importance of critical reflective practice for transformative education. Individual class projects are carried out, such that students in the M.Ed. Program will adopt an inquiry stance towards their practice, while students in the M.A. Program will deepen their understanding of the foundations of Educational Research.

GSE 518 Seminar in Research Methods 3-3-0
This compulsory course in research in education for M.A. students is designed to help participants to evaluate and conduct research in education. The course includes topics such as the selection of a research topic and generation of research question(s); collection, analysis and interpretation of qualitative and quantitative date; presentation and evaluation of research; and a range of research designs.
Prerequisite: GSE 516

GSE 520 Selected Topics in Special and Inclusive Education 3-3-0
This course has been designed to provide the student with the opportunity to examine recent developments in special education.

GSE 521 The Exceptional Learner 3-3-0
This course in special education will examine the characteristics of learners with diverse special needs, including the psychological, medical and sociological aspects of the various exceptionalities and the various ways in which they are educated. The content of this course will be of relevance to administrators and regular classroom teachers as well as to special General educators. Participants in this course will critically examine the many approaches to facilitating learning for individuals with learning disabilities and other exceptionalities.

GSE 522 Special Topics in the Psychology of Learning 3-3-0
This course provides students an opportunity to further explore topics related to the psychology of learning.
Prerequisite or Co-requisite: GSE 501

GSE 523 Educational Neuroscience: Mind, Brain, and Teaching 3-3-0
This course will provide students with an introduction to educational neuroscience framed from an interdisciplinary perspective. This course will review recent research from neuroscience, psychology, and education and will provide a balanced perspective about the potential and limits of linking these disciplines. Students will acquire the skills and concepts needed to interpret basic neuroscience research in the context of a meaningful interdisciplinary question. The course will also investigate the different histories, philosophies, and epistemological lenses through which common problems in neuroscience, psychology, and education are approached. Topics such as bilingualism, reading and language, numeracy and arithmetic, cognitive control, emotion, and creativity will be addressed.

GSE 524 Behavioral Disorders 3-3-0
This course will examine multiple types of emotional problems and behavioral disorders challenging students in today's classrooms. Theories and principles explaining these difficulties as well as how to analyze patterns and see how problems develop will be explored. Students will critically explore methods for dealing with problem behaviors in the classroom.

GSE 530 Selected Topics in Media Literacy 3-3-0
This course has been designed to provide the student with the opportunity to examine recent developments in media literacy. It will foster an expanded understanding of media and media technology, including the impact on our society and the shaping of individual and collective values and beliefs.

GSE 534 Selected Topics in Educational Theory 3-3-0
This course is designed to provide the student with opportunities to explore various theories of education. Specific topics will be chosen for each course by the professor.

GSE 535 Policy Analysis for Educators 3-3-0
This course will offer educators the opportunity to analyze public policy and the various settings typically associated with education policy making. Readings will introduce students to education policy debates, including the theoretical and ethical, as well as the political and economic, challenges facing policy makers and those impacted by education policy. Students will be guided through critical analyses of education policy, with a particular emphasis on the policies and related laws guiding the Quebec school system. Students will be given opportunities to consider the ways in which practitioners engage with policy, and how they can play a role in the making and reform of that policy.

GSE 540 Sociological Perspectives in Schooling 3-3-0
This course examines the role of schooling in society based in a comprehensive review of research in the sociology of education. Student will develop a comparative framework to analyze the competing agendas underpinning educational policy, curriculum development and a range of pedagogical practice in order to identify the forces associated with the changing landscape of public education in the 21st century (with particular forces in the forces of globalization and the neoliberal restructuring of the public sector).

GSE 541 Colonialism, Education, and Decolonization 3-3-0
In this course, students will develop a comprehensive understanding of the ongoing history of settler colonialism in Canada and of imperialism and colonialism in the global context. This grounds an examination of the role of education in colonization and in the project of decolonization in a range of national contexts. This course responds directly to the calls for action issued in the 2015 final report of Canada's historic Truth and Reconciliation Commission on Indian Residential Schools and new curriculum on the history of IRS and treaty education subsequently introduced in every Canadian province.

GSE 550 Selected Topics in Educational Technology 3-3-0
This course has been designed to provide the student with the opportunity to examine recent developments in educational technology.

GSE 552 Technology in Education 3-3-0
This course will focus on the potential which technology offers for the enrichment of learning and teaching. Drawing on current research students will examine issues of appropriate effective integration of technology in the curriculum such as the need for value-added approaches. The course will focus on modern technologies including applications of e-learning.

GSE 553 Technology and the Role of the Educator 3-3-0
This course examines the role of the educator in an increasingly technological world. Modern advances in technology have seen a concomitant change in the role of the teacher from one who passes on knowledge to one who mentors students in developing their knowledge. Students become active in their educational activities. This course will examine theoretical perspectives on the role of the educator in a technologically-defined world and the implications for current and future practices. The students in this course will also learn how to create student-centered applications of technology in the classroom, allowing students to make their own products and their own content.

GSE 559 Research in Educational Technology 3-3-0
This course has been designed to provide students with the opportunity to search and locate the literature relevant to their selected topics of interest. Students will acquire skills in conducting both electronic and hand searches. They will critically analyze the literature base related to one facet of educational technology and produce a scholarly, written review of that literature. This literature review will culminate in research questions, objectives, or hypotheses that align with the literature reviewed. This course is compulsory for students registered in the MA program with emphasis in educational technology and should be taken near the end of their program.

GSE 560 Selected Topics in Literacy 3-3-0
This course allows students to examine research related to current issues in literacy learning and teaching. Specific topics vary from year to year to take advantage of the special expertise of the faculty.

GSE 561 Language and Literacy Studies 3-3-0
Through this course, students examine current trends, issues, theory and research in teaching and learning in the English language arts classroom. Topics include media literacy, critical literacy, multiliteracies, multicultural curricula, and language learning and teaching across the curriculum.

GSE 564 Learning to Write and Writing to Learn 3-3-0
This course is designed for teachers who are interested in exploring many different approaches to learning to write in different genres. Participants should be prepared to engage in a great deal of writing as the philosophy of the course is one that is grounded in the notion that "we learn to write by writing".

GSE 570 Selected Topics in Educational Leadership and Administration 3-3-0
This course has been designed to provide the student with the opportunity to examine recent developments in educational leadership and issues related to educational administration.

GSE 571 Principles of Educational Leadership 3-3-0
This course, designed for teachers and administrators interested in becoming effective leaders, is an introduction to the study of educational leadership. Participants in this course will be introduced to the theory and research literature on issues of leadership in general and school leadership in particular. Students will explore topics such as school-based management, invitational leadership, flexible leadership, professional collaboration and individual initiative.

GSE 573 Creating and Leading Effective Schools 3-3-0
This course aims to inform practicing and aspiring school leaders about ways to mobilize a school staff toward greater effectiveness in reaching a joint mission. It examines current research and school improvement literature with a view to developing practical strategies for whole school assessment, evaluation and development.

