepartmental Group

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

Courses

* Courses offered annually. Other courses are offered on an alternate year basis and as requested.

Perimeter Scholars' Institute Courses

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

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

PHYS*6020 PSI Statistical Physics U [0.50]

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

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

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

PHYS*6040 PSI Relativity U [0.50]

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

PHYS*6050 PSI Quantum Theory U [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.

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

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

PHYS*6070 PSI Dynamical Systems U [0.50]

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

PHYS*6080 PSI Computation U [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 programing.

PHYS*6210 PSI Cosmology U [0.25]

FRW metic, 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 anisopropies, inlation and observational tests.

PHYS*6220 PSI Standard Model U [0.25]

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

PHYS*6230 PSI String Theory U [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.

PHYS*6240 PSI Mathematical Physics Topics U [0.25]

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

PHYS*6350 PSI Quantum Information Review U [0.25]

Review of selected topics in Quantum Information.

PHYS*6360 PSI Gravitational Physics Review U [0.25]

Review of selected topics in Gravitational Physics.

PHYS*6370 PSI Condensed Matter Theory U [0.25]

Review of selected topics in Condensed Matter Theory.

PHYS*6380 PSI Quantum Gravity U [0.25]

Review of selected topics in Quantum Grativity.

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

Review of selected topics in Foundations of Quantum Theory.

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

Review of selected topics in Quantum Information.

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

Review of selected topics in Gravitational Physics.

PHYS*6430 PSI Exploration in Condensed Matter Theory U [0.25]

Review of selected topics in Condensed Matter Theory.

PHYS*6440 PSI Exploration in Quantum Gravity U [0.25]

Review of selected topics in Quantum Gravity.

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

Review of selected topics in Foundations of Quantum Theory.

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

Review of selected topics in Particle Physics.

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

Review of selected topics in String Theory.

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

Review of selected topics in Complex Systems.

PHYS*6490 PSI Explorations in Cosmology U [0.25]

Review of selected topics in Cosmology.

Basic Group

PHYS*7010 Quantum Mechanics I * U [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.

PHYS*7020 Quantum Mechanics II U [0.50]

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

Prerequisite(s): PHYS*7010 or equivalent

PHYS*7040 Statistical Physics I* U [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.

PHYS*7050 Statistical Physics II U [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 or equivalent.

PHYS*7060 Electromagnetic Theory * U [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.

PHYS*7080 Applications of Group Theory U [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.

PHYS*7670 Introduction to Quantum Information Processing F [0.50]

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

Subatomic and Nuclear

PHYS*7030 Quantum Field Theory U [0.50]

Review of relativistic quantum mechanics and classical field theory. Quantization of free quantum fields (the particle interpretation of field quants). 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 or equivalent.

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

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

PHYS*7150 Nuclear Physics U [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.

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

Restriction(s): Instructor's signature required

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

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

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

Restriction(s): Instructor's signature required

Astronomy and Astrophysics

PHYS*7810 Fundamentals of Astrophysics U [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.

PHYS*7840 Advanced General Relativity W [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.

PHYS*7850 Quantum Field Theory for Cosmology U [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 space-times and application to inflationary cosmology. Hawking radiation.

Prerequisite(s): PHYS*7010

PHYS*7860 General Relativity for Cosmology U [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-Lemaitre cosmologies, scalar vector and tensor perturbations in the linear and nonlinear regimes. De Sitter space-times and inflationary models.

PHYS*7870 Cosmology U [0.50]

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

PHYS*7880 Special Topics in Astronomy U [0.50]

Offered on demand

PHYS*7890 Special Topics in Astrophysics U [0.25]

Offered on demand

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

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

Atomic and Molecular

PHYS*7100 Atomic Physics U [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.

PHYS*7130 Molecular Physics U [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 co-ordinate analysis, etc.).

Condensed Matter

PHYS*7310 Solid State Physics I U [0.50]

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

PHYS*7320 Solid State Physics II U [0.50]

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

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

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

Biophysics

PHYS*7510 Cellular Biophysics U [0.50]

The physics of cellular structure and function; membrane theories, diffusion and active transport, bioelectric phenomena; intracellular motion, thermodynamics; selected topics of current interest and seminar.

PHYS*7520 Molecular Biophysics U [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.

PHYS*7540 Special Topics in Biophysics U [0.50]

Offered on demand

PHYS*7570 Special Topics in Biophysics U [0.25]

Offered on demand

Applied Physics (including Technical Methods)

PHYS*7140 Nonlinear Optics U [0.50]

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

PHYS*7450 Special Topics in Experimental Physics * U [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.

PHYS*7470 Optical Electronics U [0.50]

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

Special Courses (offered on demand only)

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

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

PHYS*7730 Special Topics in Physics U [0.50]

PHYS*7750 Interinstitution Exchange U [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): GWPI director approval required

PHYS*7970 MSc Project U [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