2018-2019 Graduate Calendar

The information published in this Graduate Calendar outlines the rules, regulations, curricula, programs and fees for the 2018-2019 academic year, including the Summer Semester 2018, Fall Semester 2018 and the Winter Semester 2019.

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:

• Universities of Canada

Contact Information:

University of Guelph
Guelph, Ontario, Canada
N1G 2W1
519-824-4120

Revision Information:

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
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<tbody>
<tr>
<td>May 1, 2018</td>
<td>Initial Publication</td>
</tr>
<tr>
<td>August 10, 2018</td>
<td>Revision 1</td>
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</tbody>
</table>
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/DLB_Laws/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 Advanced Education and Skills Development, 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 https://www.uoguelph.ca/registrar/.

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 Registrarial Services.

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 https://www.uoguelph.ca/secretariat/office-services/university-secretariat/university-policies.
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Physcs

The Departments of Physics at the Universities of Guelph and Waterloo offer a joint program leading to 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 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 Graduate Studies in Physics, University of Guelph, University of Waterloo.

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Paul E. Garrett
BSc Queen's, MSc, PhD McMaster - Professor, Chair

Ralf Gellert
Dipl Phys, PhD Darmstadt - Associate Professor

Alexandros Gezerlis
Dipl National Technical University Athens, PhD Urbana-Champaign - Assistant Professor

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

Stefan W. Kyea
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) - Professor and Canada Research Chair in Biophysics Tier II

Michael Massa
BSc Guelph, MSc, PhD McMaster - Assistant Professor

Dennis Mücher
BSc University of Cologne, Germany, Ph.D University of Cologne, Germany - Assistant Professor

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

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

Eric Poiisson
BSc Laval, MSc, PhD Alberta - Professor

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 and Graduate Coordinator, Associate Chair (Graduate), Associate Director Graduate Studies in Physics, University of Guelph, University of Waterloo

Martin Williams
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Huan Yang
BSc California Institute of Technology, PhD California Institute of Technology - Assistant Professor

Associated Graduate Faculty

Liliana Caballero
BSc Universidad Nacional de Colombia, PhD Indiana University - Contractually Limited Faculty, Department of Physics, University of Guelph

Graduate Faculty from the University of Waterloo

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Michal Bajec
BS Harvard, PhD Harvard - Assistant Professor

Michael Balogh
BSc McMaster, PhD Victoria - Professor and Associate Chair of Department of Physics and Astronomy

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BSc, MSc University of Science and Technology China, PhD University of Toronto - Professor

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BS Tennessee, PhD North Carolina - Associate Professor

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BA, PhD Case Western Reserve - Professor

Joseph Emerson
MSc, PhD British Columbia - Associate Professor

Michael Fich
BSc Waterloo, MSc, PhD California - Professor

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

Michel Gingras
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Rae-Yeon Ha
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Robert Hill  
BSc, PhD Bristol - Associate Professor and Associate Dean of Science, Graduate Studies

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BSc Montreal, PhD Cambridge - Professor

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Thomas Jennewein  
MSc Innsbruck, PhD Vienna - Associate Professor

Achim Kempf  
BSc Heidelberg, PhD Munich - Professor and Canada Research Chair in the Physics of Information

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Raymond Laflamme  
BSc Laval, PhD Cambridge - Professor and Canada Research Chair

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Zoya Leonenko  
MSc, PhD Novosibirsk - Professor

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

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

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BSc, MSc Bucharest (Romania), PhD Netherlands - Associate Professor

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

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

Matteo Mariantoni  
MSc Chamiers University of Technology, PhD Technical University of Munich - Assistant Professor

James Martin  
BSc, MSc, PhD Waterloo - Associate Professor

Eduardo Martin-Martinez  
BSc, MSc, PhD Universidad Complutense de Madrid - Assistant Professor

Mark Matsen  
BSc Simon Fraser, MA, PhD Guelph - Professor

Brian McNamara  
BS Villanova, MA, PhD Virginia - Professor and Department Chair

Roger Melko  
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BSc Shandong University, PhD Brown University - Assistant Professor

Zoran Miskovic  
PhD University of Belgrade - Professor

Ruxandra Moraru  
- Associate Professor

Michele Mosca  
BMath Waterloo, MSc, DPhil Oxford - Professor

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Will Percival  
BSc, PhD Oxford - Assistant Professor

Kevin Resch  
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Pierre-Nicholas Roy  
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Zbigniew Wasilewski  
MSc University of Warsaw, PhD Institute of Physics, Polish Academy of Sciences - Professor

Christopher Wilson  
BS MIT, PhD Yale University - Associate Professor

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

MSc Program

The MSc programs 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://uwaterloo.ca/waterloo-guelph-physics-graduate-studies/student-resources/how-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 http://wgp.on.ca/).