GSE 574 Understanding Professional Development 3-3-0
This course will explore the many ways teachers develop as professionals, both individually and as members of educational organizations. Participants in the course will be involved in reading about and discussing topics such as the following: What knowledge is held by good teachers? What does teacher reflection contribute to development? What can be done by organizations to promote teacher learning and development? How are student learning and teacher learning related? What are the possibilities for designing professional development programs for teachers?

GSE 575 Educational Leadership Theories 3-3-0
This course is designed to provide students the opportunity to examine a set of educational leadership theories that have been or are currently used in school settings. Participants will be encouraged to critically examine the theories that are presented and explore the implication of using them in educational settings.

GSE 576 Teacher Leadership 3-3-0
Participants will explore the changing roles of teacher leaders and perspectives on teacher leadership. Participants will review relevant literature and will examine features of teacher leadership including teacher participation in institutional hierarchies and teacher involvement in shaping institutional cultures and acting as agents of transformation.

GSE 580 Selected Topics in Second Language Learning 3-3-0
This course has been designed to provide the student with the opportunity to examine recent developments in second language learning.

GSE 581 Introduction to Linguistics for Language Teaching 3-3-0
This course is a survey of linguistic theory as it relates to second language teaching. Students are exposed to major themes in linguistics as a basis for the study of second language teaching and learning.

GSE 582 Teaching ESL to Adults 3-3-0
This course provides students with an overview of theory related to the teaching of adults. It focuses on the application of this theory to the teaching of English as a second language to adults: the development of a needs analysis, selection and design of appropriate materials, and the involvement of adult learners in the learning process.

GSE 584 Teaching English Grammar 3-3-0
This course provides an overview of the theoretical background for the teaching of grammar. It includes a review of major grammatical patterns of English, as well as a focus on learner errors and the design of material appropriate to the teaching of grammatical concepts.

GSE 585 Methods in Second Language Teaching I 3-3-0
This first course in methodology introduces the student to classroom practices in teaching English as a second language. It includes a historical overview of approaches to second language teaching. The course focuses on the selection of teaching material and classroom techniques for second language teaching.

GSE 586 Methods in Second Language Teaching II 3-3-0
The second course in methodology extends the content covered in Methods I. Classroom practice and development of curriculum resources are the major topics covered in this course.
Prerequisite: GSE 585

GSE 587 Assessment and Evaluation in Second Language Teaching 3-3-0
This course includes an exploration of design strategies for effective assessment and evaluation procedures for second language teaching. It combines the theory of effective assessment with practical applications for the second language classroom.

GSE 588 The Second Language Learner 3-3-0
This course focuses on a learner-centered approach to second language teaching. It emphasizes the importance of individual learner backgrounds, special needs of learners, individual learning styles and strategies, and cultural considerations in the teaching of English as a Second Language.

GSE 589 Observation and Practice Teaching in Second Language Classrooms 6-3-0
This six-credit course involves the observation of experienced second language teachers in their classrooms, as well as peer observation of students in the course. Students will develop and teach lessons under supervision at both the primary and secondary levels. Students may observe and teach in adult classes.

GSE 590 The Creative Process in Education 3-3-0
Students will explore the creative process as it affects and is affected by the relationship between the teacher and the learner. Students will engage in creative projects and monitor their own creative process. Through readings, discussion, and experiences with different media, students will learn to articulate and evaluate learning within a creative process framework.

GSE 591 Studio Inquiry I 3-3-0
In this course students identify the content and the processes essential to their on-going studio performance. Students are expected to develop parallel inquiry into exhibitions, installations, performances, documentations, notation systems and related readings. Evaluation is based on workshop and seminar participation, studio performance and class presentations. This course may be continued as GSE 592.

GSE 592 Studio Inquiry II 3-3-0

GSE 593 Selected Topics in Art Education 3-3-0
This is a seminar course offering students the opportunity to study various aspects of art education. Specific topics vary from year to year to take advantage of the special expertise of the faculty.

GSE 594 Readings in Art Education 3-3-0
This is a seminar course in which students study selected texts to gain insight into formative notions and recurring issues in art education. Assignments include historical research questions arising out of an examination of personal experiences in the teaching and learning of art.

GSE 596 Art and Technology: an on-going dynamic 3-3-0
This course addresses the assumptions that underlie the discourse about art and technology. Technology has and continues to be used as a part of art, in the service of art, and as forms of art. Correspondingly each technological innovation in art raises a new set of practical, theoretical, and aesthetic questions that challenge theoretical underpinnings within art education. A review of some of the types of technology-based art, with examples of work by some prominent artists, establishes the range of difficulties that accompany the introduction of new technologies into art and the effects of these new visual languages on discourses in art and art education.

GSE 599 Transformative Praxis 3-3-0
The intent of this course is to cultivate Action Research based experiences with a specific focus on social justice grounded themes and collaborative interaction with relevant community. Students are expected to work in tandem with and under the supervision of faculty members who are actively engaged in such fieldwork. In addition to spending at least four weeks in the field, students can anticipate completing preparative and culminating academic activities. The result of which is meant to encourage students and community members to creatively expand their own borders of transformative possibilities through the art of praxis.

GSE 630 Independent Study in Education 3-0-0
Students in an existing graduate program may be granted permission to pursue an independent study project under the guidance of a faculty supervisor on a topic in Education significant to their program. Topics must be approved by the Graduate Program Committee of the School of Education.
Pre-requisite: Permission of the Graduate Program Committee

GSE 700 Thesis 21 credits
Under the supervision of the School of Education thesis supervisor, the M.A. student conducts a research study, which is followed by completion of an academic document that must meet the standards of scholarship established by the appropriate research community.
Prerequisite: Successful completion of GSE 705: Thesis Proposal

GSE 701F Monograph 6 credits
This 6-credit monograph, under the supervision of a mentor assigned by the School of Education, permits the student in the final stages of his/her program to use the knowledge acquired to inform the designing and composing of an original piece of scholarly writing. This document can take a variety of forms including a research report, a book, or a critical review of a body of literature. A successful graduate level monograph is an academic document that must meet the standards of scholarship established by the appropriate research community.
Prerequisite: Completion of all course requirements for the Master of Education degree with a concentration in Curriculum Studies or Educational Leadership, including GSE 706 – Exit Project Proposal.

GSE 702F Curriculum Studies Project 6 credits
This 6-credit independent project, under the supervision of a mentor assigned by the School of Education, permits the M.Ed. student in the final stages of his/her program to draw on various appropriate and significant experiences and insights to inform the designing of a novel unit of study and to facilitate the inquiry into its enactment. Each project will seek to inform practice through a significant research component.
Prerequisite: Completion of all course requirements for the Master of Education degree with a concentration in Curriculum Studies, including GSE 706 – Exit Project Proposal.

