Doctor of Philosophy (PhD) in Nuclear Engineering

Submission to the Ontario Council on Graduate Studies
January 2009

Volume I:

The Program

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1. INTRODUCTION

1.1 Brief Listing of Program

The doctoral program leads to the degree of Doctor of Philosophy (PhD) in Nuclear Engineering. The doctoral program is a new program to be offered at the University of Ontario Institute of Technology (UOIT). The program is planned to be launched in the Fall of 2009 by the Faculty of Energy Systems and Nuclear Science (FESNS) or as soon as possible after all necessary approvals have been granted.

In addition to the above proposed PhD program in Nuclear Engineering, the Faculty of Energy Systems and Nuclear Science offers MASc and MEng degrees in Nuclear Engineering (launched in May of 2008), with fields in Nuclear Power, and in Radiological and Health Physics.

Details about the graduate programs can be found at the following link:

http://nuclear.uoit.ca/EN/main/74127/gradprograms.html

1.2 Background

UOIT is Ontario's newest university. UOIT accepted its first undergraduate nuclear engineering students in the fall of 2003. Undergraduate engineering degrees at UOIT are offered by both the Faculty of Energy Systems and Nuclear Science and Faculty of Engineering and Applied Science.

Faculty of Energy Systems and Nuclear Science first offered an undergraduate program, a BEng (Hons) in Nuclear Engineering, in the fall of 2003. Concurrently, the undergraduate program BSc (Hons) in Radiation Science commenced. In the fall of 2004, the Faculty of Energy Systems and Nuclear Science added an undergraduate program BEng (Hons) in Energy Systems Engineering.

The Faculty of Energy Systems and Nuclear Science launched MASc and MEng programs in Nuclear Engineering, with fields in Nuclear Power, and in Radiological and Health Physics, in May of 2008.

The launch of PhD program in the two fields of Nuclear Power and Energy Applications, and Radiological and Health Physics, is the next step for UOIT in offering the full range of nuclear engineering and radiation science post-secondary education.

1.2.1 Other Programs in Nuclear Engineering

Existing Programs

McMaster University - Engineering Physics MEng/PhD, with Nuclear Technology Diploma (Type 4)

Royal Military College – MASc/MEng/PhD in Nuclear Engineering, MSc in Nuclear Science

McMaster University/University of Western Ontario/University of Waterloo/Queens – MEng in Nuclear Engineering, in collaboration with the University Network of Excellence in Nuclear Engineering (UNENE)

The University Network of Excellence in Nuclear Engineering (UNENE) was established to respond to the need for a significant increase in the number of graduate degree holders in nuclear engineering in Ontario. UNENE currently sponsors a course based MEng program jointly offered by McMaster, Waterloo, Queens and the University of Western Ontario, (with support from and applications pending from Toronto). A number of the professors at UOIT teach in this program, which is offered at various university campuses (including UOIT's campus) in Ontario. UOIT has the in-house capability to offer the entire MEng program by its own faculty members at one location.

McMaster University also offers an MASc in the Department of Engineering Physics, with a field in nuclear engineering, amongst others. The **Royal Military College** offers Master's and PhD degree programmes with specialty fields in Chemistry, Chemical and Materials, Environmental and Nuclear, in Engineering or Science through its Department of Chemistry and Chemical Engineering. Of the universities offering nuclear related programs, UOIT has the largest number of core and supporting faculty with close relationships to the nuclear industry. The RMC program differs in that its ties are primarily with the federal government, especially the Department of National Defence.

1.2.2 Graduate Program Demand

The Ontario Council of Graduate Studies (OCGS) has stated that the need for graduate education in Ontario will double in the near future. One of the drivers is the so-called "Double Cohort" of undergraduate students who graduated in 2007. The demand for graduates in the area of the proposed program is expected to be particularly high in the industrial, public service, and health care sectors.

The industrial jobs are expected to be mainly, but not exclusively, within the nuclear industry. Worldwide, and certainly within the province of Ontario, there is a growing realization that nuclear energy will be an important aspect of any national strategy for emissions control and climate-change mitigation; therefore, some expansion of nuclear power for electricity production is inevitable. At the same time, the demographics of the major players in Canada's nuclear industry indicate a huge exit of experience from the work force through retirement over the next two decades. These jobs require individuals with a sound understanding of the engineering principles that govern the safe and reliable operation of nuclear power plants and supporting facilities.

Nuclear engineering practice is at the intersection of a number of different disciplines, and professionals in this industry need to work closely with engineers, scientists, business, and information system specialists who perform a number of different, but interrelated tasks. Problem-solving skills and the ability to communicate and work with people from a variety of disciplines will be critical. The graduates of the proposed PhD in Nuclear Engineering will be well prepared to fill these positions and to contribute to the province's and the country's economy. Students will study a broad spectrum of engineering design and analysis techniques applicable to nuclear power plant design, operation, maintenance, decommissioning, and waste management. They will also study the underlying principles that govern the interactions of radiation with matter, the behaviour of radioactive materials in the environment, radiation dosimetry, and the biological effects of radiation on humans and non-human biota. In addition, the program will offer courses and research opportunities in advanced computational techniques such as Monte-Carlo simulation and modelling, in medical applications such as imaging, radiotherapy and diagnosis through the use of radioisotope imaging and in industrial applications of material processing and non-destructive testing. This broad range of advanced education will be achieved through the variety of courses offered, including a seminar course, and via research interactions between students and faculty involved in the program. Furthermore, because the smallest academic units at UOIT are the Faculties (i.e., there are no divisions at the departmental level), interaction between specialists of many disciplines is enhanced. These interdisciplinary interactions will provide the experience for graduates of the program to contribute effectively in an interdisciplinary group in any work environment.

We expect that the number of qualified applicants for the program will be greater than the number of students that the faculty will be able to support. In general, this is typically true for graduate programs in engineering; however, we expect that there will be a particularly high demand for the proposed program. In 2007, the first undergraduate classes graduated from the Faculty of Energy Systems and Nuclear Science, the Faculty of Engineering and Applied Science, and the Faculty of Science at UOIT, and it is anticipated that many of these students will want to pursue graduate studies. As noted previously, in this same year, Ontario students involved in the double cohort graduated. This has created a significant increase in demand for graduate programs across the province. Furthermore, the OCGS expects that the increased demand will not be limited to the graduating year of the double cohort, but, due to the changing needs of our workforce, demand will continue to increase in general. Such growth is particularly true for the nuclear industry where staff replacement rates alone generate a large need for Highly Qualified Personnel. As a result of recent applications by both Ontario Power Generation (OPG) and Bruce Power to the Canadian Nuclear Safety Commission (CNSC) to proceed with the construction of new nuclear-electric generating units, it is expected that the demand for graduate programs in nuclear engineering will be even greater. Among Canadian universities, UOIT's Faculty of Energy Systems and Nuclear Science already has the largest complement of nuclear engineers and scientists in its core faculty. The approval of the proposed PhD graduate program in nuclear engineering and the opportunities this brings for research chairs will contribute to further growth of expertise in a field that is critical to the economic well-being of Ontario.

Once it receives approval from the provincial authorities, the UOIT Nuclear Engineering doctoral program will meet the specific needs of the Ontario Nuclear Industry and strengthen the rest of Canada's reliance on Ontario for highly skilled personnel. The location of UOIT in close proximity to the Pickering and Darlington nuclear power plants (the site chosen for the first two reactor new builds in Ontario) and to OPG's nuclear head office will result in these programs being in particularly high demand. This program is also expected to draw part-time applicants from

Bruce Power, Atomic Energy of Canada Limited (AECL), Nuclear Safety Solutions (NSS), Cameco, the Canadian Nuclear Safety Commission (CNSC), and a number of nuclear service companies. UOIT's proposed program in Nuclear Engineering is unique in offering a wide range of integrated specialties with a focus on application to energy, health care, education, and public safety.

OCGS has approved UOIT's MASc degree in Nuclear Engineering. The first year intake to this program is 15 students. These numbers are above first year expectations. It is expected that approximately half of these students will be ready for the PhD program at the time this proposal is approved by OCGS.

GOALS - ADDRESSING THE KNOWLEDGE PERFORMANCE CHALLENGE

- Vastly increase public and private investments in knowledge infrastructure to improve Canada's R&D performance.

TARGETS

- By 2010, rank among the top five countries in the world in terms of R&D performance.
- By 2010, at least double the Government of Canada's current investments in R&D.

GOALS - ADDRESSING THE SKILLS CHALLENGE

- Develop the most skilled and talented labour force in the world.

TARGETS

- Through to 2010, increase the admission of Master's and PhD students at Canadian universities by an average of 5 percent per year.
- By 2004, significantly improve Canada's performance in the recruitment of foreign talent, including foreign students, by means of both the permanent immigrant and the temporary foreign workers programs.
- Over the next five years, increase the number of adults pursuing learning opportunities by 1 million.

GOALS - ADDRESSING THE INNOVATION ENVIRONMENT CHALLENGE

- Governments at all levels work together to stimulate the creation of more clusters of innovation at the community level.

- Federal, provincial/territorial, and municipal governments cooperate and supplement their current efforts to unleash the full innovation potential of communities across Canada, guided by community-based assessments of local strengths, weaknesses, and opportunities.

TARGETS

- By 2010, develop at least 10 internationally recognized technology clusters.

- By 2010, significantly improve the innovation performance of communities across Canada.

The proposed PhD program in Nuclear Engineering at UOIT is poised to help meet the above goals and targets.

The Council of Ontario Universities (COU) formed a Task Force on Future Requirements for Graduate Education in Ontario. The Task Force determined that the Government of Ontario should establish a 10-year goal of doubling graduate enrolment in Ontario's universities to meet the demand for increased graduates. The program proposed by UOIT and the location of the university make it a logical choice for creating a Nuclear Engineering PhD graduate school capacity in Ontario.

The location of UOIT is also ideal for taking advantage of a number of major companies particularly relevant to the Nuclear Engineering programs being proposed by UOIT. These companies include close proximity to the Pickering and Darlington nuclear power plants, Ontario Power Generation, Cameco, Zircatec, AECL (Sheridan Park), and others.

1.3 Objectives of the Program

There are four objectives common to all the graduate programs:

Depth: To provide students with an understanding of the fundamental knowledge prerequisites for the practice of, or for advanced study in, engineering, including their scientific principles, analysis techniques, and design methodologies.

Breadth: To provide students with the broad and advanced education necessary for productive careers in the public or private sectors and academia.

Professionalism: To develop skills necessary for clear communication and responsible teamwork and to inspire professional attitudes and ethics so that students are prepared for modern work environments and for lifelong learning.

Learning Environment: To provide an environment that will enable students to pursue their goals through innovative graduate programs that are rigorous, challenging, and supportive.

The main objective of the PhD program is to prepare graduates for a career that includes research and/or teaching in academia or industry, as well as for leadership positions that require problem solving skills with highly specialized knowledge, often in interdisciplinary fields, and the management of finances, projects, and people. Graduates of the program are expected to be able to conduct independent research.

Graduates of the program will be able to work in research labs in both industry and government or as academics in universities.

The objectives of the PhD program are achieved through a combination of advanced course work, independent research, research seminars, mandatory workshops, research publication, and a research dissertation. The research dissertation must comprise a new contribution to the field of study.

Note that a comprehensive list of program outcomes is provided in Section 4.1.3.

1.4 Method Used for the Self-study

This appraisal was prepared by the Graduate Committee of the Faculty of Energy Systems and Nuclear Science. The appraisal has gone through thorough reviews by the Curriculum Committee and the Faculty Council of the Faculty of Energy Systems and Nuclear Science as well as by the Dean of Graduate Studies, the UOIT Graduate Studies Committee, and the Academic Council of UOIT.

Graduate Committee Members of the Faculty of Energy Systems and Nuclear Science:

Dr George Bereznai (Dean of the FESNS – on academic leave as of July/08)
Dr Daniel Meneley (Acting Dean of the FESNS)
Dr Hossam Gabbar
Dr Glenn Harvel
Dr Brian Ikeda
Dr Matthew Kaye
Dr Lixuan Lu
Dr Rachid Machrafi
Dr Eleodor Nichita
Dr Igor Pioro
Dr Anthony Waker
Dr Edward Waller

1.5 Fields in the Program

The PhD program comprises the following fields:

- Nuclear Power and Energy Applications
- Radiological and Health Physics

1.6 Review of Concerns from Previous Appraisal

As this is an application for a new program, this section is not applicable.

1.7 Special Matters and Innovative Features

1.7.1 Special Matters

Although it is unusual for PhD programs to be developed and implemented when the university has not yet graduated its own Master's degree candidates, UOIT is a newcomer to Ontario's university system and has experienced rapid growth in a very short time. Its first undergraduate degree programs in engineering were implemented in September 2003 and its first Master's students were accepted in September 2007. The University has just graduated its first Master's degree candidates in mechanical engineering in the spring of 2008, and expects to graduate the first in nuclear engineering in 2009. In addition, the data presented in Section 1.2.2 show that there are more than sufficient numbers of potential program applicants from other Ontario universities. In addition, UOIT expects that the program will attract applicants from other Canadian and international institutions.

If the program is approved and implemented by the fall of 2009 as planned, it will provide an academic option for graduates of UOIT's own MASc/MEng programs in Nuclear Engineering. Graduates of the other Engineering disciplines may choose to apply to the proposed PhD program when it becomes available.

In preparation for its Master's programs, UOIT has already assembled an impressive group of well qualified faculty members who have conducted and continue to conduct research in a wide array of areas of potential interest to doctoral candidates in the discipline. All professors have solid records of success in securing funding grants to support their research. These details are provided in the faculty CVs provided in Volume II.

1.7.2 Innovative Features

UOIT provides each of its student access to its Mobile Learning Environment. Every graduate student at UOIT has wireless and wired access to library resources, email, and the internet, in addition to other online services. In addition, UOIT is a member of the Shared Hierarchical Academic Research Computing Network (SHARCNET). Further details about the computing infrastructure can be found in Section 3.3.

UOIT's Interdisciplinary Environment

The University of Ontario Institute of Technology is in a unique position to offer a program in Nuclear Engineering. By its nature, nuclear engineering is a broad interdisciplinary field, and any associated program requires core faculty members with diverse engineering and scientific backgrounds, experience and research which are of an interdisciplinary nature. The core faculty of the proposed PhD program in Nuclear Engineering satisfy this requirement. The Faculties at UOIT are themselves single interdisciplinary units; which fosters interdisciplinary collaboration across all disciplines. Furthermore, the strategic research plan of UOIT highlights interdisciplinary research as an area of importance, and the participating Faculties are committed to building on their strengths to achieve this goal.

The following are examples of UOIT's potential for interdisciplinary collaboration:

- **A Tier 1 Canada Research Chair in Aquatic Toxicology**, whose research focuses on the biological impacts of water and food-borne toxicants on aquatic organisms, has established a state-of-the-art aquatic toxicology laboratory at UOIT. The Chair's program involves the determination of the relative importance of pulse exposure versus continuous exposures in understanding how toxicants affect the ability of aquatic organisms to grow, reproduce and survive. This research program incorporates methodologies and addresses issues which are similar to those involving radiological aspects of nuclear power and environmental protection. This provides an obvious opportunity for synergistic collaboration between researchers from different Faculties and disciplines. For example, a researcher in the proposed MASc/MEng program may choose to conduct research into the assessment of nuclear power plant emissions on non-human biota and environmental radiation protection. The importance of this research is elaborated further in the following paragraph.

- **Environmental Impacts of the Nuclear Fuel Cycle:** Under routine conditions, a nuclear reactor releases small quantities of radionuclides into the environment. Likewise, in the unlikely event of a reactor accident, releases may also occur. To determine the potential impact on human and non-human biota, it is important to understand the fundamental mechanisms for the transport of radionuclide species. Current international guidelines are explicitly considering non-human biota as part of a comprehensive protection strategy. Research into plant source term modeling, escape from containment, distribution into plant environs, and dispersion into the global environment is conducted using novel dosimeters, air sampling and aerosol characterization, and analysis of receptors. The Amber, GoldSim, ResRad, and FLUENT computer codes are used to assist in understanding the transport processes. Emphasis is given to understanding H-3 and C-14 environmental transport.

- **Imaging of Visually Obscured Objects:** There are many instances when an image of an object is required when it is visually obscured from sight. Examples include human targets behind walls, pipes buried in walls, or any other structure inside a structure where access to only a single side is possible. Because of the low efficiency of the scattering process compared to transmission, a detailed real-time image is only possible by using specialized techniques. Research is being conducted on a technique known as coded aperture imaging; this is being applied to a one-sided X-ray imaging system.

- **Advanced Control:** New control techniques have evolved over the last few decades. Distributed control and networked control have been successfully adopted in other industries such as the automobile industry and building automation, and there is significant expertise in these areas in the Faculty of Engineering and Applied Science. More recently, industrial-standard wireless control technologies have become available, offering enhanced flexibility and reliability. Teams of experts will investigate the applicability of these advanced control techniques for process control in nuclear power plants. In a related area of research, reliability and safety assessments on the design of the digital control systems in nuclear power plants are performed using the risk-informed techniques.

Membership in UNENE

The University Network of Excellence in Nuclear Engineering (UNENE) is a consortium of academic, industrial, and government agencies mandated to increasing the availability of Highly Qualified Personnel (HQP) in various areas of scientific and engineering research relevant to the sustainability of the nuclear industry in Canada. UNENE was established to meet the needs of Canada's nuclear industry to develop highly educated and specialized personnel and, in particular, to increase the professional skills of its current employees. Many of the major nuclear organizations in Canada, including Ontario Power Generation, Bruce Power, Atomic Energy of Canada Ltd, the CANDU Owners Group (COG), and the Canadian Nuclear Safety Commission strongly support the UNENE initiative. There are currently NSERC-UNENE Industrial Research Chairs in the following areas:

- Nuclear Safety Analyses and Thermal Hydraulics
- Advanced Nuclear Materials
- Nano-Engineering of Alloys
- Risk-based Life Cycle Management
- Control, Instrumentation and Electrical Systems

UOIT is a member of UNENE and holds the candidature for an NSERC-UNENE Industrial Research Chair in Health Physics and Environmental Safety. Membership in UNENE provides UOIT with direct access to industrial, academic, and government partners involved in radiological health. This enables faculty and students to acquire detailed knowledge of the latest innovations and the most current issues concerning radiological safety. UOIT is uniquely positioned to ensure its graduate program and research efforts are timely, relevant, and responsive to the province's needs.

The following are examples of research capability at UOIT that will strengthen UNENE and leverage the collaborations promoted by participating in coordinated research conducted with UNENE support.

- **Health Physics and Environmental Safety** is the research area for the UNENE Chair at UOIT. The principal aim of this research is to minimize the radiation hazards to workers, the general public, and non-human biota that may result from the operation of nuclear power plants and related facilities. The scope of the research ranges from measuring, modelling, and mapping present and expected radiation fields inside nuclear power plants and in areas extending out from the power plant into urban and rural areas. Such research will incorporate the following elements: development of innovative devices to measure radiation fields in designated localities in real time; computer modeling of radiation fields; risk assessment of the impact of radiation released as a result of nuclear power plant operations on human and non-human biota; and the development of an on-line health physics and environmental protection information management system.

- **Neutronics Modelling:** Research is ongoing to improve the accuracy of the neutron-flux and power calculations for static as well as dynamic nuclear reactor behaviour. The objective is to develop methods for calculating the detailed fuel-pin-level, neutron flux, and power distribution in a nuclear reactor at an acceptable computational cost. Several approaches are being considered, including global-local iterations and heterogeneous finite elements. For each of these approaches, parallel, high-performance computing implementations are also being investigated. Methods of combining calculation results with detector measurements for a more accurate determination of the neutron flux are also being pursued. There are a number of opportunities for cooperation between this research and the work done under the McMaster University chair and associate chair in Nuclear Safety Analyses and Thermal Hydraulics.

- **Multiphysics Reactor Simulation:** Given the advances in computing power, there is increased interest in the nuclear industry for detailed simulation of reactor behaviour through coupled neutronics, thermalhydraulics, and radiation field calculations. To date, each of these areas has been developed independently and models and data representations are not always compatible. Research in this field is focused on establishing a common framework to allow communication and data exchange between the three models, and on modifying each of the individual models to ensure compatibility with the others. The opportunity exists for UOIT researchers to combine their efforts with those of colleagues at McMaster and at Waterloo to significantly improve the simulation models available to support design, safety analysis, commissioning, and operations.

- **Nuclear Fuel:** Funding of the Cameco Research Chair in Nuclear Fuel ($1.5M over five years) was announced on April 12, 2007. The Chair Professor, Dr. Brian Ikeda of UOIT's Faculty of Energy Systems and Nuclear Science, leads a team studying the physical and chemical processes affecting the production of nuclear fuel, in particular the corrosive processes in the electrochemical cells that produce the fluorine required to generate Uranium Hexafluoride (UF_6). UNENE is already supporting research into aspects of nuclear fuel at the Royal Military College that are significantly different from the work planned at UOIT. Regular meetings between the two groups will ensure that the respective research is complementary.