Degree 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 Quantum Mechanics 1 (PHYS*7010), Introduction to Quantum Field Theory (PHYS*7030), Statistical Physics (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.
Course Work and Major Research Project (MRP)

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

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

Degree Requirements

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, Electromagnetic Theory PHYS*7060 or their equivalent should be completed. This requirement may be satisfied, in full or in part, by courses taken during the MSc. (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.)

Two-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. 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.

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.

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 Physics 7010, Physics 7040 or Physics 7060 will have been taken by the end of the first year of the PhD program.

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>PHYS*6010 PSI Quantum Field Theory I U</td>
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Canonical quantization of fields, perturbation theory, derivation of Feynman diagrams, applications in particle and condensed matter theory, renormalization in phi^4.

Department(s): Department of Physics

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<th>Course Code</th>
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<tbody>
<tr>
<td>PHYS*6020 PSI Statistical Physics U</td>
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Department(s): Department of Physics

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<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>PHYS*6030 PSI Quantum Field Theory II U</td>
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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

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<th>Course Code</th>
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<tr>
<td>PHYS*6040 PSI Relativity U</td>
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Special relativity, foundations of general relativity, Riemannian geometry, Einstein's equations, FRW and Schwarzschild geometries and their properties.

Department(s): Department of Physics

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<th>Course Code</th>
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<td>PHYS*6050 PSI Quantum Theory U</td>
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Department(s): Department of Physics

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<th>Course Code</th>
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<tr>
<td>PHYS*6060 PSI Information and Data Analysis U</td>
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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

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<th>Course Code</th>
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<tr>
<td>PHYS*6070 PSI Dynamical Systems U</td>
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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

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<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>PHYS*6080 PSI Computation U</td>
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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.

Department(s): Department of Physics

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<th>Course Code</th>
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<tr>
<td>PHYS*6210 PSI Cosmology U</td>
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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

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<th>Course Code</th>
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<tbody>
<tr>
<td>PHYS*6220 PSI Standard Model U</td>
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Application of Yang-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.

Department(s): Department of Physics

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<th>Course Code</th>
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<tbody>
<tr>
<td>PHYS*6230 PSI String Theory U</td>
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</table>

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

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>S/N</th>
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<tbody>
<tr>
<td>PHYS*6240 PSI Mathematical Physics Topics U</td>
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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

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<th>Course Code</th>
<th>Course Title</th>
<th>S/N</th>
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<tbody>
<tr>
<td>PHYS*6350 PSI Quantum Information Review U</td>
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</tbody>
</table>

Review of selected topics in Quantum Information.

Department(s): Department of Physics

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>PHYS*6360 PSI Gravitational Physics Review U</td>
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</table>

Review of selected topics in Gravitational Physics.

Department(s): Department of Physics

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<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>PHYS*6370 PSI Condensed Matter Theory U</td>
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</table>

Review of selected topics in Condensed Matter Theory.