GSE 703F Educational Leadership Project 6 credits
This 6-credit independent project, under the supervision of a mentor assigned by the School of Education, permits the M.Ed. student in the final stages of his/her program to draw on various appropriate and significant experiences and insights and to apply this knowledge to a real-life problem in educational management or leadership. The student starts with an analysis of the problem and the design of a plan of action (to be approved by the mentor). However, it is expected that each project will seek to inform practice through a significant research component.
Prerequisite: Completion of all course requirements for the Master of Education degree with a concentration in Educational Leadership, including GSE 706 – Exit Project Proposal.

GSE 704F Art Exhibition and Supporting Documents 6 credits
The nature of the 6-credit art exhibition and supporting documents will be determined through consultation between the student and the supervisor.
Prerequisite: Completion of all course requirements for the Master of Education degree with a concentration in Art Education, including GSE 706 – Exit Project Proposal.

GSE 705 Thesis Proposal 3 credits

This 3-credit independent study, completed under the supervision of a thesis supervisor, leads to completion of a proposal, which is defended by the student prior to registration in the thesis. In addition to developing the proposal, the deepens understanding of research ethics and policies. Where pertinent to the proposed study, the student prepares ethics submissions.
Prerequisite: Completion of course requirements for the Master of Arts in Educational

GSE 706 Exit Project Proposal 3 -3-0
Under the supervision of a mentor, students will develop a proposal for the final Exit Project, either GSE 701, GSE 702, GSE 703, GSE 704, to be submitted to the Graduate Program Committee for approval. Stipulations regarding the proposal are provided in the Exit Project Booklet available to students.

GEA 522 The Principal 3-3-0
This course will examine the relationship of the school principal with various constituencies, including students, teachers, the larger educational community and parents. Expectations and skills related to the roles and responsibilities of the school principal will be explored.

GEA 523 School and Community Relations 3-3-0
This course is designed to facilitate the development of communication and leadership skills necessary for positive school and community interactions. Students will examine contemporary issues from both a theoretical and practical perspective and develop strategies which address a variety of complex situations.

GSL 582 Building Oral Competencies 3-3-0
This course provides students with an overview of theory related to the teaching of adults. It focuses on the application of this theory to the teaching of English as a second language to adults: the development of a needs analysis, selection and design of appropriate materials, and the involvement of adult learners in the learning process.

GSL 589F Individual Project in the Teaching of English 3-3-0
This course may be taken with the special permission of the School of Education. It provides an opportunity for a student to pursue an area of special interest in the field of second language teaching.

Graduate Certificate in Teaching Intensive English

The Graduate Certificate in Teaching Intensive English is intended for in-service ESL teachers who would like to be better equipped for intensive ESL (IESL) teaching positions. The program provides teachers with opportunities to review and extend their knowledge of language teaching pedagogy while studying in an English-environment. Please note: This program is not offered every year.

Students will gain 15 credits through the courses below:

GSL 540 Intensive English: New Trends and Theories
GSL 541 Teaching and Learning in Intensive English
GSL 544 Course and Curriculum Design in Intensive English
GSL 547 Language Learning through Cultures
GSL 549 Building Oral Competencies

GSL 540 Intensive English: New Trends and Theories 3-3-0
This course addresses issues related to second language learning and acquisition, particularly those that relate to intensive English. Topics addressed include language learning theories, such as cognitive and sociocultural perspectives; theories of bilingualism and multilingualism; new literacies - multiliteracies, critical literacy; discussion and debate about Intensive English in society; and various models of Intensive English.

GSL 541 Teaching and Learning in Intensive English 3-3-0
This course discusses both new and familiar learning theories and pedagogy in the context of the Intensive English program. Participants will explore learner-responsive teaching through examining individual differences & multiple intelligences, differentiated instruction, and cooperative learning. They will also look at the ways In which various technologies can contribute to intensive English pedagogy and computer-assisted language learning (CALL)

GSL 544 Course and Curriculum Design in Intensive English 3-3-0
Participants will examine aspects of course and curriculum design that are relevant to teachers of intensive English. They will learn about and apply Interdisciplinary design, backward design, and universal design. They will discuss content-based, task-based, and project-based approaches to language teaching and pedagogical issues related to the teaching of linguistic forms in meaning-focused instruction. The challenges and benefits of making connections with other subject areas and collaborating with other colleagues will be discussed.

GSL 547 Language Learning through Cultures 3-3-0
This course will explore the language arts approach to the teaching of ESL. Theories regarding the connection between English-language cultures and language learning will be introduced, and students will be involved in the construction of classroom learning situations based on different cultural forms (e.g.,(poetry, short stories, films, songs and other media) to promote language learning and a critical appreciation of the English-language cultures.

GSL 549 Building Oral Competencies 3-3-0
This course will address issues related to the development of listening and speaking skills in second language learners, including those related to pronunciation. In addition, it will focus on varieties of oral communication in different contexts and the different levels and ages of learners.

Graduate Certificate in Brewing Science

Program Overview CONBRW

The Graduate Certificate in Brewing Science is a two-semester graduate certificate designed specifically to meet the growing need for well-trained, scientifically educated brewers and / or brewing analysts in the craft and industrial brewing sectors. Students completing this program will be prepared to fill any position relating to the brewing process, the chemical and microbiological analysis of beer and precursor materials (water, malt, hops, yeast, wort, etc.), and research and development.

To qualify for enrolment in the Graduate Certificate in Brewing Science program, students must hold a B.Sc. in Biochemistry, Biology, Chemistry, or another discipline relating to one or more of the three (e.g. Chemical or Biological Engineering) and a minimum graduating average of 60% (C+).

The Graduate Certificate in Brewing Science is comprised of six one-semester classroom courses and a full-year practicum in the University's teaching brewery, as shown below.

Fall Semester	Winter Semester
BRS501 – Brewhouse Chemistry (3 credits)	BRS504 – Microorganisms in the Brewery (3 credits)
BRS502 – Malt and Malting (3 credits)	BRS505 – Chemical Analysis of Beer and its Ingredients (3 credits)
BRS503 – Hops (3 credits)	BRS506 – The Business of Brewing (3 credits)
BRS598 – Brewing Practicum I (3 credits)	BRS599 – Brewing Practicum II (3 credits)

Graduate Certificate in Brewing Science Courses

BRS 501 Brewhouse Chemistry 3-3-0

Water, referred to as Hot Liquor in brewing jargon, provides the medium in which all of the chemical and biochemical reactions that are involved in producing beer take place. Additionally, the mineral content of the Hot Liquor is a critical factor in determining many of the final characteristics of the beer, provides many of the essential elements for healthy yeast growth, and contributes enormously to mash pH. This course provides an in depth, comprehensive look at water, its properties, and how its mineral contents affect all aspects of beer and the brewing process.