Industry Experience of the Faculty

As a result of the unique combination of UOIT's mandate to be "market driven" and the lack of nuclear engineering degree programs at Canadian universities, most of the faculty members joining the Nuclear Engineering program have strong industrial backgrounds. The following table summarizes this industry experience:

Name	Former company	Years
Bereznai, George – Professor	Ontario Power Generation	30
Gabbar, Hossam – Associate Professor	Abu Dhabi National Oil & Gas Co., UAE	18
Harvel, Glenn – Associate Professor	Atomic Energy of Canada Ltd	11
Ikeda, Brian – Associate Professor	Atomic Energy of Canada Ltd	25
Machrafi, Rachid – Assistant Professor	Bubble Technology Industries Inc	3
Meneley, Daniel – Acting Dean	Atomic Energy of Canada Ltd Ontario Power Generation	10 12
Nichita, Eleodor – Assistant Professor	Atomic Energy of Canada Ltd	6
Pioro, Igor – Associate Professor	Atomic Energy of Canada Ltd Institute of Thermal Physics, Kiev	6 13
Waker, Anthony – Professor	Atomic Energy of Canada Ltd	13
Waller, Edward – Associate Professor	Science Applications International Corp.	15

Naturally, UOIT will continue to capitalize on these existing relationships, as well as initiating new collaborations. Arrangements have been made to share ideas, projects, software tools, equipment, and laboratories in order to augment the resources available to faculty and students on the UOIT campus.

Computing Resources (SHARCNET)

UOIT is a member of SHARCNET (Shared Hierarchical Academic Research Computer Network (http://www.sharcnet.ca)), a high-performance computing consortium of 9 universities and 2 colleges based in South-Central Ontario. A high-speed optical network connects the computing facilities located at each institution. At present, the majority of the computational facilities are located at McMaster University, the University of Western Ontario, and the University of Guelph; however, UOIT faculty and their research groups have access to any part of this state-of-the-art computing facility. SHARCNET was successful in a recent 2004 CFI Innovation Fund competition ($48.3M), which will result in a significant expansion of the facility. With the new funding, it is projected that SHARCNET will become one of the top 100 High-Performance Computing facilities in the world. As part of this expansion, UOIT will acquire a small ‘development cluster’ of approximately 32 processors that will be located on-site. This, combined with other local equipment, will give students involved with computational problems in nuclear engineering the ability to work with state-of-the-art computing infrastructure.

Unique Nuclear Research Facilities

The Faculty of Energy Systems and Nuclear Science has various laboratories available to support graduate studies coursework and research. The simulation lab contains a state-of-the-art computer and display system for simulation of nuclear power plants, such as the Pickering and Darlington nuclear-electric generating units, and the Faculty has the capability to develop software for advanced reactor designs.

A state-of-the-art aerosol research laboratory (Room UA B408) is used to investigate potential hazards from terrorist use of radiological dispersal devices (RDDs). The research is widely applicable to determination of hazards from airborne radioactive contaminants.

The existing nuclear design lab in Simcoe 1006 will support thermalhydraulic experiments in fundamental phenomena applicable to CANDU, ACR, MAPLE, PWR, and BWR type nuclear reactors. The laboratory currently contains the following equipment:

- A vertical annulus test section for two-phase flow representing steam generators and PWR/BWR technology.
- An Electrohydrodynamic (EHD) Test Section for the study of electric forces on fluid flow and heat transfer. (Applicable to EHD type heat exchangers and condensers).
- A full length/full scale CANDU fuel channel complete with mock fuel bundles.
- A MAPLE nuclear reactor fuel channel.
- A high speed ultrasonic system for measurement of two-phase flow parameters.
- A capacitance based system for measurement of two-phase flow parameters.
- Computers and associated thermalhydraulic codes for numerical analysis.

Future plans include the expansion of this facility for the study of advanced reactor concepts such as generation IV technology and integrated research programs combining nuclear design, thermalhydraulics, radiation, materials, and chemistry. Nuclear Thermalhydraulics is a limiting category in design optimization, life performance, and safety margins for nuclear reactors and nuclear power plants. The construction of this dedicated space will enable faculty and students to pursue significant research and development in the following important areas:

- Mechanistic modeling of critical heat flux.
- Applications in waste heat utilization.
- High temperature fluid behaviour including supercritical fluids.
- Development of experimental databases for code validation purposes.
- High temperature materials properties and behaviour.
- Study unique geometries for design optimization: fuel bundles, feeder arrays, etc.

As an integral part of the Faculty's proposed research program in Health Physics and Environmental Safety, specialized laboratories are being established for environmental radiation measurements and radiation detector development. The existing Environmental Radiation and Corrosion Lab, located in UA3680 of the Science Building, is equipped with a full range of counting equipment, including liquid scintillation counters and gamma spectrometry systems and fume-hoods for the handling and management of contaminated samples.

A Radiation Detector Development Laboratory is being developed for the custom design, construction and testing of advanced gas ionization detectors used for radiation protection dosimetry such as low-pressure tissue equivalent proportional counters and gas electron multipliers. Coupled with these detectors are the electronic and computer facilities necessary for the development of advanced data acquisition systems and control software. This latter laboratory is expected to be functioning by the end of May 2007.

In addition to the existing and planned facilities on the UOIT campus, the Faculty of Energy Systems and Nuclear Science have had preferred access to neutron beam port facilities and accelerator facilities at McMaster University, and materials and chemistry labs at the AECL - Whiteshell Laboratories, and at Cameco's Port Hope facility. The links to these facilities and others will be actively pursued.

2. THE FACULTY

2.1 List of Current Faculty by Field

Table 2-1 lists the faculty members involved in the graduate program and identifies their research field, gender, home unit, and supervisory privileges. With the abolition of compulsory retirement in Ontario, prediction of faculty retirements has become highly uncertain, so only one case of probable retirement in the next seven years is noted in Table 2-1.

Although most of these professors are classified as Category 3 because they are involved in the teaching and supervision of previously developed UOIT graduate programs, there is a core group of nuclear scientists whose involvement will be primarily with the Nuclear Engineering Program. As members of the Faculty of Energy Systems and Nuclear Science, their academic qualifications, experience, and research interests are most closely aligned with the foci and fields of the proposed program.

This core faculty group includes:

Dr George Bereznai – Professor and Dean of the Faculty of Energy Systems and Nuclear Science (currently on Academic Leave)

Dr Daniel Meneley – Acting Dean

Dr Hossam Gabbar – Associate Professor

Dr Glenn Harvel – Associate Professor

Dr Brian Ikeda – Associate Professor

Dr Matthew Kaye – Assistant Professor

Dr Lixuan Lu – Assistant Professor

Dr Rachid Machrafi – Assistant Professor

Dr Eleodor Nichita – Assistant Professor

Dr Igor Pioro – Associate Professor

Dr Anthony Waker – Professor

Dr Edward Waller – Associate Professor

Table 2-1 on the following page lists 11 full-time faculty members and 7 part-time definite term complementary academic instructors, sessional lecturers, and adjunct professors. Note, Dr Meneley, the Acting Dean in 2008-09, is counted as an adjunct professor. Additionally, 15 full-time faculty members from other faculties have been identified as having research interests complimentary to those in the Faculty of Energy Systems and Nuclear Science. These individuals have been assigned co-supervisory status. Graduate faculty appointments, categories of graduate teaching, and supervision privileges are described in Section 2 of Appendix B: General Policies and Procedures for Graduate Studies at the UOIT. Curricula Vitae for the faculty members listed in Table 2-1 are provided in Volume II of this submission.

Table 2-1: Faculty Members by Field

Faculty Name & Rank	M/F	Ret. Date	Home Unit [2]	Supervisory Privileges	Field 1[3]	Field 2[3]
Category 1						
Gabbar, Hossam – Associate Professor	M		FESNS	Full	**X**	**X**
Machrafi, Rachid – Assistant Professor	M		FESNS	Full	**X**	**X**
Pioro, Igor – Associate Professor	M		FESNS	Full	**X**	**X**
Waker, Anthony – Professor	M		FESNS	Full	**X**	**X**
Category 3						
Aruliah, Dhavide – Assistant Professor	M		FS	Co-supervision	**X**	**X**
Bereznai, George – Professor	M	2012	FESNS	Full	**X**	**X**
Berg, Peter – Assistant Professor	M		FS	Co-supervision	**X**	
Buono, Pietro-Luciano – Assistant Professor	M		FS	Co-supervision	**X**	**X**
Dincer, Ibrahim – Professor	M		FEAS	Co-supervision	**X**	
Forbes, Shari – Assistant Professor	F		FS	Co-supervision		**X**
Gabriel, Kamiel – Professor	M		Associate Provost - Research	Co-supervision	**X**	
Green, Mark – Professor	M		FS	Co-supervision	**X**	
Green-Johnson, Julia – Assistant Professor	F		FS	Co-supervision		**X**
Harvel, Glenn – Associate Professor	M		FESNS	Full	**X**	**X**
Holdway, Doug – Professor	M		FS	Co-supervision	**X**	**X**
Ikeda, Brian – Associate Professor	M		FESNS	Full	**X**	**X**
Kaye, Matthew – Assistant Professor	M		FESNS	Full	**X**	**X**
Lewis, Greg – Assistant Professor	M		FS	Co-supervision	**X**	**X**
Lu, Lixuan – Assistant Professor	F		FEAS/FESNS	Full	**X**	**X**
Marceau, Richard – Professor	M		Provost	Co-supervision	**X**	
Naterer, Greg – Professor	M		FEAS	Co-supervision	**X**	
Nichita, Eleodor – Assistant Professor	M		FESNS	Full	**X**	**X**
Nokleby, Scott – Assistant Professor	M		FEAS	Co-supervision	**X**	
Rosen, Marc– Professor	M		FEAS	Co-supervision	**X**	
Waller, Edward – Associate Professor	M		FESNS	Full	**X**	**X**
Category 4						
Bennett, Michael – Associate Dean FEAS	M		FEAS	Co-supervision	**X**	
Category 6						
Dymarski, Mike – Sessional Lecturer	M		FESNS	Co-supervision	**X**	
Ghafouri, Reza – Definite Term Complementary Academic Instructor	M		FESNS	Co-supervision	**X**	

Keshavarz, Ali – Definite Term Complementary Academic Instructor	M		FESNS	Co-supervision	**X**	
Meneley, Daniel – Adjunct Professor	M		FESNS	Co-supervision	**X**	
Neil, Barry – Definite Term Complementary Academic Instructor	M		FESNS	Co-supervision		**X**
Rouben, Benjamin – Adjunct Professor	M		FESNS	Co-supervision	**X**	
Schwanke, Peter – Sessional Lecturer	M		FESNS	Co-supervision	**X**	

Category 1: tenured or tenure-track core faculty members whose graduate involvement is exclusively in the graduate program under review. For this purpose the Master's and doctoral streams of a program are considered as a single program. Membership in the graduate program, not the home unit, is the defining issue.

Category 2: non-tenure-track core faculty members whose graduate involvement is exclusively in the graduate program under review.

Category 3: tenured or tenure-track core faculty members who are involved in teaching and/or supervision in other graduate program(s) in addition to being a core member of the graduate program under review.

Category 4: non-tenure track core faculty members who are involved in teaching and/or supervision in other graduate program(s) in addition to being a core member of the graduate program under review.

Category 5: other core faculty: this category may include emeritus professors with supervisory privileges and persons appointed from government laboratories or industry as adjunct professors.

Category 6: non-core faculty members who participate in the teaching of graduate courses.

[2] FEAS: Faculty of Engineering and Applied Science
FESNS: Faculty of Energy Systems and Nuclear Science
FS: Faculty of Science

[3] Field 1: Nuclear Power and Energy Applications
Field 2: Radiological and Health Physics

2.1.2 New Faculty Requirements/Gaps to be Filled

One Professor will be hired in the area of nuclear engineer/reactor physics in 2009 to support the education and research in advanced neutronic analysis. Another professor will be added in the next 4 years to complement the existing team.

UOIT is open to offering adjunct professorships both to well-qualified external academics and to professionals with extensive industrial experience, who would contribute to the program in terms of student supervision and teaching of the graduate courses. UOIT's access to a large number of nuclear engineering professionals at OPG's facilities in Durham Region, as well as in the Greater Toronto Area, has already provided the Faculty with an ample supply of adjunct faculty with extensive academic and industrial experience.

2.2 External Operating Research Funding

Table 2-2a presents the external research funding that faculty members have received to date since 2001. Note that the funding listed represents only confirmed funding and shall increase as the faculty members successfully secure additional funding. Since the first faculty member started at UOIT in 2003, the funding in Table

2-2a for the years 2001 to 2003 represents funding secured by UOIT faculty members while at other institutions.

Table 2-2a: Operating Research Funding by Source and Year

Year[1]	Granting Councils [2]	Other Peer Adjudicated [3]	Contracts	Others [4]
2001	297,523	66,370	27,375	29,530
2002	846,189	46,750	125,699	149,243
2003	670,227	38,000	70,425	109,625
2004	704,090	88,172	69,095	482,500
2005	537,835	140,122	197,946	435,067
2006	607,090	111,980	259,147	275,500
2007	1,987,012	2,358,814	246,547	195,000
2008	1,387,319	3,509,146	4,090,373	290,000
2009	1,845,022	3,421,866	3,921,533	369,000
Totals	8,882,307	9,781,220	9,008,140	2,335,465

2 NSERC, Atlantic Innovation Fund, Australia Research Council, CFI, Tier 1 CRC, Government of Japan, UNENE

3 Ontario Research Fund, Ontario Centres of Excellence, MITACS: MMSC project, PREA, Auto 21, CERG, Canadian Design Engineering Network, International Opportunities Fund, Environment Canada, Ontario Ministry of Health and Long-term Research, Canadian Health Services Research Foundation, American Health Assistance Foundation, National Heart Foundation, Ontario Ministry of Agriculture and Food, Nova Scotia Health Research Foundation, Nova Scotia Department of Agriculture & Fisheries, Canadian Foundation for Diabetic Research, Canadian Space Agency, Public Works & Government Services Canada

4 UOIT, Atomic Energy of Canada (AECL), King Fahd University of Petroleum & Minerals, City University of Hong Kong, Microsoft, Canadian Nuclear Society, JP Bickell Foundation, Garfield Kelly Cardiovascular Research & Development Fund, Nuclear Waste Management Association, Okayama University Research Support

Table 2-2b presents the total external research funding for 2001-2009. As with Table 2-2a, the amounts in Table 2-2b represent only the confirmed funding and shall increase as the faculty members successfully secure funding from the various sources listed in the footnotes above and from industry. As the number of faculty members increases over the next few years, it is fully expected that the funding presented in Tables 2-2a and 2-2b will increase substantially.

As noted in Table 2-1: Faculty Members by Field, some faculty members have the qualifications and expertise to contribute equally to the teaching of courses and supervision of students in both fields. A separate category has been added to this table to denote the funding totals from that group.

Table 2-2b: Total External Research Funding by Source and Field - 2001-2009

	Granting Councils	Other Peer Adjudicated	Contracts	Others
Field 1	4,897,234	8,997,790	7,783,663	797,590
Field 2	925,133	441,530	72,824	331,375
Combined Fields 1 and 2	3,059,940	341,900	1,151,653	1,206,500
Totals	8,882,307	9,781,220	9,008,140	2,335,465

2.3 Graduate Supervision

Table 2-3a lists the completed and current numbers of thesis supervisions by faculty member. Table 2-3a shows that although UOIT does not yet have a graduate program in Nuclear Engineering, the faculty members are active in co-supervising students with professors at other institutions in Ontario and Canada. A number of the faculty members involved in the proposed program currently hold adjunct appointments at other universities. These adjunct appointments are listed at the end of Section 2.3.

Table 2-3a: Completed and Current Numbers of Thesis Supervisions by Faculty Member

	Completed			Current		
Member	**Master's**	**PhD**	**PDF**	**Master's**	**PhD**	**PDF**
Category 1						
Gabbar, Hossam – Associate Professor	**24**	**3**	**1**	**1**	**2**	0
Machrafi, Rachid – Assistant Professor	**1**	0	0	0	0	0
Pioro, Igor – Associate Professor	0	0	0	**3**	0	0
Waker, Anthony – Professor	**3**	**5**	0	**3**	0	0
Category 3						
Aruliah, Dhavide – Assistant Professor	**1**	**1**	**1**	**2**	**1**	0
Bereznai, George – Professor	**2**	0	0	0	0	0
Berg, Peter – Assistant Professor	0	0	**1**	**3**	**1**	0
Buono, Pietro-Luciano – Assistant Professor	**1**	0	0	0	**1**	0
Dincer, Ibrahim – Professor	**10**	**8**	**17**	**14**	**9**	**6**
Forbes, Shari – Assistant Professor	0	**2**	0	**5**	**1**	**1**

Gabriel, Kamiel – Professor	**20**	**2**	**8**	**2**	0	**2**
Green, Mark – Professor	**13**	**10**	0	**1**	0	0
Green-Johnson, Julia – Associate Professor	**2**	0	**1**	**3**	0	0
Harvel, Glenn – Associate Professor	**4**	**1**	0	**2**	0	0
Holdway, Doug – Professor	**5**	**15**	**4**	**4**	0	**1**
Ikeda, Brian – Associate Professor	0	0	0	**1**	0	0
Kaye, Matthew – Assistant Professor	0	0	0	**1**	0	0
Lewis, Greg – Assistant Professor	0	0	0	**2**	**2**	0
Lu, Lixuan – Assistant Professor	**1**	0	**1**	**5**	0	0
Marceau, Richard – Professor	**12**	**5**	**1**	0	0	0
Naterer, Greg – Professor	**13**	**7**	**4**	**8**	**2**	**2**
Nichita, Eleodor – Assistant Professor	0	0	0	**5**	0	0
Nokleby, Scott – Assistant Professor	**3**	0	**1**	**9**	**2**	0
Rosen, Marc– Professor	**21**	**1**	**3**	**3**	**2**	**1**
Waller, Edward – Associate Professor	**3**	0	0	**3**	**1**	0
Category 4						
Bennett, Michael – Associate Dean FEAS	**27**	**2**	0	0	0	0
Category 6						
Dymarski, Mike – Sessional Lecturer	0	0	0	0	0	0
Ghafouri, Reza – Definite Term Complementary Academic Instructor	0	0	0	0	0	0
Keshavarz, Ali – Definite Term Complementary Academic Instructor	0	0	0	0	0	0
Meneley, Daniel – Adjunct Professor	**5**	**6**	0	0	0	0
Neil, Barry – Definite Term Complementary Academic Instructor	**1**	0	0	0	0	0
Rouben, Benjamin – Adjunct Professor	0	0	0	0	0	0
Schwanke, Peter – Sessional Lecturer	0	0	0	0	0	0

Adjunct Appointments of UOIT Faculty

Table 2-3b identifies the adjunct appointments held by faculty of the proposed PhD Program in Nuclear Engineering at UOIT at other Canadian universities.

Table 2-3b: Adjunct Appointments held by Faculty Members

Member	University
Aruliah, D.	University of Toronto – Department of Computer Science University of Western Ontario – Department of Applied Mathematics
Bennett, M	University of Western Ontario
Berg, P.	University of Waterloo – Department of Mechanical Engineering
Dincer, I.	Carleton University – Department of Mechanical Engineering University of Waterloo – Department of Mechanical Engineering University of Toronto – Department of Mechanical and Industrial Engineering
Harvel, G.	McMaster University – Department of Engineering Physics; McMaster Institute for Applied Radiation Sciences (McIARS)
Lewis, G.	University of Guelph – Department of Mathematics York University – Department of Mathematics
Lu, L.	University of Western Ontario – Department of Electrical Engineering
Naterer, G.	University of Manitoba – Department of Mechanical and Manufacturing Engineering University of Toronto – Department of Mechanical and Industrial Engineering
Nokleby, S.	University of Victoria – Department of Mechanical Engineering
Rosen, M.	Ryerson University – Department of Mechanical and Industrial Engineering University of Laval – Deptartment of Civil Engineering
Waker, A.	McMaster University – Department of Medical Physics
Waller, E.	Royal Military College of Canada – Department of Chemistry and Chemical Engineering Ryerson University – Department of Aerospace Engineering University of New Brunswick – Department of Mechanical Engineering

2.4 Current and Recent Teaching Assignments

Table 2-4a shows the teaching loads for the current year, 2008-09. Note that graduate courses in Nuclear Engineering (with the NUCL 5xxxG designation) appear for the first time. Table 2-4b, provides the teaching loads for 2007-08. Table 2-4c shows the teaching loads for the 2006-2007 academic year. Table 2-4d and Table 2-4e show the teaching assignments for the 2005-2006 and 2004-2005 academic years. Note that UOIT admitted its first undergraduate students in the 2003-2004 academic year. The teaching loads for that year are listed in Table 2-4f. In all six tables, the numbers in the brackets following the course code correspond to weekly Lecture/Laboratory/Tutorial hours, respectively. In the academic years before they were hired an X indicates that the faculty member was not yet on staff.