Department(s): Department of Physics
<table>
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<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Department(s)</th>
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<tbody>
<tr>
<td>PHYS*6380</td>
<td>PSI Quantum Gravity U</td>
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<td>Department of Physics</td>
</tr>
<tr>
<td>PHYS*6390</td>
<td>PSI Foundations of Quantum Theory U</td>
<td>0.25</td>
<td>Department of Physics</td>
</tr>
<tr>
<td>PHYS*6410</td>
<td>PSI Explorations in Quantum Information U</td>
<td>0.25</td>
<td>Department of Physics</td>
</tr>
<tr>
<td>PHYS*6420</td>
<td>PSI Explorations in Gravitational Physics U</td>
<td>0.25</td>
<td>Department of Physics</td>
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<td>PHYS*6430</td>
<td>PSI Exploration in Condensed Matter Theory U</td>
<td>0.25</td>
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<td>PHYS*6440</td>
<td>PSI Exploration in Quantum Gravity U</td>
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<td>PHYS*6450</td>
<td>PSI Explorations in Foundations of Quantum Theory U</td>
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<td>PHYS*6460</td>
<td>PSI Explorations in Particle Physics U</td>
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<td>PHYS*6470</td>
<td>PSI Explorations in String Theory U</td>
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<td>PHYS*6480</td>
<td>PSI Explorations in Complex Systems U</td>
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<td>PHYS*6490</td>
<td>PSI Explorations in Cosmology U</td>
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<td>PHYS*7010</td>
<td>Quantum Mechanics I U</td>
<td>0.50</td>
<td>Department of Physics</td>
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<td>PHYS*7080</td>
<td>Applications of Group Theory U</td>
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<td>PHYS*7670</td>
<td>Introduction to Quantum Information Processing F</td>
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<td>PHYS*7030</td>
<td>Quantum Field Theory U</td>
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<td>PHYS*7090</td>
<td>Green’s Function Method U</td>
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<td>PHYS*7180</td>
<td>Special Topics in Subatomic and Nuclear Physics U</td>
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<td>PHYS*7170</td>
<td>Nuclear Physics U</td>
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<td>PHYS*7160</td>
<td>Intermediate and High Energy Physics U</td>
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<td>PHYS*7150</td>
<td>Special Topics in Subatomic and Nuclear Physics U</td>
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<td>PHYS*7090</td>
<td>Green’s Function Method U</td>
<td>0.50</td>
<td>Department of Physics</td>
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<tr>
<td>PHYS*7180</td>
<td>Special Topics in Subatomic and Nuclear Physics U</td>
<td>0.25</td>
<td>Department of Physics</td>
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<tr>
<td>PHYS*7010</td>
<td>Quantum Mechanics I U</td>
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<td>PHYS*7070</td>
<td>Quantum Mechanics II U</td>
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<td>PHYS*7040</td>
<td>Statistical Physics I U</td>
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<td>PHYS*7050</td>
<td>Statistical Physics II U</td>
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<td>PHYS*7060</td>
<td>Electromagnetic Theory U</td>
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<td>Fundamentals of Astrophysics U</td>
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<td>PHYS*7840</td>
<td>Advanced General Relativity W</td>
<td>0.50</td>
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<td>PHYS*7850</td>
<td>Quantum Field Theory for Cosmology U</td>
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<tr>
<td>PHYS*7860</td>
<td>General Relativity for Cosmology U</td>
<td>0.50</td>
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<td>PHYS*7870 Cosmology U [0.50]</td>
<td>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.</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7880 Special Topics in Astronomy U [0.50]</td>
<td>Offered on demand</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7890 Special Topics in Astrophysics U [0.25]</td>
<td>Offered on demand</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7900 Special Topics in Gravitation and Cosmology U [0.50]</td>
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<td>Department(s): Department of Physics</td>
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<td>PHYS*7910 Special Topics in Gravitation and Cosmology U [0.25]</td>
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<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7100 Atomic Physics U [0.50]</td>
<td>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.</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7130 Molecular Physics U [0.50]</td>
<td>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.).</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7310 Solid State Physics I U [0.50]</td>
<td>Phonons, electron states, electron-electron interaction, electron-ion interaction, static properties of solids.</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7320 Solid State Physics II U [0.50]</td>
<td>Transport properties; optical properties; magnetism; superconductivity; disordered systems.</td>
<td>Department(s): Department of Physics</td>
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<td>PHYS*7330 Special Topics in Theoretical Condensed Matter Physics U [0.50]</td>
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<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7370 Special Topics in Surface Physics U [0.50]</td>
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<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7510 Clinical Applications of Physics in Medicine U [0.50]</td>
<td>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. Credit may be obtained for only one of PHYS<em>4070 or PHYS</em>7510.</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7520 Molecular Biophysics U [0.50]</td>
<td>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.</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7540 Special Topics in Biophysics U [0.50]</td>
<td>Offered on demand</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7570 Special Topics in Biophysics U [0.25]</td>
<td>Offered on demand</td>
<td>Department(s): Department of Physics</td>
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<td>PHYS*7710 Special Topics in Theoretical Physics U [0.50]</td>
<td>Offered on demand</td>
<td>Department(s): Department of Physics</td>
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<td>PHYS*7730 Special Topics in Physics U [0.50]</td>
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<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7750 Interinstitution Exchange U [0.50]</td>
<td>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.</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7880 Special Topics in Experimental Physics U [0.50]</td>
<td>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.</td>
<td>Department(s): Department of Physics</td>
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<td>PHYS*7890 Special Topics in Experimental Physics * U [0.50]</td>
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<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7900 Special Topics in Experimental Physics * U [0.50]</td>
<td>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, nose effects in fiber systems.</td>
<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7910 Special Topics in Biophysics U [0.25]</td>
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<td>Department(s): Department of Physics</td>
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<td>PHYS*7920 Special Topics in Biophysics U [0.25]</td>
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<td>Department(s): Department of Physics</td>
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<td>PHYS*7930 Special Topics in Biophysics U [0.25]</td>
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<td>Department(s): Department of Physics</td>
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<td>PHYS*7940 Special Topics in Biophysics U [0.25]</td>
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<td>PHYS*7950 Special Topics in Biophysics U [0.25]</td>
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<td>Department(s): Department of Physics</td>
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<td>PHYS*7960 Special Topics in Biophysics U [0.25]</td>
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<td>Department(s): Department of Physics</td>
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<tr>
<td>PHYS*7970 MSc Project U [1.00]</td>
<td>Study of a selected topic in physics presented in the form of a written report. For students whose MSc program consists entirely of courses</td>
<td>Department(s): Department of Physics</td>
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