BRS 502 Malt and Malting 3-3-0

Malt is produced by the germination of grain (barley, wheat, rye, etc.) followed by application of heat (kilning). It is the heat regimen, together with the type of grain that determines the characteristics of the malt. The malt is the source of the starch that is converted to sugars which the yeast ferments to produce alcohol and it is also primarily responsible for the colour of the beer. Malt is also an important contributor to flavour, aroma, characteristics of the foam (head), mouth feel, and other characteristics of the beer. This course will cover malt from farming and harvesting of the grain, through the transformations of the malting process, to its chemical and biochemical transformations in the brew house.

BRS 503 Hops 3-3-0

Hops is the ingredient that contributes the characteristic bitterness of beer. It is also responsible for much of the flavours and aromas of beer, particularly those observed in heavily hopped beers such as India Pale Ale, American Pale Ale, and even hoppier double IPAs. The first section of this course will cover the farming, harvesting and processing of hops. The second section will cover hop chemistry, focusing on the resins (bittering agents) and essential oils (flavour and aroma contributors) of the hop cone and their transformations during the brewing process.

BRS 504 Microorganisms in the Brewery 3-3-0

The role of brewer's yeast in the brewing process, particularly its fermentation of sugars to produce alcohol, is fairly well known. However, yeast is also responsible for producing dozens, if not hundreds, of chemical compounds as it metabolizes the sugars, amino acids, and other components during fermentation. Many of these compounds contribute significantly to the flavour and aroma of beer. Other microorganisms, such as wild yeast and bacteria, are also potential contributors to the complex chemistry and biochemistry that occurs in the fermenter; sometimes to the benefit of the beer but more often to its detriment. This course will look at all of the microorganisms that are commonly found in the brewery and provide a detailed description of their chemistry and thus their impact on beer flavour and aroma.

BRS 505 Chemical Analysis of Beer and its Ingredients 3-3-0

As a food product, beer is rigorously controlled at both the federal and provincial levels of government. Part of this process is ensuring that a number of analytical parameters are accurately reported (e.g. alcohol by volume). Many other properties of beer are indicators of the efficacy of the brewing process and whether the brewer is producing a quality product. Analysis of the ingredients of beer (water, malt, hops, yeast) is essential to ensure that standards of quality necessary to produce good beer are met. This course will provide students with an in depth look at the chemical analyses commonly used to analyse beer and its precursors, using the methods database of the American Society of Brewing Chemists. Students will use what they learn to analyse the ingredients and the beer that they use / produce in the co-requisite practicum in brewing.

BRS 506 The Business of Brewing 3-3-0

There is a great deal of time and hard work that goes into planning, building, equipping, and running even a small microbrewery. When a microbrewery fails, it is generally because the ownership doesn't have a particular skill set, whether it be on the brewing side or on the business side. This course will take students through all of the steps necessary to get a microbrewery from the planning to the operation stage, and also introduce them to the business knowledge necessary for running a successful microbrewery.

BRS 598 Practicum in Brewing I 3-3-0

Ultimately, brewing is a hands-on activity. The brewer must pay careful attention at every step of the brewing process in order to ensure that they have the best chance of producing the desired final product. Even then, the beer, although well crafted, may not exhibit the characteristics of flavour, aroma, colour, bitterness, etc. that the brewer was attempting to produce. Recipe development is a wonderful example of the scientific method and this approach to brewing will be the main focus of this course. Upon completion of BRS 598 and BRS 599, students will receive more than 180 hours of brewing experience, constantly comparing what they observe in the brewery with what they are learning in their BRS lecture courses. The aim is to produce a brewer who is proficient in the brewery but also understands the complex chemistry and biochemistry that is involved in producing the highest quality beers. Students in this program must complete both BRS 598 and BRS 599 as they take the six lecture courses of the Graduate Certificate in the Brewing Science program.

BRS 599 Practicum in Brewing II 3-3-0

Ultimately, brewing is a hands-on activity. The brewer must pay careful attention at every step of the brewing process in order to ensure that they have the best chance of producing the desired final product. Even then, the beer, although well crafted, may not exhibit the characteristics of flavour, aroma, colour, bitterness, etc. that the brewer was attempting to produce. Recipe development is a wonderful example of the scientific method and this approach to brewing will be the main focus of this course. Upon completion of BRS 598 and BRS 599, students will receive more than 180 hours of brewing experience, constantly comparing what they observe in the brewery with what they are learning in their BRS lecture courses. The aim is to produce a brewer who is proficient in the brewery but also understands the complex chemistry and biochemistry that is involved in producing the highest quality beers. Students in this program must complete both BRS 598 and BRS 599 as they take the six lecture courses of the Graduate Certificate in the Brewing Science program.

Graduate Micro-Program in Climate Change

Faculty

Matthew Peros,
B.Sc. (Toronto), M.Sc. (York), Ph.D.(Toronto);
Professor, Tier II Canada Research Chair in Climate and Environmental Change
Director of the Graduate Micro-Program in Climate Change

Elisabeth Levac,
B.Sc., M.Sc. (UQAM), Ph.D.(Dalhousie);
Professor

Valerio Faraoni,
B.Sc. (University of Pavia, Italy), M.Sc., Ph.D. (International School of Advanced Studies, Italy);
Professor

Program Overview (9 credits)

CONECC

Finding solutions to the problems brought on by climate change requires educating a new generation of global citizens well-versed in the concepts, issues, and challenges associated with such a complex topic. Bishop's University has responded to this need by developing a new graduate-level Micro-Program in Climate Change. The new program, the first English-language program of its kind in Québec, will offer instruction from leading experts on the science of climate change, its impacts, and strategies for its mitigation. At the end of the program, it is expected that students will be able to:

- Take a position and provide evidence to support arguments concerning major issues in climate change science
- Develop an understanding of the causes and effects of climate change on local, regional, and international scales, in major regions of the world (poles, tropics)
- Articulate a range of plausible solution strategies to confront climate change in terms of adaptation and mitigation

Graduates of the Micro-Program will be well positioned to compete for jobs in both government and the private sector. Moreover, the Micro-Program could be used as a springboard for further study, whether it involves graduate school in a climate or environment-related field, or a professional degree such as law school or an MBA. Indeed, the Micro-Program has been designed so that it will provide students with a solid understanding of both the scientific and non-scientific aspects of climate change and thus will be highly applicable to a range of career options.

Admission Requirements

The basic entry requirement will be an undergraduate degree in any field from a recognized university with at least a B standing in the final two years of study. There are no specific pre-requisites, but students will need to be comfortable with basic mathematical and scientific concepts. It is not possible to enroll in the Micro-Program before the completion of all undergraduate degree requirements.