Table 2-4a: Teaching Assignments for 2008-09

Category 1	**Rank**	**Undergraduate**	**Graduate**	**Comments**
Gabbar, H.	**Associate Professor**	ENGR 2790U (3/2/2) Electric Circuits ENGR 3740U (3/3/1) Scientific Instrumentation		
Machrafi, R.	**Assistant Professor**	RADI 3530U (3/0/0) Introduction to radiological and health physics ENGR 3530U (3/0/0) Safety and quality management RADI 4320U (3/2/0) Therapeutic applications of radiation techniques RADI 4430U (3/2/0) Industrial applications of radiation techniques	NUCL 5430G Advanced dosimetry	
Pioro, I.	**Associate Professor**	ENGR 2010U (3/2/1) Thermodynamic Cycles ENGR 2860U (3/2/1) Fluid Mechanics ENGR 3930U (3/2/1) Heat Transfer	NUCL 5240G Heat Transfer in Nuclear Reactor Applications	Graduate Program Director
Waker, A.	**Professor**	RADI 4220U (3/0/2) Radiation Biophysics and Dosimetry RADI 4995U (1/4/1) Thesis Project I RADI 4999U (1/4/1) Thesis Project II	NUCL 5060G Nuclear Concepts for Engineers and Scientists	UNENE Chairholder for Health Physics and Environmental Safety Program Director for Undergraduate Radiation Science
Category 3				
Aruliah, D.	**Assistant Professor**	MATH 2070U (3/0/1) Numerical Methods MATH 2072U (3/0/1) Computational Science I MATH 3060U (3/0/0) Complex Analysis	MCSC 6020G Numerical Analysis MCSC 6220G Advanced Topics in Numerical Analysis	
Bereznai, G.	**Professor**	Academic Leave		Dean, Faculty of Energy Systems and Nuclear Science
Berg, P.	**Assistant Professor**	ENVS 2010U (3/0/0) Introductory Environment Science ENVS 3020U (3/0/0) Introductory Energy Science PHY 3060U (3/3/0) Fluid Mechanics	MCSC 6010G Mathematical Modelling (20%)	
Buono, P-L.	**Assistant Professor**	MATH 3020U (3/0/1) Real Analysis MATH 4030U (3/0/0) Applied Functional Analysis	MCSC 6000G Modelling and Computational Science Seminar Coordinator MCSC 6010G Mathematical Modelling MCSC 6030G High-Performance Computing MATH 927 Equivariant	Graduate Program Director – Modelling and Computational Science Math 927 - At Queen's University

			Bifurcation Theory (Reading)	
Dincer, I.	**Professor**	ENGR 2320U (3/1/1) Thermodynamics ENGR 3260U (3/0/0) Introduction to Energy Systems ENGR 3930U (3/2/1) Heat Transfer	ENGR 5100G Advanced Energy Systems	
Forbes, S.	**Assistant Professor**	FSCI 3040U (3/4/0) Forensic Chemistry FSCI 4020U (3/1.5/0) Interdisciplinary Topics in Forensic Science	APBS 6400G Advanced Topics in Forensic Bioscience	
Gabriel, K.	**Professor**			Associate Provost, Research
Green, M.	**Professor**	CSCI 1200U (3/0/2) Computers and Media CSCI 2160U (3/2/0) Digital Media CSCI 3090U (3/2/0) Scientific Visualization and Computer Graphics CSCI 4020U (3/0/1) Compilers		
Green-Johnson, J.	**Associate Professor**	Research Leave		Research Leave
Harvel, G.	**Associate Professor**	ENGR 4520U (3/0/1) Nuclear Plant Safety Design ENGR 4700U (3/0/1) Nuclear Plant Design & Simulation ENGR 4780U (3/0/1) Nuclear Reactor Design	NUCL 5230G Advanced Nuclear Thermalhydraulics	Program Director for Undergraduate Nuclear Engineering
Holdway, D.	**Professor**	BIOL 2010U (3/3/2) Introductory Physiology BIOL 4030U (3/0/0) Advanced Topics in Environmental Toxicology		
Ikeda, B.	**Associate Professor**	ENGR 4620U (3/0/1) Radioactive Waste Management Design	NUCL 5080G Advanced Topics in Environmental Degradation of Materials	Cameco Research Chair in Nuclear Fuels
Kaye, M.	**Assistant Professor**	ENGR 2140U (2/0/2) Problem Solving, Modelling & Simulation ENGR 4610U (3/0/1) Corrosion for Engineers ENGR 4680U (3/0/0) Nuclear Materials	NUCL 5450G (3/0/0) Advanced Materials Analysis	
Lewis, G.	**Assistant Professor**	MATH 1850U (3/0/2) Linear Algebra for Engineers MATH 4050U (3/0/0) Dynamical Systems	MCSC 6150G Numerical Methods for Ordinary Differential Equations	
Lu, L.	**Assistant Professor**	Maternity Leave		Maternity Leave
Marceau, R.	**Professor**			Provost
Naterer, G.	**Professor**	ENGR 2860U (3/1/1) Fluid Mechanics		Tier 1 CRC: Advanced Energy Systems Director Research, Graduate Studies & Development

Nichita, E.	**Assistant Professor**	ENGR 2500U (3/0/1) Intro to Nuclear Physics RADI 3200U (3/0/0) Medical Imaging	NUCL 5210G Advanced Reactor Physics NUCL 5030G/MCSC 6160G Transport Theory	
Nokleby, S.	**Assistant Professor**	ENGR 4280U (3/1/1) Robotics and Automation ENGR 4320U (3/3/0) Advanced Mechatronics ENGR 4330U (3/3/0) Mechatronic Systems Design I ENGR 4331U (0/3/1) Mechatronic Systems Design II	ENGR 5262G Manipulator and Mechanism Design	
Rosen, M.	**Professor**	ENGR 4450U (0.75/0.25/0.25) Thermal Environmental Engineering (*25%*)		
Waller, E.	**Associate Professor**	ENGR 2950U (3/2/0) Radiation Protection ENGR 3570U (3/2/0) Environmental Effects of Radiation RADI 2100U (3/0/2) Radiological & Health Physics	NUCL 5040G Monte Carlo Methods	
Category 4				
Bennett, M.	**Associate Dean FEAS**	ENGR 3360U (3/0/0) Engineering Economics ENGR 3960U (3/0/3) Programming Languages and Compilers ENGR 4760U (3/0/0) Ethics, Law, and Professionalism for Engineers	ENGR 5005G Special Topics – Project Management for Engineers	Associate Dean FEAS
Category 6				
Dymarski, M.	**Adjunct Associate**	ENGR 3150U (3/0/0) Nuclear Plant Chemistry		
Ghafouri, R.	**Adjunct Associate**	ENGR 3280U (3/1/0) Fundamentals of Computer-Aided Design Tools ENGR 3830U (3/0/1) Wind Energy Systems ENGR 4810U (3/0/0) Nuclear Fuel Cycles		
Keshavarz, A.	**Adjunct Associate**	ENGR 3670U (3/2/0) Shielding Design ENGR 3380U (3/2/1) Strength of Materials		
Meneley, D.	**Adjunct Professor**	ENGR 4660U (3/0/1) Risk Analysis Methods ENGR 4994U (1/4/1) Thesis Design Project I	NUCL5290G Advances in Nuclear Power Plant Systems	Acting Dean FESNS
Neil, B.	**Adjunct Associate**	RADI 3550U (3/2/0) Radiation Detection & Measurement RADI 4440U (3/2/0) Radioisotopes & Radiation Machines		
Schwanke, P.	**Adjunct Associate**	ENGR 4880U (3/0/0) Principles of Fusion Energy		

Table 2-4b: Teaching Assignments for 2007-08

Category 1	Rank	Undergraduate	Graduate	Comments
Gabbar, H.	**Associate Professor**	X		
Machrafi, R.	**Assistant Professor**	X		
Pioro, I.	**Associate Professor**	ENGR 2010U (3/2/1) Thermodynamic Cycles ENGR 2860U (3/2/1) Fluid Mechanics ENGR 3930U (3/2/1) Heat Transfer		
Waker, A.	**Professor**	RADI 4220U (1.5/0/1) Radiation Biophysics and Dosimetry RADI 4320U (1.5/1/0) Medical Applications of Radiation Techniques (50%) RADI 4430U (1.5/0.5/0.5) Industrial Applications of Radiation Techniques (50%) RADI 4995U (1/4/1) Thesis Project I RADI 4999U (1/4/1) Thesis Project II RADI 3530U (0.75/0/0) Introduction to Radiological Health & Health Physics (25%)		Dr Nichita (RADI 4320U) Dr. Waller (RADI 4430U) Drs Ikeda, Nichita, and Waller (RADI 3530U)
Category 3				
Aruliah, D.	**Assistant Professor**	MATH 2860U (3/0/1) Differential Equations for Engineers MATH 2070U (3/0/1) Numerical Methods MATH 2072U (3/0/1) Computational Science I MATH 3060U (3/0/0) Complex Analysis	MCSC 6020G Numerical Analysis MCSC 6220G Advanced Topics in Numerical Analysis (reading)	
Bereznai, G.	**Professor**	ENGR 3860U (3/0/2) Introduction to Nuclear Reactor Technology ENGR 4994U (1/4/1) Thesis Design Project	UN 0801 Nuclear Plant Systems and Operation McMaster University	Dean, Faculty of Energy Systems and Nuclear Science
Berg, P.	**Assistant Professor**	ENVS 2010U Introductory Environment Science PHY 2030U (3/3/2) Mechanics I PHY 3060U (3/3/0) Fluid Mechanics PHY 4020U (3/0/0) Quantum Mechanics II	MCSC 6010G Mathematical Modelling (20%)	
Buono, P-L.	**Assistant Professor**	MATH 3020U (3/0/0) Real Analysis MATH 4030U (3/0/0) Applied Functional Analysis PHY 3040U (3/0/0) Mathematical Physics	MCSC 6000G Modelling and Computational Science Seminar Coordinator MCSC 6010G Mathematical Modelling MCSC 6030G High-Performance	Graduate Program Director – Modelling and Computational Science

			Computing	
Dincer, I.	**Professor**	ENGR 2320U (3/1/1) Thermodynamics ENGR 3260U (3/0/0) Introduction to Energy Systems ENGR 3930U (3/2/1) Heat Transfer	ENGR 5100G Advanced Energy Systems	
Forbes, S.	**Assistant Professor**	CHEM 3530U (2/4/0) Instrumental Analytical Chemistry I FSCI 3040U (3/4/0) Forensic Chemistry		
Gabriel, K.	**Professor**			Associate Provost, Research
Green, M.	**Professor**	CSCI 1020U (3/0/2) Fundamentals of Programming (CSCI 1600U prev) CSCI 2110U (3/0/2) Discrete Structures in Computer Science (CSCI 1010U prev) CSCI 3010U (3/0/2) Simulation and Modelling CSCI 3090U (3/2/0) Scientific Visualization and Computer Graphics		
Green-Johnson, J.	**Associate Professor**	BIOL 2830U (3/0/0) Microbiology for Health Science (prev.BIOL 1820) (hybrid and distance/on-line course) BIOL 3030U (3/3/0) Microbiology and Immunology MLSC 2131U (3/6/0) Clinical Microbiology I MLSC 3130U (3/3/0) Clinical Microbiology		
Harvel, G.	**Associate Professor**	ENGR 4520U (3/0/1) Nuclear Plant Safety Design ENGR 4700U (3/0/1) Nuclear Plant Design & Simulation ENGR 4780U (3/0/1) Nuclear Reactor Design		
Holdway, D.	**Professor**	BIOL 2010U (3/3/2) Introductory Physiology BIOL 4030U (3/0/0) Advanced Topics in Environmental Toxicology		
Ikeda, B.	**Associate Professor**	ENGR 4610U (1.5/0/0) Corrosion for Engineers ENGR 4620U (3/0/1) Radioactive Waste Management Design RADI 3530U (0.75/0/0) Introduction to Radiological Health & Health Physics (25%)		Cameco Research Chair in Nuclear Fuels Dr Kaye (ENGR 4610U) Drs Nichita, Waker, and Waller (RADI 3530U)
Kaye, M.	**Assistant Professor**	ENGR 2140U (1/0/1) Problem Solving, Modelling & Simulation ENGR 4680U (3/0/0) Nuclear Materials ENGR 4610U (1.5/0/0) Corrosion for Engineers		Rob Anderson (ENGR 2140U) Dr Ikeda (ENGR 4610U)
Lewis, G.	**Assistant Professor**	MATH 1850U (3/0/2) Linear Algebra for Engineers MATH 4050U (3/0/0) Dynamical Systems	MCSC 6150G Numerical Methods for Ordinary Differential Equations	
Lu, L.	**Assistant Professor**	ENGR 2450U (3/1.5/2) Digital Systems ENGR 2790U (3/1.5/1) Electric Circuits		

		ENGR 4730U (3/0/0) Reactor Instrumentation & Control		
Marceau, R.	**Professor**			Provost
Naterer, G.	**Professor**	ENGR 2640U (3/2/1) Thermodynamics and Heat Transfer		
Nichita, E.	**Assistant Professor**	ENGR 2500U (3/0/1) Intro to Nuclear Physics ENGR 3820U (3/0/1) Nuclear Reactor Kinetics RADI 3200U (3/0/0) Medical Imaging RADI 3530U (0.75/0/0) Introduction to Radiological Health & Health Physics (25%) RADI 4320U (1.5/1/0) Medical Applications of Radiation Techniques (50%)	UN0802: Reactor Physics (50%) – UNENE/McMaster MCSC 6220G Advance Topics in Numerical Analysis (Reading Course) MCSC 6160G (50%) Transport Theory	Drs Ikeda, Waker, and Waller (RADI 3530U) Dr Waker (RADI 4320U) Dr Waller (MCSC 6160G)
Nokleby, S.	**Assistant Professor**	ENGR 3390 (3/2/1) Mechatronics ENGR 4280 (3/1/1) Robotics and Automation ENGR 4320U (4/1/1) Advanced Mechatronics ENGR 4330U (3/0/2) Mechatronic Systems Design	ENGR 5010G Advanced Optimization	
Rosen, M.	**Professor**	Academic Leave		Dean, Faculty of Engineering and Applied Science
Waller, E.	**Associate Professor**	ENGR 2950U (3/2/0) Radiation Protection ENGR 3570U (3/2/0) Environmental Effects of Radiation RADI 2100U (3/0/2) Radiological & Health Physics RADI 3530U (0.75/0/0) Introduction to Radiological Health & Health Physics (25%) RADI 4430U (1.5/.5/.5) Industrial Applications of Radiation Techniques (50%)	AER 8135 Aerosol Mechanics – Ryerson MCSC 6160G (50%) Transport Theory	Drs Ikeda, Nichita, and Waller (RADI 3530U) Dr. Waker (RADI 4430U) Dr Nichita (MCSC 6160G)
Category 4				
Bennett, M.	**Program Director**	ENGR 3360U (3/0/0) Engineering Economics ENGR 3960U (3/0/3) Programming Languages and Compilers ENGR 4760U (3/0/0) Ethics, Law, and Professionalism for Engineers	ENGR 5005G Special Topics - Project Management for Engineers	
Category 6				
Dymarski, M.	**Adjunct Associate**	ENGR 3150U (3/0/0) Nuclear Plant Chemistry		
Ghafouri, R.	**Adjunct Associate**	ENGR 3280U (3/1/0) Fundamentals of Computer-Aided Design Tools ENGR 3830U (3/0/1) Wind Energy Systems ENGR 4810U (3/0/0) Nuclear Fuel Cycles		
Keshavarz, A.	**Adjunct Associate**	ENGR 3670U (3/2/0) Shielding Design ENGR 3380U (3/2/1) Strength of Materials		
Meneley, D.	**Adjunct Professor**	ENGR 4660U (3/0/1) Risk Analysis Methods		

Neil, B.	**Adjunct Associate**	RADI 2110U (1/3/3) Health Physics Laboratory RADI 3550U (3/2/0) Radiation Detection & Measurement RADI 4440U (3/2/0) Radioisotopes & Radiation Machines		
Schwanke, P.	**Adjunct Associate**	ENGR 4880U (3/0/0) Principles of Fusion Energy		

Table 2-4c: Teaching Assignments for 2006-07

Category 1	Rank	Undergraduate	Graduate	Comments
Gabbar, H.	**Associate Professor**	X		
Machrafi, R.	**Assistant Professor**	X		
Pioro, I.	**Associate Professor**	ENGR 3930U (3/2/1) Heat Transfer ENGR 2010U (3/2/1) Thermodynamic Cycles		
Waker, A.	**Professor**	RADI 3220U (3/0/2) Radiation Biophysics and Dosimetry RADI 4320U (1.5/1/0) Medical Applications of Radiation Techniques RADI 4430U (1.5/.5/.5) Industrial Applications of Radiation Techniques RADI 4995U (1/4/1) Thesis Project I		
Category 3				
Aruliah, D.	**Assistant Professor**	MATH 2010U (3/0/1) Advanced Calculus I MATH 2020U (3/0/1) Advanced Calculus II MATH 2860U (3/0/1) Differential Equations for Engineers MATH 3060U (3/0/0) Complex Analysis		
Bereznai, G.	**Professor**	ENGR 4994U (1/4/1) Thesis Design Project ENGR 4640U (3/0/1) Nuclear Plant Operation ENGR 3860U (3/0/2) Introduction to Nuclear Reactor Technology		Dean, Faculty of Energy Systems and Nuclear Science
Berg, P.	**Assistant Professor**	PHY 1010U (3/3/2) Physics I PHY 2030U (3/3/2) Mechanics I PHY 2040U (3/0/2) Mechanics II PHY 3060U (3/3/0) Fluid Mechanics PHY 4020U (3/0/0) Quantum Mechanics II		
Buono, P-L.	**Assistant Professor**	MATH 2060U (3/0/1) Differential Equations MATH 3020U (3/0/0) Real Analysis MATH 3070U (3/0/0) Algebraic Structures PHY 3040U (3/0/0) Mathematical Physics	MATH 837 Bifurcation Theory and Symmetry	At Queen's University
Dincer, I.	**Professor**	ENGR 2320U (3/1/1) Thermodynamics ENGR 3260U (3/0/0) Introduction to Energy Systems ENGR 3450U (3/2/1) Combustion and Engines ENGR 3930U (3/2/1) Heat Transfer ENGR 2860U (3/2/1) Fluid Mechanics		
Forbes, S.	**Assistant Professor**	CHEM 3530U (2/4/0) Instrumental Analytical Chemistry I CHEM 3540U (2/4/0) Instrumental Analytical Chemistry II FSCI 1010U (3/0/2) Introductory Forensic Science FSCI 2010U (3/3/3) Crime Scene Science		

Gabriel, K.	**Professor**			Associate Provost, Research
Green, M.	**Professor**	CSCI 1010U (3/0/2) Discrete Structures in Computing Science CSCI 1020U (3/0/2) Fundamentals of Programming (CSCI1600 prev) CSCI 3010U (3/0/2) Simulation and Modelling CSCI 3090U (3/2/0) Scientific Visualization and Computer Graphics MATH 2880U (3/0/2) Discrete Mathematics (=CSCI 1010)		
Green-Johnson, J.	**Assistant Professor**	BIOL 2030U (0/3/2) Cell Biology BIOL 2830U (3/0/0) Microbiology for Health Sc. (prev.BIOL 1820) BIOL 3030U (3/3/0) Microbiology and Immunology BIOL 3650U (3/0/0) Fundamentals of Nutrition		
Harvel, G.	**Associate Professor**	ENGR 2860U (3/2/1) Fluid Mechanics ENGR 4700U (3/0/1) Nuclear Plant Design & Simulation ENGR 3780U (3/0/1) Nuclear Reactor Design		
Holdway, D.	**Professor**	BIOL 2010U (3/3/2) Introductory Physiology BIOL 4030U (3/0/0) Advanced Topics in Environmental Toxicology		
Ikeda, B.	**Associate Professor**	ENGR 3610U (3/0/0) Corrosion for Engineers ENGR 3640U (3/0/1) Radioactive Waste Management		Cameco Research Chair in Nuclear Fuels
Kaye, M.	**Assistant Professor**	X		
Lewis, G.	**Assistant Professor**	MATH 1850U (3/0/2) Linear Algebra for Engineers MATH 2050U (3/0/0) Linear Algebra (with 1850) MATH 2070U(3/0/1) Numerical Methods/Computation Science I MATH 2072U MATH 3050U (3/0/0) Mathematical Modeling		
Lu, L.	**Assistant Professor**	ENGR 2360U (3/0/2) Electric Power Systems ENGR 3740U (3/3/1) Scientific Instrumentation ENGR 4730U (3/0/0) Reactor Instrumentation & Control		
Marceau, R.	**Professor**			Provost
Naterer, G.	**Professor**	ENGR 2640U (3/2/1) Thermodynamics and Heat Transfer		
Nichita, E.	**Assistant Professor**	ENGR 2500U (3/0/1) Intro to Nuclear Physics ENGR 3820U (3/0/1) Nuclear Reactor Kinetics RADI 3200U (3/0/0) Medical Imaging RADI 4320U (1.5/1/0) Medical Applications of Radiation Techniques (50%)		Dr. Waker (RADI 4320U)
Nokleby, S.	**Assistant Professor**	ENGR 4280U (3/1/1) Robotics & Automation ENGR 3390U (3/1/1) Mechatronics	ENGR 5260G Advanced Robotics and Automation	
Rosen, M.	**Professor**			Dean, Faculty of Engineering and Applied Science