List of Courses

To complete the Micro-Program, students will do three three-credit masters-level courses (for a total of nine credits) from a list of six potential courses:

ESG 525 The Anthropocene 3-3-0

The idea of an Anthropocene is changing our view of the extent to which humans have shaped the natural world. However, many questions still remain concerning the Anthropocene, such as when it began and what activities characterize it. This course will examine recent research in the Anthropocene and the controversies surrounding it. The course material will be centered around a project the class undertakes that involves the study of human impacts in the Eastern Townships using a variety of data sources

ESG 526 Environmental Impacts of Climate Change and Human Activities on the Oceans 3-3-0

People living in cities remote from the sea often forget about the role of the oceans in their economy and in the climate system. The course will examine society's relationship with the oceans, especially in coastal zones. Oceans are the site of many important human activities, and thus are sensitive to pollution and modifications brought by climate change. The goal of the course is to increase students' awareness of the major environmental issues presently affecting the oceans and the challenges facing decision makers when dealing with the impacts of climate change on the oceans (e.g., sea level rise, saltwater intrusions into aquifers, fisheries, etc.).

ESG 561 Arctic and Antarctic Environmental Change 3-3-0

The polar environments, especially the Arctic, are undoing change at a rate far faster than most other regions. Change at the poles has happened in the past and will continue to have important consequences for all Earth's systems. This course will examine the development of these extreme environments and examine what can be expected for the future.

ESG 570 Special Topics in Climate and Environmental Change 3-3-0

A graduate-level lecture/seminar course offered by regular and visiting faculty on topics related to their research interests in climate and environmental change. Topics are determined by the instructor therefore content of the course varies year by year. The course will be offered on an occasional basis.

ESG 573 Energy and the Environment 3-3-0

This course introduces the concepts of energy and power and their units and reviews energy sources, fossil fuels, their environmental impacts, and resource consumption. The basics of heat transfer, energy conversion, and its efficiency according to thermodynamics are covered (including the concepts of temperature, specific and latent heat, the first and second law of thermodynamics, heat engines, and thermal systems). Other topics discussed include electromagnetic and blackbody radiation, the greenhouse effect, the Earth's energy balance, the basics of electromagnetism, and electric power. Radioactivity, nuclear energy, and renewable energy sources are introduced.

ESG 575 Tropical Environments and Climate Change 3-3-0

This course attempts to provide an overview of the tropics as a unique environment and one that poses special problems to its human occupants. The working assumption in the course is that the tropics comprise a far too complex and heterogeneous environment for simple generalizations to apply. However, by gaining some understanding of how its component systems work, one can be in a better position to identify the appropriate questions to be asked and experiments to be performed, so that site-specific solutions can be developed for management problems in different parts of the tropical world. The course will provide a review of tropical climatology, soils, and biomes, in addition to discussing more applied issues such as forestry and agriculture.

ESG 577 The Health Impacts of Climate Change 3-3-0

Climate change is expected to affect human health in numerous ways. The most obvious health impacts are those associated with thermal stress and extreme weather events such as floods and hurricanes (premature deaths, infectious diseases; diarrhoeal disease). Global warming will also be associated with a spread of vector-borne diseases (such as malaria, dengue fever, yellow fever, Lyme disease, etc.) and increases in seasonal allergies. The course will examine

the overall impact of environmental degradation, displacement and loss of livelihood on the general physical and mental health of populations.

All courses will be offered in the winter semester of each year. Students may take all three courses in one semester, or take courses over a period of several years. The courses will consist of a combination of seminar, lecture, fieldtrip, and laboratory instruction.

Graduate Certificate in Knowledge Mobilization

Program Overview

(15 credits) CONKMB

Knowledge Mobilization (KMB) is the process by which we share and uptake information for the benefit of society. The goal of this Graduate Certificate is to develop the students' knowledge, skills and values with respect to KMB and build the capacity to select and apply KMB tools and techniques in research and/or applied contexts. The basic entry requirement will be an undergraduate degree in any field from a recognized university with at least a B standing in the final two years of study. There are no specific pre-requisites, though it is highly recommended that students have some background in research methods and scientific concepts. Students in this program will complete 3 courses (15 credits) in a 12-week span during the Spring term, including a 6-week practicum.

KMB 510 Theories of Knowledge Mobilization 6-6-0
This course is an overview of the theories and practices involved in the creation, synthesis, translation and dissemination of knowledge. We will discuss various contexts in which knowledge is created, various perspectives on how 'knowledge moves', how to identify audiences for specific areas of knowledge, and how to identify barriers and facilitators to using and sharing knowledge. Across various disciplines, we will identify current tools and techniques to evaluate the success of KMB initiatives. Students in this class will create their own KMB package to inform or raise awareness, and will design an evaluation of their KMB project.

KMB 520 Science Communication 3-3-0
This course will focus on skill development, writing and communication strategies for online and print media, such as online blogs, and columns in local newspapers, as well as current innovations in communication such as infographics. Students will hone their skills in writing technique, particularly in communicating complex scientific material to a broader audience.

KMB 530 Knowledge Mobilization Practicum 6-6-0
The practicum would explore the application of knowledge gained from the theoretical courses taken in the first half of the Certificate. Students would be placed in a local organization with a mandate to translate knowledge into action. Examples of projects that could be conducted during a practicum include establishing a KMB strategy for an organization, creating KMB materials that would meet the organization's needs, researching and writing a column in a local newspaper, developing a workshop, or participating in a KMB internship at Bishop's University's Research Office. At the end of the practicum, students would submit a portfolio that would include the KMB projects that they have led and/or supported over its duration, a preliminary evaluation of these projects, as well as a journal outlining how previous study of KMB theories and of science communication informed their practicum experience.
Prerequisites: KMB 510 and KMB 520

Master's Degree in Computer Science

Master's Degree Program (45 credits)

I. Thesis Option CONCSC

Entrance Requirements

The minimum requirements for admittance to the Master's program are an undergraduate degree with a major in Computing Science or equivalent, and a high upper-second class standing.

Candidates with high graduate academic standing in an undergraduate degree other than computer science, who have some computer science background either graduate academic or professional, may be admitted as graduate preparatory students. Preparatory students will be asked to complete up to one year of undergraduate courses to enhance their background.

In addition to graduate academic performance, a combination of factors is taken into consideration in assessing the eligibility of a candidate for admission into graduate programs.

One important such a factor is the availability of a faculty member competent and willing to supervise the graduate academic program of studies and research of the candidate; a candidate will not be admitted to the program under any circumstance unless such a faculty member exists.

Other factors graduate the performance of the candidate and the assessment provided by his/her referees as a measure of the likelihood that the candidate can graduate complete the course of studies and research.

Program Requirements

45 CSC credits:

15 cr: five 500-level CS courses
6 cr: Graduate Seminar CS 597
24 cr: Master's Thesis CS 599

Graduate students should familiarize themselves with the University and divisional calendar and regulations. Some of the information herein is adapted from these regulations, but is not intended as a replacement.

Completing the degree normally requires five one-term 500-level courses, registration and participation in the Graduate Seminar (CS 597), together with a Master's thesis (CS 599). Courses are chosen by students in consultation with their supervisor. All courses prescribed for a student's approved program of study are designated as primary. Courses additional to the student's approved program are designated as secondary. Failure to attain a minimum of 65% in any of the primary courses may result in the student being required to withdraw from the program.

Under certain circumstances, it is permissible for a student admitted to the program to follow an approved graduate-level credit course at another university. All interested students should consult their supervisor and the chair of their department prior to registration in order to obtain further information on procedures and conditions of eligibility.

A thesis proposal should be completed as soon as possible and by the end of the second term in the program at the latest. Students are expected to present their proposal in the Graduate Seminar course and also expected to give more detailed seminars describing their work later.

Thesis topics are chosen after discussion with potential supervisors. The amount of flexibility allowed in pursuing a particular topic will vary according to the supervisor's needs and interests. Theses are defended before an examining committee consisting of two members of the department, and an external examiner.

Any candidate (full-time or part-time), after initial registration in a thesis must maintain this registration in all successive terms (including the term in which the student is examined) until his/her thesis is completed. Completion means submission of a final grade to the Division after modifications, any retyping involved, etc. Students should note that faculty approval to register in the thesis is given on the understanding that the student will be in regular contact with his/her supervisor, and that thesis research will be actively pursued in each term of registration.

Preparatory Students

Candidates who do not satisfy the admission requirements may be admitted to a qualifying program. If successful in this qualifying period and upon formal application to the Division, the student may eventually proceed to the Master's program. However, admission to the qualifying program does not imply automatic admission to the Master's program; at the end of the qualifying period the student will be required to apply for entry into the Master's program, at which time the department will determine the student's eligibility. If successful, the student will be informed of this decision by the Admissions Office.

Credits taken to fulfill the requirements of the qualifying program may not be used for credit for the Master's degree. Courses taken extra to the program requirements of the qualifying year and which have been successfully completed may be considered for credit towards the Master's degree.

Students in the Thesis Option stream can switch to the Project Option stream at any time. Any graduate courses they already passed will count toward the requirements of their new program. No credits for the graduate seminar or the Master's thesis can be transferred.

II. Project Option CONCSP

Entrance Requirements

The minimum requirements for admittance to the Master's program are an undergraduate degree (minimum of a 70%) with a major in any of the following disciplines: Computing Science, Information Technology, Computer Engineering, Electrical Engineering, Mathematics or Physics.

Candidates with insufficient academic background in Computer Science may be admitted as graduate preparatory students. Preparatory students will be asked to complete up to one year of undergraduate courses to enhance their background. Admission to the qualifying program does not imply automatic admission to the Master's program; at the end of the qualifying period the student will be required to apply for entry into the Master's program, at which time the department will determine the student's eligibility. If successful, the student will be informed of this decision by the Admission office. Credits taken to fulfill the requirements of the qualifying program may not be used for credit for the Master's degree. Courses taken extra to the program requirements of the qualifying year and which have been successfully completed may be considered for credit towards the Master's degree.

Program Requirements

45 CSC credits:

36 cr: twelve 500-level CS courses
9 cr: Master's Project CS 590

CS Graduate students should familiarize themselves with the University and divisional calendar and regulations. Some of the information herein is adapted from these regulations, but is not intended as a replacement.

Completing the degree normally requires twelve one-term 500-level courses, together with a Master's project (CS 590). Courses are available during the regular semesters (Fall and Winter), and are chosen by students depending on their interest, their background, and on course availability. The Master's project is normally available only during the Spring/Summer semester.

Failure to maintain a minimum of a 65% cumulative average may result in the student being required to withdraw from the program.

Students in the Project Option stream can switch to the Thesis Option stream as long as they meet the following conditions: (a) they have taken and passed at least five graduate courses at Bishop's, (b) they have an average grade of 75 or better in the graduate courses taken at Bishop's, and (c) at least one faculty expresses interest in supervising their research toward the Master's thesis. No more than five graduate courses can be counted toward the requirements of the new program.

List of Graduate Courses

Master's students may take any five graduate courses as long as these are approved by their supervisor. Graduate students in the department may include in their programs relevant courses from other departments within the Division.

The department currently offers the following courses. The actual courses offered each term will be determined by student demand and the availability of faculty.

CS 501 The Internet of Things 3-3-0

How can companies deal with the vast amount of data coming from a variety of different devices? In the 'Internet of Things' there are many different devices, sensors and data logs. How can a computer scientist take this data and turn it into a readable or graphical form (dashboard) for people to make sense of. The course will consist of looking at how devices such as the 'Fitbit', smartphones, in house security systems send data over the Internet to a server and how this data can be interpreted into something that large corporations can use.

CS 502 Digital Topology & Mathematical Morphology 3-3-0

Digital topology deals with topological properties of digital images. Its concepts and results are used to specify and justify some important image processing algorithms, including algorithms for thinning, boundary extraction, object counting, and contour-filling. Mathematical Morphology is a set-theoretic method of image analysis allowing to extract image components that are useful for representation and description. It can provide boundaries of objects, their skeletons, and their convex hulls. It is also useful for many pre-and post- processing techniques, especially in edge thinning. The goal of this course is to provide a full exposure to these techniques, their mathematical backgrounds, and their different applications.

CS 503 Data Visualization 3-3-0
The course explores analytical methods paired with appropriate visualizations for automated and human-assisted analysis for data sets. Several visualization techniques allowing to present data to an observer in a way that yields insight and understanding will be investigated. These big data analysis and visualization techniques are applied to data sets from a wide variety of scientific domains such as biology, physics, engineering, and medicine. The analysis and visualization methods will be illustrated through concrete examples.

CS 504 Programming Languages for Data Analysis 3-3-0
In this course students will be introduces to the most popular languages and software environments used in statistical computing and visualization. The course will involve significant programming projects in SAS, Weka, R and Python.

CS 505 Data Mining 3-3-0
Cross-listed with CS 405. Data is now created faster than humans are able to understand it and use it. There may be patterns hiding within this data with potentially useful information. This course will teach students, how to discover these patterns for the purpose of solving problems, gaining knowledge, and making predictions. Topics covered in this course include data preparation, clustering, classification, association rules for mining and models combination. This course includes assignments and a final project where the students are required to perform mining on real datasets. Students are expected to perform a substantial analysis of the data set, or prepare a research paper.

CS 506 Parallel Models and Algorithms 3-3-0
This course provides an introduction to the design and analysis of parallel algorithms and to the various models of parallel computation. The course will discuss parallel algorithms for problems such as: basic arithmetic, sorting, searching, selection, graph theory, matrix computations, combinatorial enumeration, optimization, computational geometry, and numerical analysis. Parallel computational models and their properties will be presented. Other typical topics include: complexity classes, and the parallel computation thesis.