Waller, E.	**Associate Professor**	ENGR 2140U (1/0/1) Problem Solving, Modelling & Simulation (50%) ENGR 2950U (3/2/0) Radiation Protection ENGR 3570U (3/2/0) Environmental Effects of Radiation RADI 2100U (3/0/2) Radiological & Health Physics RADI 2110U (1/3/3) Health Physics Laboratory RADI 4430U (1.5/0.5/0.5) Industrial Applications of Radiation Techniques (50%)		Rob Anderson (ENGR 2140U) Dr. Waker (RADI 4430U)
Category 4				
Bennett, M.	**Program Director**		UN 0603 / Project Management for Nuclear Engineers	University of Western Ontario
Category 6				
Dymarski, M.	**Adjunct Associate**	ENGR 3150U (3/0/0) Nuclear Plant Chemistry		
Ghafouri, R.	**Adjunct Associate**	ENGR 3280U (3/1/0) Fundamentals of Computer-Aided Design Tools ENGR 3830U (3/0/1) Wind Energy Systems ENGR 4810U (3/0/0) Nuclear Fuel Cycles		
Keshavarz, A.	**Adjunct Associate**	ENGR 3670U (3/2/0) Shielding Design ENGR 3380U (3/2/1) Strength of Materials		
Meneley, D.	**Adjunct Professor**	ENGR 4520U (3/0/1) Nuclear Plant Safety Design ENGR 4660U (3/0/1) Risk Analysis Methods		
Neil, B.	**Adjunct Associate**	RADI 3550U (3/2/0) Radiation Detection & Measurement RADI 4440U (3/2/0) Radioisotopes & Radiation Machines		
Schwanke, P.	**Adjunct Associate**	ENGR 4880U (3/0/0) Principles of Fusion Energy		

Table 2-4d: Teaching Assignments for 2005-06

	Rank	Undergraduate	Graduate	Comments
Category 1				
Gabbar, H.	**Associate Professor**	X		
Machrafi, R.	**Assistant Professor**	X		
Pioro, I.	**Associate Professor**	X		
Waker, A.	**Professor**	RADI 3220U (3/0/2)		
Category 3				
Aruliah, D.	**Assistant Professor**	MATH 2010U Advanced Calculus I MATH 2020U Advanced Calculus II MATH 2860U Differential Equations for Engineers PHY 3040U Mathematical Physics		
Bereznai, G.	**Professor**	ENGR 4640U (3/0/1) Nuclear Plant Operation ENGR 3860U (3/0/2) Introduction to Nuclear Reactor Technology	UN 0801 Nuclear Plant Systems and Operation	McMaster University sessional lecturer
Berg, P.	**Assistant Professor**	PHY 1010U (3/1.5/1)2 (2 Sections) Physics I PHY 1020U (3/1.5/1)2 (2 Sections) Physics II PHY 2030U (3/0/2) Mechanics I PHY 2040U (3/0/2) Mechanics II PHY 3060U (3/0/0) Fluid Mechanics		
Buono, P-L.	**Assistant Professor**	MATH 1010U (2 sections) Calculus I MATH 2060U Differential Equations MATH2810U Advanced Engineering Mathematics		
Dincer, I.	**Professor**	ENGR 2320U (3/1/1) Thermodynamics ENGR 2860U (3/1/1) (2 sections) Fluid Mechanics		Programs Director, Faculty of Engineering and Applied Science
Forbes, S.	**Assistant Professor**	CHEM 3530U Instrumental Analytical Chemistry I CHEM 3540U Instrumental Analytical Chemistry I FSCI 1010U Introductory Forensic Science		
Gabriel, K.	**Professor**			Associate Provost, Research
Green, M.	**Professor**	CSCI 1010U (3/0/2) Discrete Structures in Computing Science CSCI 1020U (3/0/2) Fundamentals of Programming MATH 2080U (3/0/2) Discrete Mathematics		

		SCIE 1910U (3/0/0) Science in Context		
Green-Johnson, J.	**Assistant Professor**	BIOL 1010U Biology I (50%) BIOL 2030U Cell Biology BIOL 2830U Microbiology for Health Science BIOL 3030U Microbiology & Immunology		
Harvel, G.	**Associate Professor**	X		
Holdway, D.	**Professor**	BIOL 2010U Introductory Physiology ENVS 1000U Environmental Science (25%) BIOL 3020U Principles of Pharmacology & Toxicology (50%)		
Ikeda, B.	**Associate Professor**	ENGR 3610U (3/0/0)		
Kaye, M.	**Assistant Professor**	X		
Lewis, G.	**Assistant Professor**	MATH 1850U/MATH 2050U (2 sections) Linear Algebra for Engineers/ Linear Algebra MATH 2070/MATH 2072 Numerical Methods/Computational Science I (formerly Numerical Methods) MATH 3050 Mathematical Modelling		
Lu, L.	**Assistant Professor**	ENGR 3740U (3/3/1) Scientific Instrumentation ENGR 4730U (3/0/0) Reactor Instrumentation & Control		
Marceau, R.	**Professor**	X		Provost
Naterer, G.	**Professor**	ENGR 2640U (3/1/1) Thermodynamics & Heat Transfer		
Nichita, E.	**Assistant Professor**	ENGR 2500U (3/0/1) Introduction to Nuclear Physics ENGR 3780U (3/0/1) Nuclear Reactor Design ENGR 3820U (3/0/1) Nuclear Reactor Kinetics RADI 3200U (3/0/0) Introduction to Imaging RADI 4440U (3/2/0) Radioisotopes & Radiation Machines (33%)	UN0802: Reactor Physics (50%) – UNENE/McMaster	Drs Neil and Waller (RADI 4440U)
Nokleby, S.	**Assistant Professor**	ENGR 3200U (3/1.5/1.5) Engineering Graphics & Design ENGR 3270U (3/1/1) Kinematics & Dynamics of Machines ENGR 3390U (3/1/1) Mechatronics		
Rosen, M.	**Professor**			Dean, Faculty of Engineering and Applied Science
Waller, E.	**Associate Professor**	ENGR 2140U (1/0/1) Problem Solving, Modelling & Simulation ENGR 2950U (3/2/0) Radiation Protection ENGR 3570U (3/2/0) Environmental Effects of Radiation RADI 2100U (3/0/2) Radiological & Health Physics RADI 2110U (1/3/3) Health Physics Laboratory RADI 4440U (3/2/0) Radioisotopes & Radiation Machines (33%)		Drs Neil and Nichita (RADI 4440U)
Category 4				

Bennett, M.	**Program Director**	SE312 (3/2) Introduction to Computer Networks SE313 (3/2) Operating Systems for Software Engineering		University of Western Ontario
Category 6				
Dymarski, M.	**Adjunct Associate**	X		
Ghafouri, R.	**Adjunct Associate**	X		
Keshavarz, A.	**Adjunct Associate**	X		
Meneley, D.	**Adjunct Professor**	X		
Neil, B.	**Adjunct Associate**	RADI 3550U (3/2/0) Radiation Detection & Measurement RADI 4440U (3/2/0) Radioisotopes & Radiation Machines (33%)		Drs Nichita and Waller (RADI 4440U)
Schwanke, P.	**Adjunct Associate**	X		

Table 2-4e: Teaching Assignments for 2004-05

Category 1	Rank	Undergraduate	Graduate	Comments
Gabbar, H.	**Associate Professor**	X		
Machrafi, R.	**Assistant Professor**	X		
Pioro, I.	**Associate Professor**	X		
Waker, A.	**Professor**	X		
Category 3				
Aruliah, D.	**Assistant Professor**	MATH 2010U Advanced Calculus I MATH 2020U Advanced Calculus II MATH 2860U Differential Equations for Engineers MATH 2070/2072U Numerical Methods/Computational Science I (formerly Numerical Methods)		
Bereznai, G.	**Professor**	X		Dean, Faculty of Energy Systems and Nuclear Science
Berg, P.	**Assistant Professor**	PHY 1010U (3/1.5/1) (2 Sections) Physics I PHY 1020U (3/1.5/1) (2 Sections) Physics II PHY 2030U (3/0/2) Mechanics I		
Buono, P-L.	**Assistant Professor**	MATH 1010U (2 sections) Calculus I MATH 2860U Differential Equations for Engineers MATH 2810U Advanced Engineering Mathematics		
Dincer, I.	**Professor**	ENGR 2320U (3/1/1) Thermodynamics ENGR 2860U (3/1/1) Fluid Mechanics		
Forbes, S.	**Assistant Professor**			
Gabriel, K.	**Professor**	X		Associate Provost, Research
Green, M.	**Professor**	SM 2215 (2/0/1) SM 3121 (2/0/1) SM 4130 (2/0/1)		City University of Hong Kong
Green-Johnson, J.	**Assistant Professor**	BIOL 1010U Biology I BIOL 2030U Cell Biology BIOL 1810U Biochemistry for Health Science SCIE 1900U Participation in Science in Context (team taught course)		

Harvel, G.	**Associate Professor**	X		
Holdway, D.	**Professor**	BIOL 2010U Introductory Physiology ENVS 1000U Environmental Science		
Ikeda, B.	**Associate Professor**	X		
Kaye, M.	**Assistant Professor**	X		
Lewis, G.	**Assistant Professor**	MATH 1850/2050 (2 sections) Linear Algebra for Engineers/ Linear Algebra CSCI 1020U Fundamentals of Programming		
Lu, L.	**Assistant Professor**	X		
Naterer, G.	**Professor**			
Nichita, E.	**Assistant Professor**	ENGR 2500U (3/0/1) Introduction to Nuclear Physics ENGR 3820U (3/0/1) Nuclear Reactor Kinetics		
Nokleby, S.	**Assistant Professor**	ENGR 3200 (3/1.5/1.5) Engineering Graphics & Design		
Marceau, R.	**Professor**	X		Provost
Rosen, M.	**Professor**			Dean, Faculty of Engineering and Applied Science
Waller, E.	**Associate Professor**	ENGR 2140U (1/0/1) Problem Solving, Modelling & Simulation ENGR 2950U (3/2/0) Radiation Protection RADI 2100U (3/0/2) Radiological & Health Physics RADI 2110U (1/3/3) Health Physics Laboratory		
Category 4				
Bennett, M.	**Program Director**	SE312 (3/2) Introduction to Computer Networks SE313 (3/2) Operating Systems for Software Engineering SE454 (3/0) Software Law & Social Responsibility SE310 (3/0) Theoretical Foundations of Software Engineering		U. of Western Ontario and U. of Ottawa Knowledge Institute for Gov. Professionals
Category 6				
Dymarski, M.	**Adjunct Associate**	X		
Ghafouri, R.	**Adjunct Associate**	X		
Keshavarz, A.	**Adjunct Associate**	X		
Meneley, D.	**Adjunct Professor**	X		

Neil, B.	**Adjunct Associate**	X		
Schwanke, P.	**Adjunct Associate**	X		

Table 2-4f: Teaching Assignments for 2003-04

Category 1	Rank	Undergraduate	Graduate	Comments
Gabbar, H.	**Associate Professor**	X		
Machrafi, R.	**Assistant Professor**	X		
Pioro, I.	**Associate Professor**	X		
Waker, A.	**Professor**	X		
Category 3				
Aruliah, D.	**Assistant Professor**	Calculus 1 Numerical Analysis		University of Western Ontario
Bereznai, G.	**Professor**	X	ENG PHY 6P03 Nuclear Plant Systems and Operation	McMaster University sessional lecturer
Berg, P.	**Assistant Professor**	Calculus II		Simon Fraser University
Buono, P-L.	**Assistant Professor**	Mathematical Methods for Chemists 1 Group Theory in Physics Vector Calculus		Université de Montréal
Dincer, I.	**Professor**			
Forbes, S.	**Assistant Professor**	Mysteries of Forensic Science	Research Issues Soils & Taphonomy	University of Western Australia
Gabriel, K.	**Professor**	X		Associate Provost, Research
Green, M.	**Professor**	SM 1001 (2/0/2) SM 2215 (2/0/1) SM 3120 (2/0/1) SM 3121 (2/0/1) SM 4130 (2/0/1)		City University of Hong Kong
Green-Johnson, J.	**Assistant Professor**	BIOL 1820U Microbiology for Health Science CSCI 1000U Scientific Computing Tools (team taught) SCIE 1910U Science in Context (team taught)		
Harvel, G.	**Associate Professor**	X		
Holdway, D.	**Professor**	BIOL 1010U Biology I		

		BIOL 1020U Biology II CSCI 1000U Scientific Computing Tools (team taught) SCIE 1910U Science in Context (team taught)		
Ikeda, B.	**Associate Professor**	X		
Kaye, M.	**Assistant Professor**	X		
Lewis, G.	**Assistant Professor**	MATH 1850U (2 sections) Linear Algebra for Engineers CSCI 1020U Fundamentals of Programming		
Lu, L.	**Assistant Professor**			
Marceau, R.	**Professor**			Provost
Naterer, G.	**Professor**			
Nichita, E.	**Assistant Professor**	X		
Nokleby, S.	**Assistant Professor**			
Rosen, M.	**Professor**			Dean, Faculty of Engineering and Applied Science
Waller, E.	**Associate Professor**	Impact of Science and Technology on Society MCNPX for Dosimetry Calculations		
Category 4				
Bennett, M.	**Program Director**	SE312 (3/2) Introduction to Computer Networks SE313 (3/2) Operating Systems for Software Engineering SE454 (3/0) Software Law and Social Responsibility SE310 (3/2) Theoretical Foundations of Software Engineering SEG 3310(4/2) Object Oriented Analysis, Design & Programming SEG 4100(3/3) Software Project Management GNG 2100(3/0) Topics for Engineers	EMP5117 (3/0) Foundations of Software Engineering	University of Western Ontario University of Ottawa Knowledge Institute for Government Professionals
Category 6				
Dymarski, M.	**Adjunct Associate**	X		
Ghafouri, R.	**Adjunct Associate**	X		
Keshavarz, A.	**Adjunct Associate**	X		
Meneley, D.	**Adjunct Professor**	X		
Neil, B.	**Adjunct Associate**	X		

Schwanke, P.	**Adjunct Associate**	X		

2.5 Commitment of Faculty Members from Other Graduate Programs and/or Other Institutions

All members of the Faculty of Energy Systems and Nuclear Science are involved in the MASc/MEng programs in Nuclear Engineering. Most are members of one or more additional graduate programs at UOIT.

Professor Lu holds a cross appointment between the Faculty of Engineering and Applied Science and the Faculty of Energy Systems and Nuclear Science.

3. PHYSICAL AND FINANCIAL RESOURCES

3.1 Library Resources

The University of Ontario Institute of Technology Library enriches the research, learning and teaching carried out by the university through exceptional information services and facilities to support all academic programs.

The construction of a new, state-of-the-art library for the University of Ontario Institute of Technology was completed in the fall of 2004. Designed by internationally renowned Diamond and Schmitt Architects Incorporated, the 75,000-square-foot library serves students, faculty, and staff. The four-storey, $20.7-million library houses individual and collaborative learning spaces including both group study rooms and a quiet graduate study zone, research workstations, electronic classrooms, a reading room and periodicals collection.

Library collections and accessibility are discussed in detail in Appendix A. Paper copy and electronic resources supporting the PhD in Nuclear Engineering are highlighted including the 1,750 international nuclear engineering reports housed in the Library's Special Collections room. Amongst the key databases relevant to this Program are IEEE (Institute of Electrical and Electronics Engineers), Compendex, Inspec, ASTM (American Society of Testing & Materials) Digital Library and Standards, CSA (Canadian Standards Association) Online, and INIS (International Nuclear Information System). While most databases offer indexing and/or full text for periodicals (magazines, journals, newspapers), many also offer full text for technical reports, conference proceedings and standards.

Students, staff and faculty have access to library resources using their wireless laptops, anytime from anywhere. Both digital resources and complementary print collections are available and librarians provide students with the skills needed to navigate effectively through the information environment. Tools such as JCR (Journal Citation Reports), an electronic resource that ranks journals by impact factor and indicates which journals are most frequently cited in each field, and thesis databases such as PQDT (Proquest Dissertations and Theses) and Theses Canada Portal also assist researchers in making appropriate resource selections. The Library offers free interlibrary loan service to the UOIT population.

A more detailed presentation on the library resources is listed in Appendix A: Library Submission.

3.2 Laboratory Facilities

Students in the PhD program will have access to major equipment and common facilities which have been or will be financially supported by UOIT, and through a wide range of grants and significant donations from the industry (both product manufacturers and service providers) and various government funding agencies, such as CFI, NSERC, and OCE. As the number of faculty members in the Faculty increases and the research expertise broadens over the next few years, the facilities will be enhanced by major equipment acquisitions to maintain and upgrade laboratory equipment and to reflect state-of-the-art technology and industry-focused research.

3.2.1 Environmental Radiation and Corrosion Lab

This lab is located in UA 3680 in the University's Science Building. It provides a wide variety of radiation sources and equipment used to sample and measure radiation that may be encountered in the environment. Equipment is being acquired to conduct corrosion experiments under conditions that are expected to be encountered during the manufacture of nuclear fuel and its interim, as well as long term, storage and possible disposal in deep geological formations. The research is widely applicable to determination of hazards from airborne radioactive contaminants.

3.2.2 Applied Radiation Lab

The Applied Radiation Lab is located in Room ENG B030 in the Ontario Power Generation Building. Additional neutron, gamma, alpha, and beta sources will be purchased to expand our research capability in Industrial Radiography, Radiation Physics, and Health Physics.

3.2.3 Aerosol and Radiation Research Lab

The lab is located in Room UA B408 in the Science Building. Its equipment includes a medium scale aerosol test cell incorporating a Malvern Spraytech laser diffraction particle sizer, Anderson cascade impactor with throat extension for determining respirable fractions, and portable instrumentation such as a portable particle sizer, hot wire anemometer, and thermo-hygrometer.

3.2.4 Nuclear Computations and Control Research Lab

Distributed control systems are being used more and more frequently in nuclear power plants and related industrial systems. Parallel computing is frequently needed to solve complex simulations, such as those encountered in nuclear reactor core physics calculations. Computers in the lab are used for these and related applications. This lab is located in UA 4150 in the University's Science Building.

3.2.5 Radiation Protection and Scientific Instrumentation Lab

The laboratory, located in ENG B035 in the Ontario Power Generation Building, houses the specialized equipment that helps to ensure that radiation is used safely. This includes safe use of the labs by students and staff, as well as developing techniques that protect the public and non-human biota from being exposed to unsafe levels of radiation. The equipment includes spectrometers, dosimeters, spectral and liquid scintillation analyzers, ion chambers, and NaI counting systems. Representative measuring and test instruments used in various nuclear applications, along with AD-DA and other signal processing equipment, are available for the use of researchers and graduate students.

3.2.6 Nuclear Simulation Lab

Simulation of complex systems, such as those used in power plants in general and nuclear plants in particular, is essential to their design, safety analysis, commissioning and operation. The user interface has been found to have a critical role in the safe and reliable operation of nuclear power plants. The system installed in the Simulation Lab, comprised of six 70” Hitachi Visioncubes, Jupiter 960 Wall Controller, and server-type computers capable of multiple graphical outputs, can show up to six different displays generated by a computer or recorded on a CD or DVD. This can provide the real-time display of responses of various systems of a given plant simulation, or compare the responses of different simulations of various systems. This lab is located in ENG 3035 in the Ontario Power Generation Building.

3.2.7 Nuclear Design Laboratory

The Faculty has developed a Nuclear Design Laboratory to support advanced reactor concepts such as generation IV technology and integrated research programs combining nuclear design, thermalhydraulics, radiation, materials, and chemistry. (See further details in Section 1.6.) The laboratory is located in the Simcoe Building Room 1006.

3.2.8 Advanced Materials Engineering Laboratory

This facility is used to research wood plastic composites and polymer bonding, along with other areas such as the development of production processes and the characterization of new composites, nano-materials, bio-based materials, and foamed materials. UOIT is unique in its capability to test the effects of exposure to various types and amounts of radiation on material properties. This laboratory is located in ENG 1030 in the Ontario Power Generation Building.

3.2.9 Centre for Engineering Design, Automation, and Robotics (CEDAR)

A group of faculty members from the Faculty of Engineering and Applied Science has been awarded a New Opportunities Grant from the Canada Foundation for Innovation (CFI) to purchase infrastructure for the Centre for Engineering Design, Automation, and Robotics (CEDAR). The initial infrastructure for CEDAR will comprise a reconfigurable manipulator system, a mobile-manipulator system, and a machine vision system. The facilities will be used to conduct research into robotics, mechatronics, and manufacturing. The CEDAR facilities will also be used in conjunction with the Integrated Manufacturing Centre (IMC) to increase the IMC’s ability to conduct research into flexible manufacturing. CEDAR currently has two affiliated laboratories: the Intelligent Robotics and Manufacturing Laboratory and the Mechatronic and Robotic Systems Laboratory. Nuclear-specific applications include research into the use of robotics and mechatronics in the manufacture of fuel bundles, the handling of irradiated fuel, and the use of remote inspection equipment in radiological fields.