CS 507 Statistical Learning 3-3-0
Statistical learning is concerned with modelling and understanding vast and complex datasets using methods rooted in statistics. The main objective is for the students to master how and when to apply statistical learning techniques in real world applications. Topics covered include linear regression, classification, linear discriminant analysis, tree based methods, support vector machines, graphical models, random forests and boosting. Projects illustrating how to implement each of the statistical learning methods are carried out using a statistical software package.

CS 509 Pattern Recognition 3-3-0
This course addresses the fundamental theory and techniques of pattern and features classification in numerical data. Pattern recognition methods can be useful in diverse real world applications such as medical data processing, data mining, information retrieval, computer vision, handwriting and speech recognition, and more. The course topics include Bayesian decision theory, statistical classification, maximum likelihood estimation, nonparametric techniques, stochastic methods and unsupervised learning.

CS 510 Model-Based Testing of Reactive Systems 3-3-0
The course provides an in-depth exposure to the area of formal methods called model-based testing. Various testing models will be presented, including traces, may- and must-testing, refusals, and failure traces. Relations to related specification and verification techniques such as temporal logic and model checking will also be investigated. Students are expected to participate in the presentation of the lecture material and perform independent research.

CS 512 Computer Games Design 3-3-0
Cross-listed with CS 412. This course will explore the theory and practice of video game design and programming. Students will learn the basic concepts and techniques for the design and development of digital games. The topics covered in this course will include the history and taxonomy of video games, the basic building blocks of a game, computer graphics and programming, user interface and interaction design, and the software architecture for video games. Students are expected to prepare a research paper during the course, or pursue a larger applied project.

CS 515 Concurrent & Real-Time Systems 3-3-0
This course provides an introduction to a process algebra such as CSP. It then uses this language for the specification, analysis, and verification of concurrent and real-time systems. Finally, the course presents the use of such a process algebra as a formal method for concurrency at different stages in the development process.

CS 516 Volumetric Image Analysis & Visualization 3-3-0
Digital volumetric images are stacks of two dimensional image slices produced for instance by tomographic scanner. The goal of this course is to study the different techniques and algorithms for the analysis of volumetric images including a discussion about some sources of volumetric images, especially those occurring in medical imaging with different modalities (Radiology, Computed Tomography, Magnetic Resonance Imaging, Nuclear Medicine, Ultrasound, Positron Emission Tomography). The course will also address the different techniques used to display and visualize volumetric images including volume slicing, surface rendering, and volume rendering.

CS 520 Advanced Topics in Software 3-3-0
The course will present topics of current interest or research directions in software and related areas. The course content is expected to vary to reflect the current interests of students and faculty. Students are expected to participate in the presentation of the lecture material and engage in independent research.

CS 555 Automata Theory & Computational Complexity 3-3-0
Cross-listed with CS 455. The course will address finite-state machines, context-free languages and pushdown automata, computability. A systematic study of the known relations between the most important resource bounded complexity classes, reductions, separation results and translation techniques is also included. Students are expected to prepare a research paper during the course.

CS 556 Compilers and Interpreters 3-3-0
Cross-listed with CS 406. This course is intended as an introduction to the fundamentals of language translation and compiler construction. Topics will include language theory and syntax; grammars, finite state machines, non-deterministic push-down automata; a thorough treatment of parsing methods covering top-down, bottom-up and precedence parsers; Syntax directed translation; Run-time environments; optimization and error recovery; code generation. Students are expected to implement complex semantic analysis and a complex compiler back-end. In particular they are expected to implement various aspects of machine code optimization.

CS 557 Database Software Design 3-3-0
Cross-listed with CS 457. This course covers how one can implement a Database Management system. Major topics are Storage management, Query processing, and Transaction management. As a basic assumption, data will not all fit in main memory, so algorithms and data structures appropriate for effective disk storage and quick access must be used. For example, one may use index structures such as B-trees or hash tables. We cover parsing of queries and optimizing of query plans. Finally, we cover durability of transactions using logging, and concurrency control for isolation of transactions. Additional topics in distributed databases are also presented. Students are expected to prepare a research paper during the course, or pursue a larger applied project.

CS 560 Software Engineering 3-3-0
Cross-listed with CS 410. *Software is an engineered product that requires planning, analysis, design, implementation, testing and maintenance. This course is a presentation of the techniques used in each step of the software product process. Topics: software requirements analysis and specifications; software design process, object oriented design; testing, reliability and maintenance; automated design tools, programming environments. Students are expected to prepare a research paper during the course, and work on large applied projects.*

CS 562 Mathematical Models in Image Processing 3-3-0
Cross-listed with CS 462. Image processing is a rapidly growing field. As such, it requires and necessitates a number of mathematical models and domains to achieve efficient processing algorithms. Designing a successful processing technique invariably relies on having a successful model for images themselves. The mathematical techniques needed could range from Partial differential equations, Differential geometry, Morse theory, Topology, Algebraic topology, Wavelets, Statistical techniques, Calculus of variations, Numerical methods, Graph theory, and Optimization. The objective of this course is to discuss in depth a number of selected mathematical topics (and their use in image processing) that are of interest to the students at the moment the course is given.

CS 563 Image Analysis 3-3-0
Cross-listed with CS 463. Image analysis is concerned with the development of machine algorithms in order mimic the biological organism's ability to see and understand images and videos. The course content include: camera models and calibration, image enhancement, features extraction and representation, shape from shading, stereo and texture, optical flow, motion analysis, high level vision and case studies.

CS 564 Computer Networks & Distributed Algorithms 3-3-0
Cross-listed with CS 464. The course presents computer networks at a functional level, with strong emphasis on programming distributed applications over a network. Discussion will be based on open networking and application standards such as the TCP/IP protocol suite and the Portable Operating System Interface (POSIX). The concept of distributed algorithms together with the associated challenges and examples are then presented. Programming distributed applications (in C or C++) is an integral part of the course. Students are expected to work on a large, distributed, and practically meaningful application as part of the course.

CS 565 Advanced Topics in Computer Analysis 3-3-0
The course will present advanced topics of current interest or research directions in Computer Applications. The course content is expected to vary according to the interests of students and faculty. Students are expected to prepare a research paper during the course, or pursue an applied project.

CS 567 Advanced Topics in Algorithms 3-3-0
Cross-listed with CS 467. The course covers some advanced aspects of algorithms and complexity. It studies the topic of NP- complete problems. Some specialized algorithms in several areas will be discussed, such as Bioinformatics, Computational Geometry and Network Flow.

CS 569 Special Topics in Computer Science 3-3-0
The course will present topics of current interest in Computer Science. The course content varies reflecting the interests of the faculty. Students are expected to participate in the presentation of the lecture material and engage in independent research.

CS 590 Master's Project 9-0-0
The Master's project consists of addressing a CS research topic which may be theoretical or practical. Research topics may be given individually or as "grand challenges" to several candidates; however, all the work for the project must be individual. Students can choose to do a project from the topics proposed by the department or opt for an internship at a public institution or a private company. All topics must be approved in advance by the course coordinator. The project must demonstrate that a student understands and is capable of employing research methods and has command of the subject, must show evidence of perspective on the topic, and must show that appropriate methodology has been understood and applied. The deliverable for the project is a report (with appended code if applicable) that, in addition to the above, should show that the student is capable of writing a professional technical document.