3.2.10 UOIT Scanning Electron Microscope (SEM) Laboratory

SEM facility located in the Science Building Room UA 1660 has capabilities of secondary electronic imaging, backscatter electronic imaging, and energy dispersive X-ray spectroscopy. The facility also has a carbon coater, grinder, and stereo microscope to help prepare the samples. The Faculty of Energy System and Nuclear science will be using the SEM to examine corrosion specimens to identify corrosion products, mechanisms, and quantify damage. The morphology of the corrosion products and the microscopic characteristics of corroded surfaces are useful indicators of the corrosion mechanism. The SEM could also be used for characterizing catalytic surfaces used in fuel cell development. The pre/post- condition of an electrode surface could be used to characterize the effect of process variables on the overall performance of the electrode. This facility has greatly increased our capability to teach particle morphology and to do research in aerosol particulate, with particular emphasis on respirable range characterization, as a part of ongoing research with the international scientific community working towards to making our lives safer. The SEM is also used for surface characterization (e.g., condition, surface roughness, particle shape, particle size of deposits) of aging components. The SEM is also used to look at new foam materials and carbon nano tubes.

3.2.11 Sustainable Energy Systems Laboratory

Advanced energy systems, ranging from fuel cells to energy storage systems, are now widely used in various sectors, and the key issues are analysis, design, modeling, performance improvement, and economic and environmental considerations. Research activities in the area of energy in this lab are concentrated in advanced energy systems and applications as well as alternative energy sources and technologies. The paramount objective is to make such advanced energy systems more efficient, more cost-effective, more environmentally benign, and more sustainable. Some research projects are: energy and exergy analysis of PEM and SO fuel cells; transport phenomena in PEM and SO fuel cells; life cycle assessment of fuel cell vehicles; hybrid energy systems for hydrogen production; energy and exergy analysis of thermal energy storage systems; energy and exergy analysis of crude oil distillation systems; energy and exergy analysis of cogeneration and district heating systems; energy and exergy analysis of wind energy systems; energy and exergy analysis of power plants; energy and exergy analysis of solar thermal systems (e.g., solar ponds); hybrid energy systems for snow melting and freeze protection for highways and bridges; and performance assessment of integrated energy systems. This facility is housed in the Boyce Emerging Energy Laboratory.

3.2.12 Thermal Engineering and Microfluidics Laboratory

This laboratory investigates fundamental and applied problems involving heat transfer and microfluidic energy conversion. Detailed understanding of heat transfer has importance in various applications, such as manufacturing and materials solidification problems in extrusion, welding, casting, and injection molding. Experimental studies of convective heat transfer with phase change are performed in a closed test cell. Thermocouples and interferometric / pulsed laser measurements provide new temperature and velocity data involving convective irreversibilities within the fluid. Also, predictive design tools are developed with CFD (Computational Fluid Dynamics). In this laboratory, the research infrastructure includes test cells for forced and free convection, computer workstations, microchannel experiments, fluid and heat transfer instrumentation (including laser based measurements), and temperature control systems.

Additional research includes micro-scale heat transfer. Advanced miniaturization involving microfluidic systems has considerable potential in the development of ultra small power sources (micro-heat engines), sensors, waste heat recovery, fluid control, and advanced insulation materials. For example, micro-heat engines could replace batteries in some portable electronic devices, as batteries can be problematic in terms of their bulk, cost, and power generation capabilities. This laboratory investigates microfluidic transport processes in energy conversion and flow control problems. Embedded microchannels, micro-engines, or micro-tabs within a surface are used to delay boundary layer separation or reduce wall friction. It is known that micro-scale heat and fluid flow become appreciably different from large-scale systems, due to surface, electromagnetic, and thermocapillary effects. Experimental and theoretical studies of these effects are conducted. The micro-heat engine experiment involves a suspended droplet within a microchannel and a thermal bridge providing a cyclic heat source to the microchannel. Also, it includes sensors responsive to a pressure change within the microchannel to induce a voltage drop.

3.2.13 Two-Phase Flow Laboratory

The Two-Phase Flow Laboratory comprises two major apparatuses: the terrestrial two-phase flow experimental facility and the Flight qualified two-phase flow experimental facility. The ground based two-phase flow experimental apparatus is used to study the behaviour of two-phase flow under different orientations and flow conditions. It is a fully automated, closed loop system with vertical upward and vertical downward observation sections, heated test sections, and a 180 degree bend. This facility allows for the study of heat transfer, film thickness, void fraction, pressure drop, and phase distribution properties of terrestrial two-phase flows. A NAC HSV-1000 high speed video camera capable of recording at 500 or 1000 frames per second in colour or black & white is used to record flow regimes and their transitions.

The flight qualified two-phase flow experimental apparatus is used to study the behaviour of two-phase flow in a simulated space environment (microgravity). It is a closed loop system with three main subsystems: 1) Fluid Management- includes the test section, pump/separator, air blower, flow meter, valves, etc.; 2) Thermal Management- includes heat sources, radiator, temperature measurement devices, etc.; and 3) Data Acquisition and Control. This facility is flight qualified for the NASA KC-135 microgravity platform. It can be used to study microgravity heat transfer, film thickness, void fraction, pressure drop, and phase distribution in various geometries. These flows can be studied over a 1.7m development length.

Additional equipment planned for the laboratory includes: circumferentially and volumetrically heated channels; concentric heaters piping; condensers and/or heat exchangers; manifolds; low-flow meters; pressure and differential transducers; void-fraction meters; thermocouples; and other instruments. The equipment will be used to conduct research on natural circulation phenomena under single-phase and two-phase flow conditions in simple pipes and interconnected piping, manifolds, and heat exchangers.

3.3 Laboratories Under Development

3.3.1 Corrosion and Electrochemistry Laboratory.

The Corrosion and Electrochemistry Laboratory is located in the Simcoe Building. It houses basic electrochemical equipment for performing corrosion experiments and more equipment is being acquired. The facility is under renovation to accommodate walk-in fume hoods and safety enclosures for housing elevated temperature experiments in toxic environments. It will be designed specifically to handle HF and HCl gases, and can be modified to contain other toxic gases. This facility will be used to support the work of the Cameco Research Chair in Nuclear Fuels in the areas of corrosion of fluorine generating cells, and electrochemistry of materials degradation during fluorine generation. It will also be used to support corrosion work associated with hydrogen generation by the copper-chlorine cycle. Future expansion of the space will be provided to include stress corrosion cracking work directed to various problems encountered in the nuclear and other energy industries.

3.3.2 Energy Safety and Control Systems Laboratory

The Energy Safety and Control Systems Laboratory is located in Simcoe Building Room 1038. This laboratory will pursue safety technologies and advanced process control systems that support the design and implementation of future energy systems. Safety modelling and a simulation environment will enable the next generation of energy specialists and engineers to acquire essential knowledge on safety engineering. Fault simulation, safety design, recovery operation, operation support, and disaster management systems will be designed and implemented.

3.4 Additional Laboratory Facilities

A new 3,835 m^2 Ontario Power Generation Engineering Laboratory Building opened in the fall of 2006. The building features 17 state-of-the-art laboratories. Although primarily for undergraduate use, the labs will also be available for graduate students. Graduate students will have access to the following shared laboratories:

- Combustion/HVAC Laboratory
- Component Design Laboratory
- Computer Aided Design (CAD) Laboratory
- Emerging Energy Laboratory
- Fluid Mechanics/Heat Transfer Laboratories
- Manufacturing Laboratory with CNC and Plastics Processing Equipment
- Mechatronics and Robotics Laboratory
- Solid Mechanics Laboratory

3.5 Computing Resources

Individual supervisors will provide computer facilities, including appropriate computer systems and software packages, for their PhD students. These facilities will enable them to carry out their research, meet their computational, modelling, and simulation needs, and access the internet, email, and library resources (such as online journals and conference proceedings). Graduate students will also have the option to subscribe to UOIT's laptop program. UOIT's laptop program provides students with a current model laptop that is equipped with a suite of program specific software. Additional shared computer facilities (several hundred PCs) are available in the Learning Commons and library.

Through its contacts with industry, the Faculty has been able to acquire real-time simulation software for the currently operating OPG nuclear-electric units, as well as design codes used by AECL and the Nuclear Industry, such as RFSP, CATHENA, TUF, and FLUENT code.

UOIT has joined the PACE Program – Partners for the Advancement of Collaborative Engineering Education[1]. PACE is a program between General Motors, Sun Microsystems, and UGS that provides state-of-the-art hardware and software for engineering schools. Dedicated engineering computer labs featuring state-of-the-art workstations and software will be established at UOIT through PACE. PhD graduate students will have full access to the PACE hardware and software located in these labs.

UOIT is a member of SHARCNET (Shared Hierarchical Academic Research Computer Network (http://www.sharcnet.ca), a high-performance computing consortium of 9 universities and 2 colleges based in South-Central Ontario. A high-speed optical network connects the computing facilities located at each institution. At present, the majority of the computational facilities are located at McMaster University, the University of Western Ontario, and the University of Guelph; however, UOIT faculty members and their research groups have access to any part of this state-of-the-art computing facility. SHARCNET was successful in a recent 2004 CFI Innovation Fund competition ($48.3M), which will result in a significant expansion of the facility. With the new funding, it is projected that SHARCNET will become one of the top 100 High-Performance Computing facilities in the world. As part of this expansion, UOIT will acquire a small 'development cluster' of approximately 32 processors that will be located on-site. This, combined with other local equipment, will give students involved in the Doctoral program in Nuclear Engineering the ability to work on cutting-edge research in their respective fields. AccessGrid facilities will also be installed as part of the local SHARCNET installation. AccessGrid is an ensemble of resources which support group-to-group interactions across SHARCNET. These resources, including multimedia large-format displays, presentation and interactive environments, and interfaces to Grid middleware and to visualization environments, will facilitate collaboration among faculty members and students across SHARCNET.

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[1] *Source: PACE web site: http://www.pacepartners.org/*

3.6 Space

The Faculty of Energy Systems and Nuclear Science is located in UOIT's Engineering and Science Buildings. These are new buildings that feature office space for faculty members and graduate students in addition to research lab space. The current total research space allocated to Engineering is 1,500 m^2. Currently, the Faculty is using research laboratory space in the order of 100 m^2; an additional 500 m^2 is expected to be added over the next two or three years.

All offices and research spaces are wired for access to UOIT's network. In addition, wireless and wired access is available throughout the Engineering and Science Buildings as well as the library and other spaces on campus. Faculty members have private offices with telephone lines. Faculty office space averages 13 m^2 and faculty member research space averages ~25 m^2.

Graduate students will have access to shared office facilities and/or research labs. There will be shared office space available for PhD students who are teaching assistants. In addition, there will be shared computer facilities along with a limited number of shared spaces for PhD students to work. It is expected that the majority of graduate students will have their office space within the research laboratories of their respective supervisors. A portable structure was erected in the summer of 2007 to house the Office of Graduate Studies and the Office of Research Services. Shared workspaces will be allocated in this facility for graduate students from a number of UOIT graduate programs. The various shared spaces will provide opportunities for graduate students from different programs to interact with one another. The amount of space allocated to graduate students will increase as the various graduate programs come on line.

UOIT has a plan for two more large buildings, pending government approval. The Nuclear Engineering program, with a heavy focus on research and graduate studies, is an active supporter of UOIT's mandate in the advancement of higher education.

3.7 Financial Support of Graduate Students

Every PhD student offered admission to a graduate program in the Faculty of Energy Systems and Nuclear Science should be able to complete his/her program regardless of his/her financial status.

It is expected that the average support for PhD students will be approximately $20,000 per year with funding coming from a variety of sources, including the following:

- UOIT Scholarships/Bursaries.
- External Awards – These include NSERC postgraduate awards and provincial awards. In addition to the NSERC-UNENE IRC, several smaller UNENE research awards (in the order of $100-300 K over three years) are available. Other companies in the nuclear industry, including OPG, Bruce Power, AECL, SNC-Lavallin, Cameco, Babcock

and Wilcox, Wardrop, and Nordion are expected to offer scholarships and bursaries.

- Teaching Assistantships – PhD students will be eligible to earn up to approximately $8,000 per year through teaching assistantships.

- Research Assistantships/Awards – Additional support from individual supervisors will be available to students. Faculty members have been successful in getting research contracts from industry, and some of these contracts are expected to be used to fund graduate student research.

- Work-Study and Other Forms of Employment-Based Learning will be available.

- Provincial Loan Programs are also available.

Once the program achieves steady state, the Faculty of Energy Systems and Nuclear Science hopes to be able to offer a number of merit-based Research Excellence Awards, as well as to provide additional funding which can be distributed on a needs basis in the form of bursaries.

It is expected that the majority of funding for PhD students will come from research and teaching assistantships. Normally, funding will not be provided to part-time students.

3.7.1 Financial Counselling

UOIT's Financial Aid and Awards Office offers a range of financial services, including financial counselling, to students.

4. PROGRAM REGULATIONS AND COURSES

Graduate students taking part in the PhD program in Nuclear Engineering will have the opportunity to participate in a variety of challenging educational experiences. A high degree of quality in the development of the student will be fostered and monitored by the faculty members involved in the program.

The faculty members of the PhD program have a strong demonstrated commitment to pursuing scholarly activities at levels approved by international peers in their respective areas of specialization. The University is also committed to hiring new professors with proven track records in research who will augment and complement the present membership.

4.1 The Intellectual Development and the Educational Experience of the Student

There are four general objectives for the graduate program in Nuclear Engineering:

Depth: To provide students with an understanding of the fundamental knowledge prerequisites for practice and advanced study in the field of nuclear engineering; this includes principles, analysis techniques, and research design methodologies.

Breadth: To provide students with the broad and advanced education necessary for productive careers in the public or private sectors or in academia.

Professionalism: To facilitate the development of skills necessary for clear communication and responsible teamwork, and to inspire professional attitudes and ethics, so that students are prepared for modern work environments and for lifelong learning.

Learning Environment: To provide a safe and high quality learning environment that will enable students to pursue their goals through innovative graduate programs that are rigorous, challenging and supportive.

These objectives will be achieved in the following ways:

Depth: The first objective will be achieved in part by courses such as NUCL 5020G Mathematical Methods in Nuclear Applications, NUCL 5030G Transport Theory, NUCL 5040G Monte Carlo Methods, NUCL 5050G Applied Risk Analysis, NUCL 5060G Nuclear Concepts for Engineers and Scientists, NUCL 5070G Environmental Modelling, and NUCL 5090G Occupational Health and Safety, by taking courses of increasing complexity in the student's chosen field, and by meeting the research requirements in NUCL 6001G PhD Thesis.

Breadth: The second objective will be achieved primarily through the wide selection of courses offered by the program. In addition to study in their chosen fields, opportunities exist for students to select subjects from a wide range of theoretical and practical offerings. Prior to entry to the program, each student will be paired with a supervisor under whose guidance the student will carry out a thesis or research project. On completing the proposed program, students will have achieved a level of engineering maturity which comes from successful completion of a thesis or project. Through participation in the program, students will develop skills in problem solving, experimental design, and critical analysis, as well as research initiative and the ability to work independently. It is expected that students will have opportunities to attend national and international conferences and encouraged to publish in peer-reviewed journals.

Professionalism: The third objective will be achieved through effective program design. Students will acquire expertise in a particular area of nuclear engineering, thereby developing technical skills of interest to employers across the industrial, institutional, and regulatory sectors. NUCL 5010G Project Management for Nuclear Engineers, and ENGR 5750G Software Quality Management were specifically included in the program as a result of advice from industry.

Learning Environment: The fourth objective will be achieved by including research components and written and oral presentations in the majority of the courses and by providing a supportive faculty with extensive industrial and life-long learning experience. The Doctoral Graduate Seminar course (NUCL 6003G) is designed to help students enhance their abilities to effectively communicate technical information to an audience with diverse scientific backgrounds.

4.1.1 University Vision, Mission, and Values

The mission and values of the university provide the foundation for all activities and are reflected in the plans for the intellectual development and educational experience of graduate students in the Faculty of Energy Systems and Nuclear Science.

Vision:

- The University of Ontario Institute of Technology is an innovative and market-oriented institution, pursuing inquiry, discovery, and application through excellence in teaching and learning, value-added research, and vibrant student life.

Mission:

- Provide career-oriented undergraduate and graduate university programs with a primary focus on those programs that are innovative and responsive to the needs of students and employers.
- Advance the highest quality of research.
- Advance the highest quality of learning, teaching, and professional practice in a technologically enabled environment.
- Contribute to the advancement of Ontario and Canada in the global context with particular focus on Durham Region and Northumberland County

- Foster a fulfilling student experience and a rewarding educational (work) environment.
- Offer programs with a view to creating opportunities for college graduates to complete a university degree.

Values:

- Integrity and Respect: We will treat each other with dignity, including those with challenges.
- Honesty and Accountability: Our actions reflect our values, and we are accountable for both.
- Intellectual Rigor: We strive for excellence and challenge convention.

4.1.2 The Academic Unit

In keeping with the part of its mission to foster a fulfilling student experience and a rewarding educational (work) environment, UOIT has developed operational and support processes and services to enhance the learning environment for students.

Faculty Mission: The mission of the Faculty of Energy Systems and Nuclear Science is to become recognized world-wide as a leading research and educational unit that creates, enhances, and transfers knowledge to individuals and organizations in the application of nuclear, radiation, and other energy technologies for the betterment of society and the protection of the environment. We will provide for our graduate students a rigorous education and endeavour to instil in them the attitudes, values, and vision that will prepare them for a lifetime of continued learning and leadership in their chosen careers.

In order for our students and faculty members to fulfill the Faculty mission, UOIT has made every effort to provide state-of-the-art learning resources, including the library, learning technologies, and laboratories. In addition, academic support staff, and student support services also contribute to the operation of the Faculty and provide service, guidance, and support for graduate students.

As described in Section 2 of this brief, a team of well-qualified faculty members is in place to support students and monitor their progress and to ensure that the program is of high quality and meets graduate level standards. There is a plan to hire additional faculty members to add to the strengths of the existing team.

4.1.3 Curriculum and Program Requirements

Program learning outcomes

Graduates of the Faculty of Energy Systems and Nuclear Science graduate programs shall be able to:

1. Demonstrate specialized knowledge and understanding of essential facts, concepts, principles, and theories in a specific area of advanced study.
2. Recognize and be guided by social, professional, and ethical expectations and concerns involved in advanced education and research.
3. Effectively use advanced tools/techniques for research.
4. Apply the principles of effective data management, information organization, and information-retrieval skills to data of various types.
5. Utilize analytical, methodological, interpretive, and expository skills in conducting projects and research.
6. Expand and enhance the application of specific and well-concentrated research to problems and practice in nuclear engineering.
7. Critically evaluate advanced information and knowledge and examine their application in nuclear engineering practice.
8. Identify problems and opportunities for system analysis, design, improvement, and optimization.
9. Understand, explain, and solve problems using quantitative and qualitative methods.
10. Demonstrate effective oral and written communication skills.
11. Appreciate the importance of and develop strategies for further education and lifelong learning.
12. Design and conduct experiments and analyze and interpret experimental data and computational results.
13. Understand the basics of Intellectual Property (IP) and its management.
14. Develop effective project management and teamwork skills.
15. Create grant proposals.
16. Develop an appreciation for other disciplines and the important issues that face society.

The objectives of the PhD program are achieved through a combination of advanced course work, independent research, research seminars, mandatory workshops, research publication, and a research dissertation. The research dissertation must comprise a new contribution to the field of study.

The combination of courses and research will be designed collaboratively between the student and an assigned faculty advisor/mentor. Each learner will have the opportunity to develop the prerequisites for specialized practice of, or for advanced study in, the field of nuclear engineering. Learning activities and materials in graduate courses will be carefully designed to ensure that learners are deliberately exposed to study, the majority of which is at, or informed by, the forefront of engineering theory and practice.

The courses have been designed to give students in-depth learning in a specialized area of engineering, opportunity for advanced development of generic skills such as communication, teamwork, professionalism, project management, leadership, personal effectiveness, and career management, as well as participation in the scholarly activities of research, seminars, and presentations.

Throughout the curriculum, learning activities are planned, and student progress will be monitored to ensure that safety, professional guidelines, and ethical responsibilities relevant to engineering and for specific areas of advanced study are modelled, developed, and evaluated.

Professional skills

UOIT intends to provide pathways for students to develop key professional skills as outlined by the Federal Research Councils and the Canadian Association of Graduate Studies.

In both North America and in Europe there has been considerable debate and development in the introduction of professional skills into academic PhD programs. The most comprehensively developed program to broaden PhD education beyond a narrow academic focus is the GRAD program in the United Kingdom. This program initially was focused on PhDs in science and engineering. The GRAD program runs a series of national workshops. In Canada, NSERC/CIHR/SSHRC, along with CAGS and assistance from the Society for Teaching and Learning in Higher Education, have been developing a set of key professional skills that is modeled on the British example. Our PhD program will provide opportunities for students to acquire these professional skills.

These skills include: research skills techniques and management; personal effectiveness; communication skills; networking and teamwork; and career management.

The university will operate a series of workshops based on Key Professional Skills outcomes. Individual programs may incorporate some or all of these workshops into their curriculum or pursue other avenues to ensure the attainment of these outcomes.

The emphasis on the inclusion of these important professional skills in the PhD program is a clear reflection of the university's mission to offer programs that are innovative and responsive to the needs of students and employers.

Further details about these professional skills and the rationale for their inclusion in programs for new researchers are provided in two documents included as Appendix C at the end of this brief. These documents are: *Tri-Agency Statement of Principles on Key Professional Skills for New Researchers* and *Professional Skills Development – From Ideas to Action* from the Natural Sciences and Engineering Research Council of Canada.

Learning community

UOIT is committed to providing innovative programs through excellence in teaching and learning, value-added research, and “vibrant student life.” The PhD program will exemplify this commitment. The physical design of the university environment provides many places and spaces for groups to meet and interact, for academic and social purposes. The technological links available to students ensure that a network of communication and support among students and between students and university resources is established and strengthened during their years at UOIT. Facilities and personnel are available to support learning and development in all areas – academic, physical, social, and emotional.

The student-centred philosophy of UOIT is designed to develop and continually enhance a strong sense of academic community in which students, faculty, support staff, and administrators share ideas and experiences. Graduate courses will have smaller numbers of students, thereby facilitating the exchange of ideas. This sense of academic community is further reinforced through the seminars series.

Students in the PhD program will benefit from the relationship with faculty in a learning partnership.

Regularly scheduled scientific presentations, guest speakers, and research colloquia which are open to the university community, are already a part of academic life at UOIT. With the development of graduate programs in Nuclear Engineering, the number of seminars offered by the Faculty of Energy Systems and Nuclear Science and the Faculty of Engineering and Applied Science has increased. In addition, the Faculty of Energy Systems and Nuclear Science invites recognized experts and leading-edge researchers to present seminars and to offer advice on student and faculty research. UOIT’s rich network of industry and academic contacts, as exemplified by its close relationship with the Canadian nuclear industry and the University Network of Excellence in Nuclear Engineering (UNENE), will provide faculty and students with access to exceptional researchers and industry professionals.

Scholarly activities

As can be seen in the basic course outlines provided in Section 4.3, students are required to undertake significant independent work and to prepare and deliver reports and seminars. This facilitates the development of leadership, organization, communication, and professional presentation skills. These sessions will be conducted in an environment which supports intellectual debate, allows for critique and constructive feedback, and encourages reflective practice.

All students in the Nuclear Engineering doctoral program will be encouraged to attend professional conferences and educational sessions which may take place at UOIT or outside the University. Doctoral students will be encouraged to attend and participate in conferences and workshops relevant to their specialized areas of interest. Financial support will be made available by faculty supervisors. Students will be encouraged and mentored to present their thesis and project work at professional conferences and to other audiences through industry and academic networks.

The learning activities and academic culture of UOIT is guided by its mission and values. The graduate program being developed by the Faculty of Energy Systems and Nuclear Science will be a model of our university values.

4.2 Program Regulations

The PhD program is governed by UOIT's Graduate Studies Policies, details of which can be found in Appendix B.

Additional policies are defined by the Faculty of Energy Systems and Nuclear Science as outlined below.

4.2.1 Part-time Studies

To facilitate access to all potential students, part-time studies may be permitted on a case by case basis. For the PhD program, students must spend a minimum of two years in residence at UOIT.

4.2.2 Admission Requirements

The minimum admission requirement for the PhD program is completion of a MASc level degree in engineering from a Canadian university or its equivalent from a recognized institution, with a minimum of a B+ average.

Under exceptional circumstances, MASc students may transfer directly to the PhD program after completing one academic year in the MASc program if the following conditions are met: 1) completion of a full Master's program of course work (five courses worth a total of 15 credits) with at least an A average; 2) strong evidence of research ability; and 3) approval of the direct transfer by the thesis supervisor(s) and the supervisory committee. The transfer must also be approved by the Faculty Graduate Programs Director. The Faculty will usually require up to 12 additional credits of course work in the PhD program.

Prior to being accepted into the program, PhD students must find a professor who specializes in the applicant's desired area of research and is willing to act as a supervisor.

4.2.3 Language Requirements

All applicants are required to give evidence of their oral and written proficiency in English. This requirement can be satisfied with one of the following criteria:

i) The student's mother tongue or first language is English

ii) The student has studied full-time for at least three years (or equivalent in part-time studies) in a secondary school or university where the language of instruction and examination was English; or

iii) The student has achieved the required proficiency on one of the tests in English language acceptable to the University of Ontario Institute of

Technology. The recommended scores for various English Language Proficiency Tests (higher scores may be required) are: TOEFL (computer based) 220; or TOEFL (paper based) 560; or IELTS 7; or MELAB 85; or CAEL 60.

4.2.4 Degree Requirements

For the PhD program, a student must complete four courses worth a total of 12 credits and a dissertation worth 40 credits (NUCL 6001: Dissertation). In addition to the four courses and dissertation, the student must successfully complete NUCL 6002G: Workshops and NUCL 6003G: Seminar, which are assessed as pass/fail. Table outlines the

Table 4-1: Credit Requirements

Required courses:	Credits
NUCL 6001G: Dissertation	40
NUCL 6002G: Workshops	0 – Pass/Fail
NUCL 6003G: Seminar	0 – Pass/Fail
Elective courses:	
4 courses to be selected from the list in Table 4-2	12

For a student who has transferred directly from a MASc program into the PhD program, the student must complete nine courses worth a total of 27 credits and a dissertation worth 40 credits (NUCL 6001: Dissertation). In addition to the nine courses, the student must successfully complete NUCL 6002G: Workshops and NUCL 6003G: Seminar.

PhD students must spend a minimum of two years of study in residence at UOIT. The maximum time for completion of a PhD degree is six years, eight years for those who switch to part-time status. This is measured from the student's date of entry into the program. No financial support will be required from the Faculty after four years.

Within 18 months of entry into the PhD program, PhD students must prepare a written research proposal and pass an oral candidacy exam.

4.2.5 Progress Reports

After completing the first year of their program and in each year thereafter, PhD students must complete a progress report that outlines what they have done in the previous year and outline their objectives for the following year. This progress report must be submitted to the student's supervisory committee. Permission to continue in the program will be based on a satisfactory report as determined by the student's supervisory committee.

4.2.6 Thesis Evaluation Procedures

Thesis procedures and evaluations will be conducted in accordance with the guidelines outlined in Section 6 of the General Policies and Procedures for Graduate Studies. (See Appendix B)

4.2.7 Distance Delivery

The program will not be delivered in a distance delivery manner at the present time. In the future, it is expected that distance/hybrid delivery of parts of the programs will be used where the subject matter permits. Distance delivery of courses will comply fully with Section 31 of the OCGS By-Laws governing distance delivery.

4.2.8 Residency Requirement

The PhD program has a minimum residence requirement where the student must be enrolled and attending the University of Ontario Institute of Technology. For the PhD program, students must spend a minimum of two years of full-time study in residence at UOIT. Details are provided in Appendix B.

4.3 Graduate Course Listing and Outlines

Table 4-2 lists the proposed graduate courses to be offered, followed by detailed outlines for the proposed courses. Note that NUCL 6xxxG level courses are restricted to PhD students only.

PhD students may not take any undergraduate level courses in lieu of their graduate course requirements. Courses in other graduate programs at UOIT may be taken provided the student has not taken similar courses during their undergraduate or Master's degrees, and the courses are first approved by the Faculty Graduate Program Director of the Faculty of Energy Systems and Nuclear Science.

Courses will be offered on the basis of demand with the expectation that courses will be offered at a minimum of once every two years. Note that all 5000 level courses are shared with the MASc/MEng programs in Nuclear Engineering.

Outlines for all courses are provided in the section that follows.

Table 4-2: Proposed Courses

Course	Title
NUCL 6001G	PhD Thesis
NUCL 6002G	Workshop and Professional Development
NUCL 6003G	Doctoral Seminar
NUCL 6004G	Directed Studies for Doctoral Candidates
NUCL 6005G	Special Topics for Doctoral Candidates
NUCL 5010G	Project Management for Nuclear Engineers
NUCL 5020G	Mathematical Methods in Nuclear Applications
NUCL 5030G	Transport Theory (cross listed with MCSC 6160G)
NUCL 5040G	Monte Carlo Methods (cross listed with MCSC 6165G)
NUCL 5050G	Applied Risk Analysis
NUCL 5060G	Nuclear Concepts for Engineers and Scientists
NUCL 5070G	Environmental Modelling
NUCL 5080G	Advanced Topics in Environmental Degradation of Materials
NUCL 5090G	Occupational Health and Safety
NUCL 5200G	Reactor Physics
NUCL 5210G	Advanced Reactor Physics
NUCL 5215G	Advanced Reactor Engineering
NUCL 5220G	Fuel Management in Nuclear Reactors
NUCL 5230G	Advanced Nuclear Thermalhydraulics
NUCL 5240G	Heat Transfer in Nuclear Reactor Applications
NUCL 5250G	Power Plant Thermodynamics
NUCL 5260G	Reactor Containment Systems
NUCL 5270G	Control, Instrumentation, and Electrical Systems in CANDU based Nuclear Power Plants
NUCL 5275G	Safety Instrumented Systems
NUCL 5280G	Advanced Reactor Control
NUCL 5285G	Advanced Process Control Systems
NUCL 5290G	Advances in Nuclear Power Plant Systems
NUCL 5300G	Advanced Topics in Radioactive Waste Management
NUCL 5310G	Transmutation of Nuclear Waste
NUCL 5400G	Advanced Radiation Science
NUCL 5410G	Physics of Radiation Therapy

Table 4-2: Proposed Courses continued…

NUCL 5420G	**Aerosol Mechanics**
NUCL 5430G	**Advanced Dosimetry**
NUCL 5440G	**Advanced Radiation Biophysics and Microdosimetry**
NUCL 5450G	**Non-destructive Analysis**
NUCL 5460G	**Industrial Radiography**
NUCL 5470G	**Nuclear Forensic Analysis**

Course	**Elective graduate courses from the Faculty of Engineering and Applied Science**
ENGR 5010G	Advanced Optimization
ENGR 5121G	Advanced Turbo Machinery
ENGR 5122G	Computational Fluid Dynamics
ENGR 5740G	User Interface Design
ENGR 5750G	Software Quality Management
ENGR 5910G	Embedded Real-Time Control Systems
ENGR 5920G	Analysis and Control of Nonlinear Systems
ENGR 5930G	Adaptive Control
ENGR 5940G	Intelligent Control Systems
ENGR 5960G	Power System Operations, Analysis and Planning
Course	**Elective graduate courses from the Faculty of Science**
MCSC 6010G	Mathematical Modelling
MCSC 6030G	High-Performance Computing
MCSC 6120G	Numerical Methods for Ordinary Differential Equations
MCSC 6125G	Numerical Methods for Partial Ordinary Differential Equations

Course Outlines

Course Title: NUCL 6001G – PhD Thesis
Course Description and Content Outline: The dissertation is the primary component of the PhD degree requirement. The research must lead to an original contribution to knowledge in the field and must be reported fully in the candidate's dissertation. The research is carried out under the direction of the candidate's supervisor or co-supervisors, in co-operation with a supervisory committee. **Delivery Mode and Teaching Method:** N/A **Student Evaluation:** Within 18 months of entry into the PhD program, PhD students must prepare a written research proposal and pass a candidacy exam. The student is required to write a research dissertation. Upon completion, the student must defend the dissertation in front of an examination committee comprised of his or her supervisory committee plus an external examiner. Details regarding the evaluation procedures for theses and dissertations are provided in Section 6 of the Policies and Procedures for Graduate Studies (see Appendix B). **Textbook Requirements:** None **Resources to be purchased by students:** None **Learning Outcomes:** Students who successfully complete the PhD dissertation have reliably demonstrated the ability to: • Understand and explain the essential facts, concepts, principles, and theories relating to their research topic. • Effectively use advanced tools for research. • Apply the principles of effective data management, information organization, and information-retrieval skills to data of various types. • Critically evaluate advanced information and knowledge and their implementation. • Understand, explain, and solve problems using quantitative and qualitative methods. • Design and conduct experiments, analyze and interpret experimental data, and/or computational results. • Prepare and present, orally and in writing, to peers and experts, an original contribution to the field of study.
Information about course designer/developer: Course designed by G. Bereznai, PhD, Faculty of Energy Systems and Nuclear Science
Identify faculty to teach the course and/or statement "faculty to be hired": All core faculty members of Faculty of Energy Systems and Nuclear Science
If the method of instruction includes on-line delivery (technology-based, computer-based and web-based), what percentage of the course content will be offered on-line? N/A
Faculty qualifications required to teach/supervise the course: PhD degree in engineering or science and relevant experience in teaching and research.
Classroom requirements: None
Equipment requirements: Dependent on the topic

Course Title: NUCL 6002G – Workshop and Professional Development

Course Description and Content Outline: The course consists of a series of mandatory workshops to aid in the professional development of PhD candidates. Workshop topics may include, but are not limited to, the following: project management; intellectual property; grantsmanship; communications; and career management.

Delivery Mode and Teaching Method: A series of workshops of varying lengths on a variety of topics to develop additional competencies in PhD candidates.

Student Evaluation: Pass/Fail

Textbook Requirements: None

Resources to be purchased by students: None

Learning Outcomes: Students who successfully complete the workshops course have reliably demonstrated the ability to:

- Understand project management.
- Understand the basics of Intellectual Property (IP) and its management.
- Create effective grant proposals.
- Effectively communicate both orally and in writing to technical and non-technical audiences through workshops that include skill development for teaching in an instructional course setting and effective technical writing.
- Understand the needs for career management and continued professional development.

Information about course designer/developer:
Course designed by core faculty, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
The workshops will be taught by a variety of persons who are experts in the various topic areas.

If the method of instruction includes on-line delivery (technology-based, computer-based and web-based), what percentage of the course content will be offered on-line? N/A

Faculty qualifications required to teach/supervise the course:
Expertise in the topic area.

Classroom requirements: Workshops will require the use of a classroom/meeting room with VRC, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: None

Course Title: NUCL 6003G – Doctoral Seminar

Course Description and Content Outline: Participation in a program of seminars by internal and external speakers on current research topics. All PhD students are required to give seminars on their thesis research during each year that they are registered in the program.

Delivery Mode and Teaching Method: Mandatory attendance in a series of seminars by internal and external speakers. There are no academic credits given for this course.

Student Evaluation: Pass/Fail

Textbook Requirements: None

Resources to be purchased by students: None

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- Comply with the social, professional, and ethical requirements involved in advanced education and research.
- Examine and reflect on contemporary issues and professional and ethical responsibilities which impact both nuclear engineering and society as whole, and their specific area of interest.
- Appreciate the need, and have the knowledge and skills required to further their education through lifelong learning.
- Be able to critically examine topics outside the scope of their research and participate in lively scientific discussion.
- Prepare and present a research seminar on a significant topic, to an audience of peers and experts.
- Receive and respond to questions, critique, and other feedback from peers and experts.

Information about course designer/developer:

Course designed by faculty eligible to teach this course: M.H. Kaye, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired": N/A

If the method of instruction includes on-line delivery (technology-based, computer-based and web-based), what percentage of the course content will be offered on-line? N/A

Faculty qualifications required to teach/supervise the course: N/A

Classroom requirements: Seminars will require the use of a classroom/meeting room with VRC, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: None

Course Title: NUCL 6004G – Directed Studies for Doctoral Candidates

Course Description and Content Outline: Faculty permission may be given for supervised research and development projects, individual study, or directed readings. Students wishing to pursue a course of directed studies must, with a faculty member who is willing to supervise such a course, formulate a proposal that accurately describes the course content, the learning goals, the intended method and extent of supervision, and the method(s) by which the student's work will be evaluated. This course may only be taken once.

Delivery Mode and Teaching Method: Dependent on the Topic

Student Evaluation: Dependent on the Topic

Textbook Requirements: Dependent on the Topic

Resources to be purchased by students: Dependent on the Topic

Learning Outcomes: Dependent on the Topic

Information about course designer/developer:

Course designed by G. Bereznai, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":

All faculty members

If the method of instruction includes on-line delivery (technology-based, computer-based and web-based), what percentage of the course content will be offered on-line? N/A

Faculty qualifications required to teach/supervise the course:

PhD degree in engineering and relevant experience in teaching and research.

Classroom requirements: None

Equipment requirements: None

Course Title: NUCL 6005G – Special Topics for Doctoral Candidates

Course Description and Content Outline: The course covers material in an emerging area or in a subject not covered in regular offerings. This course may be taken more than once, provided the subject matter is substantially different.

Delivery Mode and Teaching Method: Dependent on the Topic

Student Evaluation: Dependent on the Topic

Resources to be purchased by students: Dependent on the Topic

Textbook Requirements: Dependent on the Topic

Resources to be purchased by students: Dependent on the Topic

Learning Outcomes: Dependent on the Topic

Information About Course Designer/Developer:

Course designed by G. Bereznai, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":

All Faculty Members, Adjunct Professors, and Sessional Lecturers.

If the method of instruction includes on-line delivery (technology-based, computer-based and web-based), what percentage of the course content will be offered on-line? N/A

Faculty qualifications required to teach/supervise the course:

PhD degree in engineering and relevant experience in teaching and research.

Classroom requirements: None

Equipment requirements: None

Course Title: NUCL 5010G – Project Management for Nuclear Engineers

Prerequisite(s): none

Course Description and Content Outline: This course in Project Management prepares nuclear engineers and scientists in the application of this discipline in their work. It is an intensive investigation into the major principles of project management slanted towards, but not exclusively about, the management of nuclear engineering projects. The course uses the Project Management Institute's PMBOK (Project Management Body of Knowledge) as a skeleton and expands that coverage with relevant examples from nuclear, software and general engineering. Special emphasis will be placed on risk management, particularly in the area of safety-critical projects. The graduates will be well-positioned both to apply the knowledge in their area of engineering and to sit the PMI's PMP examination. The course will be taught using many case studies from industry and engineering.

Topics include:

- The Engineering Project Management Context
- Project Management Processes
- Project Integration Management
- Project Scope Management
- Project Cost Management
- Project Time Management
- Project Quality Management
- Project Human Resource Management
- Project Communications Management
- Project Risk Management
- Project Procurement Management

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be given to students: MS Project, course notes

Representative Texts: H. Kerzner, Project Management, 8th Edition, John Wiley & Sons, ISBN 0-471-39342-8, and excerpts from PMBOK

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- Develop plans of various types used in the nuclear industry, such as work plans, project execution plans
- Develop project schedules for small, medium, and large size projects
- Schedule inputs of manpower, materials, and other costs
- Discuss the role of software in executing plans
- Use Cost Performance Index and Schedule Performance Index
- Use project reporting methods
- Interface with other engineering groups
- Use the concepts of critical path

Information about course designer/developer:
Course designed by M. Bennett PhD, PEng, PMP, Faculty of Engineering and Applied Science.

Identify faculty to teach the course and/or statement "faculty to be hired":
M. Bennett, PhD, PEng, PMP, Faculty of Engineering and Applied Science.

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.

Faculty qualifications required to teach/supervise the course: PhD and PEng holding the PMP certification.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5020G – Mathematical Methods in Nuclear Applications

Prerequisite(s): None

Course Description and Content Outline: Numerical analysis is the study of computer algorithms developed to solve the problems of continuous mathematics. Students taking this course gain a foundation in approximation theory, functional analysis, and numerical linear algebra from which the practical algorithms of scientific computing are derived. A major goal of this course is to develop skills in analysing numerical algorithms in terms of their accuracy, stability, and computational complexity. Topics include best approximations, least squares problems (continuous, discrete, and weighted), eigenvalue problems, and iterative methods for systems of linear and nonlinear equations. Demonstrations and programming assignments are used to encourage the use of available software tools for the solution of modelling problems that arise in physical, biological, economic, or engineering applications.

Topics include:

- Mathematical preliminaries
  - Normed linear spaces & inner product spaces
  - Triangle & Cauchy-Schwarz inequalities
  - Orthogonality & projection operators
- Approximation theory
  - Best approximations
  - Chebyschev approximation
  - Least squares problems (weighted, continuous, discrete)
  - Orthogonal functions and orthogonal polynomials
- Eigenvalue problems
  - Schur & Jordan canonical form
  - Power method and inverse power method
  - Householder method
  - QR method and Gram-Schmidt factorisation
  - Singular value decomposition
- Classical stationary iterative methods for linear systems
  - Jacobi, Gauss-Seidel, SOR
- Krylov subspace methods for linear systems
  - Invariant subspaces, Krylov subspaces
  - Arnoldi decomposition and Lanczos algorithm
  - Method of conjugate gradients
- Variants of Newton's method for systems of nonlinear equations
  - Fixed point iteration for nonlinear systems
  - Newton's method for systems
  - Quasi-Newton methods
  - Inexact Newton methods and Newton-Krylov methods
  - Homotopy & continuation methods

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature:

E. Anderson, Z. Bai, C. Bischoff, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorenson. LAPACK Users' Guide (3rd Ed). SIAM, 1999

J. Demmel. Applied Numerical Linear Algebra. SIAM, 1997

W. Gautschi. Numerical Analysis: an introduction. Birkhauser, 1997

N. Higham. Accuracy and Stability of Numerical Algorithms (2nd Ed). SIAM, 2002

D. Kincaid and W. Cheney. Numerical Analysis: Mathematics of Scientific Computing (3rd

ed). Brooks/Cole, 2001

G. W. Stewart. Afternotes goes to Graduate School. SIAM, 1997

L.N. Trefethen and D. Bau. Numerical Linear Algebra. SIAM, 1997.