CS 596 Research Topics in Computer Science 3-3-0
This course provides an introduction to the primary and secondary sources of information in the computing science literature. Faculty discuss their own research objectives and present an overview of research issues in the major subject areas of Computer Science. Students are required to submit and present a paper on a topic that relates to their research.

CS 597F Graduate Seminar 6-0-0
Students are expected to participate in the departmental seminars and give at a minimum two presentations (one outlining their thesis proposal, and another one about their thesis work). All Master's students are normally expected to enrol in this course in their first year in the program. Students will not receive credit for both this course and CS 598 at the same time.

CS 599 Master's Thesis 24-0-0

MSc in Physics

Program Overview

The Master of Science (MSc) program is designed to give students a much deeper appreciation of physics while at the same time training them to become independent researchers and scientists. Graduate supervision is available in a wide variety of disciplines including astrophysics, exoplanetary science, theoretical cosmology, gravitational theory, and particle physics.

Master's in Physics (45 credits) CONPHY

Students who have completed a BSc degree in physics with at least a B average will be considered for admission into the graduate program. Students who have completed only a major in the subject may be required to take additional courses at the Master's level. Students who have been admitted will be assigned a supervisor by the Chair of Physics and Astronomy. The student's research interests will be taken into consideration when a supervisor is assigned. Current areas of research in the department include astrophysics, gravity and cosmology, particle physics, and theoretical physics.

Course Requirements (MSc):
The MSc degree requires the successful defense of a thesis (15 credits), satisfactory participation in the seminar series (18 credits), and the completion of a minimum of 12 credits in course work. Course selection is determined in consultation with the thesis supervisor and departmental chair. All MSc students must make an oral presentation and defense of their thesis before graduating. The normal period for completion of the M.Sc. degree requirements is two academic years (five semesters). The minimum number of credits required to complete the program is 45.

List of Courses

PHY 561 Quantum Mechanics I 3-3-0
Foundation of quantum mechanics; Schrodinger equation, angular momentum, central potentials, harmonic oscillator, hydrogen atom.
Students who have received credit for PHY 461 may not enrol in this course.

PHY 562 Quantum Mechanics II 3-3-0
Matrix mechanics and applications of quantum mechanics to various branches of physics. Perturbation theory, scattering, molecular applications, and Hartree-Fock Theory.
Students who have received credit for PHY 462 may not enrol in this course.

PHY 564 Condensed Matter Physics 3-3-0
Topics to be studied include the one-electron theory of solids, energy bands, lattice vibrations, transport theory, and thermodynamic properties.
Students who have received credit for PHY 464 may not enrol in this course.

PHY 565 Electromagnetic Theory 3-3-0
Static and dynamic electric and magnetic fields: Maxwell's equations and solutions involving plane waves. Covariant formulation of electromagnetic field theory.
Students who have received credit for PHY 475 may not enrol in this course.

PHY 566 Theoretical Topics 3-3-0
Topics to be studied will be selected from the areas of special and general relativity, particle physics, astrophysics and cosmology. In particular, the covariant nature of physics and various physical symmetries will be investigated.

PHY 567 Advanced Statistical Mechanics 3-3-0
Derivation of the laws of thermodynamics from statistical principles. Quantum statistics, arbitrarily degenerate and relativistic perfect gases, transport theory, thermodynamic fluctuations, and low-temperature physics will also be studied.
Students who have received credit for PHY 467 may not enrol in this course.

PHY 571 Advanced Quantum Theory 3-3-0
Topics to be studied include: Path integral and second quantization approaches to non-relativistic quantum mechanics. Feynman rules and diagrams. Relativistic quantum field of spin-zero particles.

PHY 572 Particle Physics 3-3-0
Quantum field theory of spin 1⁄2 and spin 1 particles will be introduced. Topics include: renormalization and the renormalization group; quantum electrodynamics and quantum chromodynamics; the Standard Model of particle physics; overview of string theory.

PHY 573 Advanced General Relativity 3-3-0
Topics to be studied include: differential geometry, Einstein equations, junction conditions, shell and dust collapse, gravitational waves and black hole thermodynamics.

PHY 574 Relativistic Astrophysics 3-3-0
Topics to be studied include: Cosmology, inflation, dark energy, compact objects, relativistic fluid dynamics, gravitational lensing, and gravitational waves.

PHY 575 Numerical Methods & Simulations 3-3-0
This course will cover selected topics in High Performance Computing including cellular automata, finite element methods, molecular dynamics, Monte Carlo methods, and multigrid methods, with applications to classical fields, fluid dynamics, materials properties, nanostructures, and biomolecules.

PHY 576 Stellar Astrophysics I 3-3-0
An introduction to the properties of stellar atmospheres and interiors. The equations of stellar evolution, nuclear energy generation, radiative transport and stellar model building will be studied. Further topics include the formation of starts, and the physics associated with supernovae, white dwarfs, neutron stars, and pulsars.

PHY 577 Many-Body Quantum Theory in Condensed Matter Systems 3-3-0
The following topics will be studied: Green's functions at zero and finite temperature; the interacting electron gas; the Hubbard model and strongly correlated systems; electron-phonon interaction; superconductivity and superfluidity.

PHY 578 Selected Topics in Astronomy & Astrophysics 3-3-0
Topics to be determined in consultation with prospective students.

PHY 579 Selected Theoretical Topics 3-3-0
Topics to be determined in consultation with prospective students.

PHY 580F Graduate Seminar I 9-0-0
Students are expected to participate in the departmental seminar series and to make a presentation on either their own work or on a research-related topic. All M.Sc. Students are normally expected to enrol in this course at the beginning of their first year of studies.
Offered alternate years with PHY 581.

PHY 581F Graduate Seminar II 9-0-0
Students in the second year of their degree program are expected to participate in the departmental seminar series and to make a presentation on either their own work or on a research-related topic.
Offered alternate years with PHY 580.

PHY 586 Stellar Astrophysics II 3-3-0
A detailed study of the physics that determines the evolution of stars during all of their possible phases. This includes radiative hydrodynamics and atmospheric modeling, specialized equations of state, and the nuclear physics needed to understand the various channels that lead to the creation of the heavy elements. The physics of neutrino production and detection will also be investigated. These topics will form the basis for a study of the evolution of supernovae and other high-energy phenomena in stellar astrophysics.

PHY 600 Thesis Research Dissertation 15-0-0
Each student is required to carry out independent, publishable research that is presented in the form of a thesis. The research is conducted under the supervision of a faculty member. The thesis will be evaluated externally and must be successfully defended in a meeting for which the presentation of the thesis results is open to all members of the academic community.