Proposed Textbook Requirements: A. Quarteroni, R. Sacco, F. Saleri. Numerical Mathematics. Springer, 2000

Learning Outcomes. Students who successfully complete the course have reliably demonstrated the ability to:

- formulate approximation problems in a suitable linear space, e.g., a continuous or discrete least squares problem with or without weights
- implement the solution of a least squares problem with either the QR algorithm or the SVD for the solution of the normal equations using LAPACK or a problem-solving environment
- formulate eigenvalue problems suitable for applied computation
- implement the solution of an eigenvalue problem with the power method, the inverse power method, Householder's algorithm or the QR algorithm using LAPACK or a problem-solving environment
- formulate and implement a matrix-free matrix-vector product for use with a Krylov-subspace iteration given a sparse system of linear equations using LAPACK or a problem-solving environment
- implement the iterative solution of a system of linear equations with classical stationary iterative methods or Krylov subspace methods using LAPACK or a problem-solving environment
- formulate and implement a routine for the computation of the nonlinear residual given a system of nonlinear equations using LAPACK or a problem-solving environment
- implement the solution of a system of nonlinear equations with Newton's method using LAPACK or a problem-solving environment

Information about course designer/developer:
Dhavide Aruliah, PhD, Computer Science, Faculty of Science, UOIT.

Identify faculty to teach the course and/or statement "faculty to be hired":
Dhavide Aruliah, PhD, Greg Lewis, PhD, William Smith, PhD

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.

Faculty qualifications required to teach/supervise the course:
PhD in mathematics or computer science with experience in numerical analysis.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5030G – Transport Theory

Prerequisite(s): Linear Algebra, Differential Equations, Vector Calculus.

Course Description and Content Outline: This course is a general introduction to transport theory. Continuous-medium transport and discrete-particle transport are presented in a unified manner through the use of the probability distribution function. Various types of transport problems are presented together with analytic solutions for the simpler problems that allow them. Approximate and numerical methods are also covered. This course is cross-listed with MCSC 6160G – Transport Theory.

Topics include:

- Particle distribution functions
- Generic form of transport equation
- Particle streaming
- One-speed transport theory
- Linear collision operators
- The Boltzmann collision term
- Diffusion theory
- Hydrodynamic equations
- Eigenvalue problems
- Boundary value problems
- Perturbation and variational approximation methods
- Deterministic numerical methods
- Monte Carlo simulations

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:
Transport Theory. J.J. Duderstadt & W.R. Martin. John Wiley & Sons, 1979, ISBN 0-471-04492-XJ.

Learning Outcomes. Students who successfully complete the course have reliably demonstrated the ability to:

- identify the general terms of the transport equation for particle fields as well as for continuous media
- express the Boltzman equation and the hydrodynamic equations for various systems
- solve the Boltzman equation analytically for simple configurations
- express specific forms of the transport equations for different types of particles
- differentiate between fixed-source and eigenvalue transport problems
- derive the diffusion equation as a first-order angular approximaton to the transport equation
- solve the diffusion equation analytically for simple configurations
- apply perturbation and/or variational approximate methods to solve the transport equation
- formulate discretized versions of the transport equation using different discretization methods
- decide which discretization method is appropriate for a specific transport problem
- utilize Monte Carlo simulations for otherwise intractable transport problems

Information about course designer/developer:
Course designed by E Nichita, PhD, Faculty of Energy Systems and Nuclear Science.

Identify faculty to teach the course and/or statement "faculty to be hired":
E. Nichita, PhD, E. Waller, PhD, PEng

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments,

solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in science or engineering, with experience in teaching transport theory and numerical methods. .
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5040G – Monte Carlo Methods

Prerequisite(s): Undergraduate theory of ordinary and partial differential equations and introductory statistics

Course Description and Content Outline: This course provides an introduction to simulation of stochastic processes using Monte Carlo methods. The emphasis of the course will be Monte Carlo solution to the Boltzmann transport equation, specifically for radiation transport. Other applications of Monte Carlo analysis will be introduced to include, but not be limited to, molecular dynamics, statistical physics, biophysics, and queuing theory. Concepts presented will include pseudo-random number and random variate generation, direct simulation of physical processes, Monte Carlo integration and variance reduction, detector response and estimators, and Monte Carlo optimization

Topics include:

- Random number generation
- Monte Carlo integration
- Variance reduction techniques
- Linear equations and Markov chains
- Stochastic Optimization
- Sensitivity analysis
- Modelling of physical processes
- Collision density and importance equations
- Moment equations
- Game playing
- Applications

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:

R. Rubinstein and B. Melamed, Modern Simulation and Modelling, Wiley, Toronto, 1998.

Representative Texts:

- R. Rubinstein, Simulation and the Monte Carlo Method, Wiley and Sons, Toronto, 1981.
- R. Rubinstein, Monte Carlo Optimization, Simulation, and Sensitivity of Queueing Networks, Wiley and Sons, Toronto, 1986.
- I. Lux and L. Koblinger, Monte Carlo Particle Transport Methods: Neutron and Photon Calculations, CRC Press, Boston, 1990.
- E. Lewis and W. Miller, Computational Methods of Neutron Transport, ANS Publications, Illinois, 1993.
- C. Cassandras and S. Lafortune, Introduction to Discrete Event Systems, Kluwer, Boston, 1999.
- A. Gosavi, Simulation-Based Optimization: Parametric Optimization Techniques and Reinforcement Learning, Kluwer, Boston, 2003.
- A. Law and W. Kelton, Simulation Modelling and Analysis (3rd ed.), McGraw-Hill, New York, 2000.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- generate stochastic forms of physical equations, with emphasis on radiation transport theorems
- apply various random sampling schemes to Monte Carlo problems
- understand the application of the central limit theorem to Monte Carlo analysis
- understand the limitations and applications of random number generators, with emphasis on congruential generators

- apply statistical tests on pseudorandom numbers, such as Chi-square goodness of fit, Kolmogorov-Smirnov goodness of fit, Cramer von Mises goodness of fit, serial tests, run up/down tests, gap tests, and maximum tests
- generate random variates using the inverse transform method, composition method, acceptance-rejection method, random vector simulation, continuous distributions and discrete distributions
- applications of random sampling physical processes related to radiation transport, including photon energy selection from the Klein-Nishina formula, thermal neutron energy selection, Fission neutron energy selection and anisotropic scattering angle selection
- apply Monte Carlo techniques to solution of differential and integral problems.
- apply variance reduction techniques to solution sampling and scoring
- apply collision density and importance equations to Monte Carlo problems
- understand principles of application of adjoint Monte Carlo
- generate moment equations in both non-multiplying and multiplying games
- understand how special games can be applied to Monte Carlo analysis to improve solution convergence. Some examples include next-event estimation and perturbation analysis

Information about course designer/developer:
Course designed by Ed Waller, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Ed Waller, PhD, PEng

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-ine instruction.

Faculty qualifications required to teach/supervise the course:
PhD in physics, mathematics or engineering with experience in Monte Carlo simulation.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: See classroom requirements; access to parallel computing facilities.

Course Title: NUCL 5050G – Applied Risk Analysis

Prerequisite(s): none

Course Description and Content Outline: This course presents principles and methods for assessing and managing technological risks. The following subjects will be covered: probability theory; failure rates; availability; reliability; test frequencies; dormant and active systems; initiating events; fault trees and event trees; dual failures; defense in depth; principle of control, cool, contain; accident prevention, mitigation and accommodation; separation and independence; redundancy; common mode events; safety culture; safety analysis techniques; inherent safety features; plant safety systems; probability evaluation for simple systems; quantitative and probabilistic safety assessment; calculation of frequency and consequences of power plant accidents; risk-based decision making; and risk-based regulation. Applications include aerospace, energy, and nuclear systems safety analysis.

Topics include:

- Probability theory
- Modeling of uncertainty
- Parameter estimation
- Reliability and availability
- Fault tree and event tree analysis
- Common Mode Failures
- Probabilistic Safety Assessment
- Risk-based decision making

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:

H. Kumamoto and E. J. Henley, Probabilistic Risk Assessment and Management for Engineers and Scientists. New York: IEEE Press, 1996.

Learning Outcomes. Students who successfully complete the course have reliably demonstrated the ability to:

- understand probabilistic risk assessment methodology
- apply fault tree and event tree for risk analysis
- understand risk-informed decision making
- apply risk-informed decision making for maintenance or design
- use related software to perform reliability and safety assessment
- calculate uncertainty in the calculated risk level
- simulate failure propagation

Information about course designer/developer:
Course designed by L. Lu, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. L. Lu.

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.

Faculty qualifications required to teach/supervise the course:
PhD in engineering, science or mathematics, with experience in applying safety analysis in nuclear power plants or related systems.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5060G Nuclear Concepts for Engineers and Scientists

Prerequisite(s): Differential Equations, Partial Differential Equations, Vector Calculus

Course Description and Content Outline: The course is a fast introduction to atomic, nuclear and reactor physics for graduate students without an adequate background in these areas. Topics covered include nuclear structure, radioactivity, interaction of radiation with matter, neutron flux, neutron diffusion, nuclear reactors, reactor kinetics.

Topics include:

- Nuclear structure
- Radioactivity
- Nuclear reactions
- Interaction of radiation with matter
- Radiation detection
- Radiation dose and protection.
- Nuclear fission as used for power production
- Nuclear reactors
- Basic quantities and methods used to describe the behaviour of neutrons in a nuclear reactor
- Neutron diffusion equation
- Methods of solution for the neutron diffusion equation.
- Criticality
- Reactor kinetics
- Elementary solution methods for reactor kinetics.
- Fission product poisoning

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:
Introduction to Nuclear Engineering (third edition), J.R. Lamarsh & A.J. Baratta, Prentice-Hall, 2001, ISBN: 0-201-82498-1

Representative Texts:
Fundamentals of Nuclear Science and Engineering, CRC; 1 edition (July 24, 2002), Language: English, ISBN-10: 0824708342

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand the structure of the atom and the main components of the nucleus
- find isotopes on the Table of Nuclei, and identify the nature of radioactive decay (if any) of a given isotope
- describe the main differences between alpha, beta and gamma decay
- understand the concept of binding energy and how nuclei of different binding energies may undergo fission or fusion
- compute the energy released in fission or fusion reactions
- describe the way different types of radiation interact with matter
- name the main radiation detector types and describe their functioning
- define radiation dose and the basic principles of radiation protection
- understand the concept of chain reaction and each component of the four (six)-factor formula
- formulate the neutron diffusion equation
- solve the static diffusion equation for simple geometries
- find the effective multiplication constant and flux shape in simple-geometry homogeneous

reactors

- formulate the point kinetics equations
- solve approximately the point kinetics equations
- describe fission-product poisoning (Xe, Sm)

Information about course designer/developer:
Course designed by E. Nichita, PhD, Faculty of Energy Systems and Nuclear Science.

Identify faculty to teach the course and/or statement "faculty to be hired":

Dr. E. Nichita, Dr. E. Waller.

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.

Faculty qualifications required to teach/supervise the course:

PhD in engineering or physics with experience in teaching nuclear physics.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5070G – Environmental Modeling

Prerequisites: undergraduate courses in physics, chemistry, differential equations, and statistics. A working knowledge of MS EXCEL is required.

Course Description and Content Outline: The transport of pollutants through the total environment depends upon complex interactions between the atmosphere, geosphere and hydrosphere. Understanding the details of pollutant transport between source, environmental compartments and receptors allow for determination of potential dose, and thereby estimation of risk. This course explores the fundamental theory, equations and solutions to standard environmental transport models (with emphasis on radionuclide transport). In addition, this course introduces the student to the RESRAD codes for environmental modeling.

Topics include:

- Pollutants in the environment
- The total environment
- Concepts of environmental modeling
- Processing and visualization of environmental data
- Human-Environment interactions
- Population Dynamics
- Atmospheric dispersion models
- Terrestrial transport models
- Hydrological transport models
- Biofeedback
- Human receptor models
- Non-human biota models
- Dose construction and reconstruction

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week. Tutorial sessions (involving the RESRAD modeling code and/or Excel) will be conducted every second week.

Student Evaluation: Assignments, Exams, Modeling Project

Textbook requirements:

J. Hardisty, D. M. Taylor, S. E. Metcalfe, Computerised Environmental Modelling: A Practical Introduction Using Excel, Wiley, 1993

or

J. Wainwright and M. Mulligan, Environmental Modelling: Finding Simplicity in Complexity, Wiley, 2004.

J.E. Lovelock, Gaia, Oxford Paperbacks, Oxford, 2000

Custom Handouts

Literature:

- M. Eisenbud and T. Gesell, Environmental Radioactivity – From Natural, Industrial and Military Sources, 4th Edition, Academic Press, 1997
- J. Cooper, K. Randle and R. Sokhi, Radioactive Releases in the Environment: Impact and Assessment, Wiley, 2003
- D. Alstad, Basic Populus Models of Ecology, Prentice Hall, 2001
- G.S. Campbell and J.M. Norman, An Introduction to Environmental Biophysics, Springer, 1998
- R.J. Charbeneau, Groundwater Hydraulics and Pollutant Transport, Prentice Hall, 2000
- D. Moeller, Environmental Health, Harvard, 1992
- R.J. Chorley and P. Haggett (eds.), Models in Geography, Methuen, 1967
- M.J. Kirkby, P.S. Naden, T.P. Burt, and D.P. Butcher, Computer Simulation in Physical Geography, Second Edition, John Wiley, 1992
- N. Ostler (ed), Introduction to Environmental Technology, Prentice Hall, 1996

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- analyze the sources of pollutants (esp. radionuclides) in the environment
- understand how various environmental compartments interact when transporting pollutants
- analyze and utilize atmospheric, terrestrial and hydrological transport models
- predict source-receptor relationships using environmental transport models
- discuss population dynamics as related to environmental modeling
- determine dose and risk to human and non-human biota
- explain complex facets of the total environment to the public

Information about course designer/developer:

Course designed by E. Waller, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":

Dr. E. Waller

Faculty qualifications required to teach/supervise the course:

PhD degree in physics, chemistry, geography or engineering

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5080G – Advanced Topics in Environmental Degradation of Materials

Prerequisite(s): undergraduate course in corrosion

Course Description and Content Outline: Predicting the corrosion performance-lifetime of components is an ongoing area of interest in maintaining nuclear power plants. Unexpected or premature degradation of components often occurs by localized corrosion processes such as pitting, crevice, or stress-assisted corrosion. In this course, we will examine current theories of various localized corrosion mechanisms, current practices for measuring and identifying corrosion processes, models and methodologies for predicting the occurrence of localized corrosion, and the application of this knowledge to specific aspects of the nuclear fuel cycle.

Topics include:

- Initiation, propagation, repassivation, and cessation of localized corrosion processes
- Pitting and Crevice corrosion
- Stress corrosion cracking
- Hydrogen assisted cracking
- Radiation and radiolysis effects on corrosion
- Passivity
- Effect of metal structure, composition, and treatment
- Corrosion measurements at elevated temperature
- Lifetime prediction models

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Texts:

"Electrochemical Techniques in Corrosion Science and Engineering", Robert G. Kelly, John R. Scully, David Shoesmith, and Rudolph G. Buchheit, 2002)

"Corrosion Mechanisms in Theory and Practice", Second Edition, Philippe Marcus (Ed)

"Pitting and Crevice Corrosion", Z. Szklarska-Smialowska

"Prediction of Long Term Corrosion Behavior in Nuclear Waste Systems" (EFC 36),

D. Féron and Digby D. Macdonald (Eds)

"Control of Corrosion on the Secondary Side of Steam Generators", R. Staehle (Ed)

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand the basic processes for initiation, propagation, and cessation of localized corrosion processes and their damage consequences
- predict the conditions for which localized corrosion could occur, could be accelerated, or could be stifled
- determine reasonable chemistry control required for minimizing localized corrosion
- determine methodologies for identifying corrosion processes and measuring their rate
- use appropriate judgment for specifying material requirements
- use appropriate models to predict lifetime performance of components

Information about course designer/developer:
Course designed by B.M. Ikeda, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. B.M. Ikeda

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in engineering or science with experience in teaching and research in the corrosion of materials.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5090G – Occupational Health and Safety

Prerequisite: N/A

Course Description and Content Outline: This course explores the often neglected, although highly important, subject of occupational health and safety as it relates to industrial operations and complex processes. Concepts such as hazard avoidance, health and environmental control, machine guarding, electrical hazards and process safety will be discussed. In addition, management and institutional controls for workplace safety will be considered, such as communicating vital information, pre-task briefings and shift turnovers. Case studies and lessons learned from numerous industrial and manufacturing industry accidents will be used to highlight important information. Pre-requisites: Undergraduate courses in physics, differential equations, and statistics.

Topics include:

- Why Accidents Happen, or, The Nature of Industrial Failure
  - Analysis of Major Technological Disasters
  - Occupational Health and Safety Statistics
- Common Accident Modes
- Concepts of Hazard Avoidance
  - Enforcement
  - Psychological
  - Engineering
  - Analytical
- Manufacturing and Industry Topics
  - Buildings & Facilities
  - Toxic Substances
  - Ventilation and Air Quality
  - Noise
  - Flammables and Explosives
  - Personal Protection
  - Fire Protection
  - Materials Handling & Storage
  - Transportation of Dangerous Goods
  - Machine Guarding
  - Welding
  - Electrical Hazards
  - Construction
  - Ionizing Radiation
  - Non-Ionizing Radiation
  - Temperature
  - Ergonomics
  - Management
- Industrial process safety strategies

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Project

Textbook Requirements:
C. Ray Asfahl, Industrial Safety and Health Management, Prentice-Hall, 1999.
Custom Handouts

Literature:
H.C. Howlett II, The Industrial Operator's Handbook, Techstar, 1995.
R. Scott, Basic Concepts of Industrial Hygiene, Lewis, 1997.
J. Looker, Disaster Canada, Lynx, 2000.
J.G. Marone and E. J. Woodhouse, Averting Catastrophe, Uni of California, 1986
Health and Safety Acts of Ontario and Canada.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand the nature of industrial failure
- analyze occupational health and safety statistics
- discuss common accident modes and relate to institutional failure
- understand, analyze and design hazard avoidance strategies
- understand the health and safety concepts of machine guarding, welding, electrical

systems and construction
- understand the health and safety concepts of toxic substances, materials handling and storage and transportation of dangerous goods
- understand the health and safety concepts of ionizing and non-ionizing radiation
- understand the health and safety concepts of building health, ventilation, air quality, noise control and temperature
- understand the health and safety concepts of ergonomics and safety management
- determine process strategies for industrial safety

Information about course designer/developer:
Course designed by E. Waller, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. E. Waller, Dr. D. Gorman

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty qualifications required to teach/supervise the course:
PhD degree in physics or engineering with experience in occupational health, safety, or industrial hygiene

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5200G – Reactor Physics

Prerequisite(s): undergraduate courses in linear algebra, differential equations, vector calculus

Course Description and Content Outline: The course is a graduate-level treatment of reactor physics, with emphasis on reactor statics. Topics covered include: static neutron balance equations, neutron slowing down, resonance absorption, multigroup transport and diffusion equations, homogenization methods and variational methods. Lattice and full-core numerical methods are also covered.

Topics include:

- Static Neutron Balance Equations
- Fundamental Neutronic Problems (Fixed Source and Eigenvalue)
- Space-Energy Separation of Variables
- Multigroup Separation of Variables
- Flux Shape in Homogeneous Reactors
- One-Group Source Problems in Infinite Media
- Neutron Slowing Down with Resonance Absorption
- Neutron Transport
- Multigroup Diffusion
- Numerical Methods for Multigroup Diffusion
- Homogenization Methods and Equivalence Theory
- Lattice vs. Core Calculations
- Variational and Modal Methods for Static Problems
- Static Computer Codes

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Texts:

Nuclear Reactor Physics, Weston M. Stacey, Wiley-Interscience, 2001, ISBN: 0-471-39127-1

Nuclear Reactor Analysis, J.J. Dudderstadt & L.J. Hamilton, John Wiley & Sons, 1976, ISBN: 0-471-22363-8

Introductory Nuclear Reactor Statics, Karl O. Ott & Winfred A. Bezella, American Nuclear Society, 1989, ISBN: 0-89448-033-2

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- write the Boltzmann equation and explain its main terms
- differentiate between fixed-source and eigenvalue problems
- solve the Boltzmann equation analytically for simple configurations
- derive the diffusion equation as a first-order angular approximation to the transport equation
- solve the diffusion equation analytically for simple configurations
- understand neutron slowing down with and without resonance absorption
- understand the application of the finite-difference, finite element and nodal methods to the solution of the multigroup diffusion equation
- understand the use of the discrete-ordinate and collision-probability methods to the solution of the multigroup transport equation
- apply equivalence theory to find multigroup homogenized cross sections
- understand the basis of applying variational methods to reactor physics problems

Information about course designer/developer:
Course designed by E. Nichita PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired": Dr. E. Nichita, Dr. E. Waller
Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in nuclear engineering or physics and experience in teaching reactor/radiation physics and numerical methods.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5210G – Advanced Reactor Physics

Prerequisite(s): NUCL 5200G – Reactor Physics

Course Description and Content Outline: The course is a graduate-level treatment of reactor physics, with emphasis on reactor dynamics. Topics covered include: point kinetics, space-time kinetics, perturbation and generalized perturbation theory, fuel depletion, fission-product poisoning, elements of reactor control.

Topics include:

- Time-Dependent Phenomena in Nuclear Reactors
- Prompt and Delayed Neutrons
- Point Kinetics Equations
- Perturbation Theory
- Approximate Solutions of the Point Kinetics Equations
- Measurement of Reactivity
- Fission Product Poisoning – Xe Oscillations
- Fuel Depletion
- Space-Time Reactor Kinetics
- Numerical Methods for Space-Time Reactor Kinetics
- Elements of Reactor Control
- Kinetics Codes

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Texts:

Nuclear Reactor Physics, Weston M. Stacey, Wiley-Interscience, 2001, ISBN: 0-471-39127-1

Nuclear Reactor Analysis, J.J. Dudderstadt & L.J. Hamilton, John Wiley & Sons, 1976, ISBN: 0-471-22363-8

Introductory Nuclear Reactor Statics, Karl O. Ott & Winfred A. Bezella, American Nuclear Society, 1989, ISBN: 0-89448-033-2

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- write and solve the point kinetics equation and explain its main terms
- solve approximately the point kinetics equations
- use (generalized) perturbation theory to calculate reactivity
- describe static and dynamic reactivity measurement methods
- understand Space-Time Kinetics and write the Space-Time Kinetics Equations in Diffusion or Transport Form
- understand Solution Methods for Space-Time Kinetics in Diffusion
- understand fuel depletion
- understand fission product poisoning and Xe poisoning
- write Xe Kinetics Equations and solve them for simple cases

Information about Course Designer/Developer:
Course designed by E. Nichita PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. E. Nichita, Dr. E. Waller

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line

instruction.
Faculty qualifications required to teach/supervise the course: PhD in nuclear engineering or physics and experience in teaching reactor/radiation physics and numerical methods.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5215G – Advanced Nuclear Engineering

Pre-requisites: Courses in linear algebra, differential equations, vector calculus.

Course Description and Content Outline: The course is comprised of advanced topics in nuclear engineering, with emphasis on reactor physics. Topics covered include neutron slowing down, resonance absorption, multigroup transport and diffusion equations, reactor kinetics, and homogenization methods. Lattice and full-core numerical methods are also covered. This course is cross-listed with ENGR 5180 Advanced Nuclear Engineering

Topics include:

- Neutronic Nuclear Reactions
- Multigroup Neutron Diffusion
- Numerical Methods for the Steady-State Multigroup Diffusion Equation
- Neutron Transport Equation
- Numerical Methods for the Steady-State Multigroup Transport Equation
- Reactor Kinetics
- Numerical Methods for the Space-Time-Dependent Multigroup Diffusion Equation
- Generation of Multigroup Cross Sections
- Homogenization (Equivalence Theory)
- Perturbation Theory
- Variational Methods

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Textbook Requirements:

Stacey, W. M., 2001, *Nuclear Reactor Physics*, Wiley-Interscience.

Literature:

Stacey, W. M., 2001, *Nuclear Reactor Physics*, Wiley-Interscience.
Dudderstadt, J. J. and Hamilton, L. J., 1976, *Nuclear Reactor Analysis*, John Wiley & Sons.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- write the Boltzmann equation and explain its main terms
- solve the Boltzmann equation analytically for simple configurations
- differentiate between fixed-source and eigenvalue transport problems
- derive the diffusion equation as a first-order angular approximation to the transport equation
- solve the diffusion equation analytically for simple configurations
- understand the application of the finite-difference, finite element and nodal methods to the solution of the multigroup diffusion equation
- understand the use of the discrete-ordinate and collision-probability methods to the solution of the multigroup transport equation
- apply equivalence theory to find multigroup homogenized cross sections
- derive the point-kinetics equations with six delayed neutron groups
- apply approximate solution methods to the point-kinetics equations
- understand the application of finite-difference and modal methods to the solution of space-time kinetics problems
- understand the basis of applying perturbation and/or variational methods to reactor physics problems

Information about course designer/developer:
Course designed by E. Nichita, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":

Dr. E. Nichita and Dr. E. Waller

Are there any plans to teach all or portions of this course on-line? A WebCT course website

will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.
Faculty qualifications required to teach/supervise the course: PhD in Science or Engineering, with experience in teaching reactor/radiation physics and numerical methods.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5220G – Fuel Management in Nuclear Reactors

Prerequisite(s): knowledge of reactor physics at the undergraduate level is recommended

Course Description and Content Outline: Nuclear fuel cycles are studied from mining to ultimate disposal of the spent fuel, including the enrichment processes and the reprocessing techniques, from a point of view of the decision-making processes and the evaluation of the operational and economical consequences of these decisions. For the steps within the fuel cycles, the method of determining the associated costs, in particular those relevant to the disposal of nuclear waste, and the overall fuel cycle costs are described. Burn-up calculations are performed for the swelling time of the fuel within the reactor core. The objectives and merits of in-core and out-of-core fuel management for CANDU Pressurized Heavy Water Reactors (PHWR) and Light Water Reactors (LWR) are analyzed in detail, for the refueling equilibrium as well as for the approach to refueling equilibrium. The course also covers fuel management for thorium-fuelled CANDU reactors and other advanced fuels such as MOX containing plutonium from discarded nuclear warheads, and DUPIC (Direct Use of PWR fuel in CANDU reactors). The fuel management problem is treated as an optimization problem, with objective functions or performance indexes identified, as well as decision variables and appropriate constraints (active and non-active). The course also includes a review of the major work done in this area along with the most important computer codes.

Topics include:

- Nuclear Fuel mining operations
- Fuel processing
- Fuel Enrichment
- Fuel Transport
- Fuel Design Concepts
- Advanced Fuels: MOX Fuel, SEU Fuel, LVRF Fuel
- Refuelling methods
- Burnup Optimizarion
- On-Site Storage of Used Fuel

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:
Course Notes.

Representative Texts:
Literature Surveys (Journal Papers, Conference Proceedings)

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- explain the nuclear fuel cycle from source to final disposal
- explain the various methods of enrichment
- demonstrate knowledge of design constraints on nuclear fuel
- discuss the relative merits of advanced fuels

Information about course designer/developer:
Course designed by G. Harvel, PhD, P.Eng., Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Faculty to be hired.

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course: PhD in nuclear engineering or physics with experience in reactor fuels.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5230G – Advanced Nuclear Thermalhydraulics

Prerequisite(s): undergraduate courses in fluid mechanics and heat transfer

Course Description and Content Outline: This course expands on the importance of thermalhdyraulics in Nuclear Power Plant Design, Operation and Safety. Thermalhydraulic problems and solutions relevant to Nuclear Power Plants and Nuclear Research Reactors will be discussed. The course will discuss in detail Mass, Momentum, and Energy Equations and discuss various numerical techniques for solving these equations especially for applications to two-phase flow. Boiling, condensation, cavitation and waterhammer problems will be discussed. Special topics of recent interest such as Impact of Ageing Phenomena and Application of Electrohydrodynamic and Magnetohydrodynamic forces will be presented.

Topics include:

- Mass, Momentum, and Energy Equations for Thermalhydraulic Applications
- Two-Phase Flow Phenomena: Flow regime, void fraction, phase velocity, Interfacial Area
- Homogeneous, Separated flows, drift flux, and two-fluid models
- Boiling, Condensation, Dryout Phenomena
- Nuclear Fuel Heat Transfer
- Heat Transport Systems
- Cavitation, Waterhammer, and Unique Accidents
- Engineered Safety Systems
- Ageing Mechanisms
- EHD and MHD Forces

Length in Contact Hours: Lectures 3 hours/week, 4 Lab sessions (experimental and numerical) 3 credits

Delivery Mode and Teaching Method(s): Lecture and Laboratory.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:
No specific textbook. Students will be required to perform literature searches in texts, handbooks, and journal papers.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- identify the fundamental phenomena in multi-phase flow
- build their own numerical models of thermalhydraulic systems
- identify nuclear thermalhydraulic systems and designs
- design safety systems for thermalhydraulic phenomena
- identify ageing phenomena
- understand how EHD and MHD forces affect two-phase flow
- be knowledgeable of the current state of the art of nuclear thermalhydraulic design

Information about course designer/developer:
Course designed by Glenn Harvel, PhD, PEng, Faculty of Energy Systems and Nuclear Science.

Identify faculty to teach the course and/or statement "faculty to be hired":

Glenn Harvel, PhD, PEng; Igor Pioro, PhD

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course:
Ph.D. in science or engineering, with adequate background in thermalhydraulics, nuclear design, ageing phenomena, numerical modelling and multi-phase flow.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: Nuclear Design Laboratories, with some or all of the following equipment:

1. A two-phase thermalhydraulic loop for natural circulation experiments.
2. Access to FLUENT code for numerical modelling problems
3. A two-phase once through loop for force flow experiments.
4. Nuclear Industrial code such as CATHENA or TUF or ASSERT.

Course Title: NUCL 5240G – Heat Transfer in Nuclear Reactor Applications

Prerequisite(s): undergraduate course in heat transfer

Course Description and Content Outline: This course will discuss advance heat transfer phenomena related to Nuclear Reactors in both current and future designs.

Topics include:

- Heat transfer phenomena (conduction, convection, radiation)
- Boiling and condensation phenomena
- Critical heat flux and boiling crisis
- Supercritical fluids
- Correlations for heat transfer at high pressure and high temperature
- Advanced numerical methods

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:
Course notes.

Representative Texts:

Incropera, F.P., DeWitt, D.P., Bergman Th.L. and Lavine, A.S., 2007. Fundamentals of Heat and Mass Transfer", 6th edition, J. Wiley and Sons, New York, NY, USA, 997 pages.

Pioro, I.L. and Duffey, R.B., Heat Transfer and Hydraulic Resistance at Supercritical Pressures in Power Engineering Applications, ASME Press, New York, NY, USA, 2007, 328 pages.

Lahey, R.T., Jr. and Moody, F.J., 1993. The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, 2nd Edition, American Nuclear Society, La Grange Park, IL, USA, 631 pages.

Tong, L.S. and Weisman, J., 1996. Thermal Analysis of Pressurized Water Reactors, 3rd Edition, American Nuclear Society, La Grange Park, IL, USA, 748 pages.

Collier, J.G. and Thome, J.R., 1996. Convective Boiling and Condensation, 3rd Edition, Clarendon Press, Oxford, UK, 631 pages.

Levy, S., 1999. Two-Phase Flow in Complex Systems, J. Wiley & Sons, New York, NY, USA, 425 pages.

Tong, L.S. and Tang, Y.S., 1997. Boiling Heat Transfer and Two-Phase Flow, 2nd Edition, Taylor & Francis, Washington, D.C., USA, 542 pages.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- utilize insights and theory into the phenomena of advanced heat transfer topics in conduction, convection and radiation, phase change heat transfer and mass transfer
- utilize the theory and skills needed to solve advanced heat transfer problems both analytically and numerically
- model the heat transfer taking place in nuclear fuel and nuclear heat exchangers
- explain the significance of critical heat flux
- describe the key features of supercritical reactor designs

Information about Course Designer/Developer:
Course designed by I. Pioro, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired": Dr. I. Pioro, Dr. G. Harvel.
Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in nuclear engineering or physics with experience in teaching reactor heat transfer.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5250G – Power Plant Thermodynamics

Prerequisite(s): undergraduate course in thermodynamics

Course Description and Content Outline: This course presents the theoretical and practical analysis of the following with particular reference to CANDU plants.

- Thermodynamic Cycles: Nuclear versus conventional steam cycles, regenerative feedwater heating, moisture separation and reheating, turbine expansion lines, heat balance diagrams, available energy, cycle efficiency and exergy analysis.
- Nuclear Heat Removal: Heat conduction and convection in fuel rods and heat exchanger tubes, heat transfer in boilers and condensers, boiler influence on heat transport system, boiler swelling and shrinking, boiler level control, condenser performance.
- Steam Turbine Operation: Turbine configuration, impulse and reaction blading, blade velocity diagrams, turbine seals and sealing systems, moisture in turbines, part load operation, back pressure effects, thermal effects and turbine governing.

Topics include:

- Balance of Plant Systems such as Main Steam Supply
- High and Low Pressure Turbines
- Condensers, Reheaters, Moisture Separators, and Feedwater Systems
- Wet Steam and Gas Turbines
- Turbine efficiency and design
- Design optimization of Balance of Plant
- Balance of Plant matching to Nuclear Steam Supply

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:

Course notes

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- explain the detailed workings of a Balance of Plant Cycle
- understand the design, operation, and ageing issues of a steam or gas turbine
- perform conceptual design of Balance of Plant systems that support a steam or gas turbine

Information about course designer/developer:
Course designed by G. Bereznai, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
I. Pioro, PhD, G. Harvel, PhD

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course:
PhD in nuclear engineering or physics with experience in reactor thermalhydraulics

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5260G – Reactor Containment Systems

Prerequisite(s): undergraduate course in thermodynamics

Course Description and Content Outline: This course covers the design and main operating features of nuclear reactor containment systems, considering both normal and accident conditions. The course includes definition and purpose of containment, design requirements and considerations, a survey of containment designs in actual use and the use of simulation for safety analysis and design.

Topics include:

- hydrogen, radionuclides and severe accidents
- overview of negative pressure containment
- reactor building and dousing system
- ventilation, cooling and vapour recovery
- efads and connections between containment volumes
- operational perspective
- thermodynamics of air-vapour mixtures
- closed vessel model
- perfect gas in a closed vessel
- steam thermodynamics
- steam and air
- modelling containment:
  - air coolers and heat sources
  - walls and structures
  - flow modelling

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be provided to the students: course notes

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- define the objectives of containment
- specify the requirements for containment design
- use methods by which containment designs achieve these objectives
- describe the main components of a containment system
- allow for the influence of hydrogen, radionuclides and core meltdown on containment design
- approximate magnitudes of containment parameters
- describes trends in containment design
- perform specific containment designs
- implement a detailed realization of the CANDU containment design
- model the behaviour of thermodynamics of steam-air mixtures
- use mathematical techniques for modelling containment system features

Information about course designer/developer:
Course designed by G. Bereznai, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Faculty to be hired.

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course: PhD in engineering or physics with experience in the design of reactor containment systems.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5270G – Control, Instrumentation and Electrical Systems in CANDU based Nuclear Power Plants

Prerequisite(s): undergraduate course in process control

Course Description and Content Outline: This course covers the basic control, instrumentation and electrical systems commonly found in CANDU based nuclear power plants. The course starts with an overall view of the dynamics associated with different parts of the plant, i.e., reactor, heat transport systems, moderator, steam generator, turbine, and electrical generator. Based on such knowledge, the control and regulation functions in the above systems are then defined. Different instrumentation and measurement techniques are examined, along with control strategies. The time and frequency domain performance characterizations of control loops are introduced with consideration of actuator and sensor limitations. Different controller design and tuning methods and instrumentation calibration procedures are discussed. Two modes of operation of CANDU plants will be analyzed, i.e., normal mode and alternate mode. Advanced control technologies, such as distributed control systems, field bus communication protocols are introduced in view of their potential applications in the existing and newly constructed CANDU power plants. The electric systems in the CANDU plant will be examined. The modeling of the dynamics and control devices for the generator will be covered in detail. The dynamic interaction between the power plants and the rest of the electric power grid with other generating facilities and various types of loads will be studied.

Topics include:

- Review of Basic Concepts of Feedback Control and Regulation
- Modeling of Major Dynamic Processes in a Nuclear Power Plant
- Control/Regulation of Dynamic Processes
- Control System Synthesis, Controller Tuning, and Simulation
- Electrical Systems in a Nuclear Power Plant
- Modern Control Systems with Potential Applications

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Texts: handouts will be provided

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- apply the principles of feedback control and regulation to the main processes found in a nuclear power plant
- develop mathematical models of the main processes systems of a nuclear power plant
- explain how dynamic processes can be regulated and controlled
- demonstrate via simulation the synthesis and tuning of control systems
- explain the design and operating principles of the classes of electric power systems used in nuclear plants
- describe the electrical output system of a nuclear power plant and the alternate sources of electric power available to the plant
- demonstrate the application of modern control systems in the context of a nuclear power plant

Information about course designer/developer:
Course designed by G. Bereznai, PhD, PEng

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. L. Lu, Dr. G. Bereznai

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments,

solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in nuclear engineering or physics with experience in CANDU electrical instrumentation and control systems.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5275G – Safety Instrumented Systems (SIS)

Prerequisite(s): undergraduate courses of radiation, health, and nuclear reactor design

Course Description and Content Outline: Safety is an essential part of nuclear and energy systems. This course will cover fundamentals of safety engineering, including safety system design, and safety instrumented systems. Safety assessment techniques are used to evaluate failure modes scenarios and to design and validate nuclear safety systems. This will be achieved through the review of previous nuclear accidents and possible failure scenarios. Environmental and other external fault scenarios will be discussed and assessed to design and validate appropriate safety systems. Design and validate recovery and shutdown systems for disaster and sever accident scenarios. Design safety systems for control of nuclear releases with the analysis of health and environment.

Topics include:

- Introduction to safety systems
- Safety analysis using qualitative and quantitative methods
- Fault propagation analysis and fault modeling
- Analysis of previous nuclear accidents (reactivity, etc.)
- Inherent safety and safety design approaches
- Process control vs. safety control
- Safety system design: SIS, non-SIS, and passive safety systems
- Independent protection layers and layers of protection analysis
- Safety integrity level calculation and verification of nuclear reactor
- Recovery and disaster management systems for nuclear reactors / nuclear power plants
- Safety systems for earthquake, tornado and other external effects
- Safety systems for health and environmental protection

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Text:
Nuclear Safety: Gianni Petrangeli. Elsevier Butterworth-Heinemann, 2006
Control Systems Safety Evaluation & Reliability (2nd Ed.): William M. Goble, ISA, 1998
Safety Instrumented Systems: Design, Analysis and Justification (2nd Ed.): Paul Gruhn and Harry L. Cheddie, 2006

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand milestones of safety life cycle
- understand and demonstrate safety design of SIS and non-SIS systems
- understand verification techniques of control system safety
- understand failure modes of nuclear reactors and nuclear power plants
- understand safety assessment techniques and demonstrate ability to apply to nuclear reactors and nuclear power plants
- understand and analyze nuclear accidents and define suitable counteractions
- understand safety systems, and design considerations to select suitable design alternatives for sever risks in nuclear reactors and nuclear power plants
- understand impacts of containment of toxic and radioactive materials

Information about course designer/developer:
Course designed by H.A. Gabbar, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. H.A. Gabbar, PhD, Associate Professor

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in engineering with experience in teaching and research in safety engineering and nuclear process engineering.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5280G – Advanced Reactor Control

Prerequisite(s): undergraduate course in control theory

Course Description and Content Outline: This course presents the state-variable approach and the application of various state-space techniques to reactor dynamics and control. Topics include: state variables and the concept of the system state; stability in the state space; various definitions of stability; the second method of Liapunov; stability of nuclear systems; centralized versus distributed control; analogue and digital control; hardware and software; licensing requirements; computers in shutdown systems; and applying the principles of separation, diversity, redundancy.

Topics include:

- State-space representation of a system
- Stability analysis in the state space
- Liapunov stability of nuclear systems
- Distributed control
- Digital control
- Safety protection systems

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature and Resources to be purchased by students:

L. E. Weaver, Reactor Dynamics and Control, American Elseviewer Publishing Company, Inc., New York, 1968.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand modern control theory
- apply modern control theory to reactor control analysis
- understand advanced control techniques
- design advanced control systems for nuclear power plants
- understand stability
- apply stability analysis techniques to reactor control

Information about course designer/developer:
Course designed by L. Lu, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
L. Lu, PhD

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course:
PhD in engineering, science or mathematics, with experience in modern control systems

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5285G Advanced Process Control Systems

Prerequisite or Co-requisite: Undergraduate course in control, instrumentation and safety design, such as ENGR 3740.

Course Description and Content Outline:
Control systems are the brain of production plants. This course will enable participants to review process control foundations and practice advanced process control systems as applied on nuclear and energy production systems. They will practice process modeling and simulation of dynamic systems and apply on selected control design projects. Advanced programmable logic controllers and distributed control systems (DCS) and implementation in industrial projects will be explained. Examples of spatial flux, reactivity and reactor shutdown control systems will be discussed in selected design projects. The following are the main topics that will be covered in this course:

Topics include:

- Process modeling of dynamic systems (theoretical, empirical)
- Process variables and process measurements
- Concepts of process control
  - Inverse-response systems and time-delay systems
  - Linear and nonlinear systems
  - Cascade, feedback, feedforward control systems
  - Control loops
- Sensor and alarm control design and tuning
- Actuators settings
- Design cases: spatial flux and reactivity
- Recovery, shutdown, and safety control systems
- Data analysis of control data: PLS, PCA, FDA, SPC
- Fault diagnosis and safety verification of process control systems
- Distributed Control Systems (DCS) and operator interface
- Programmable Logic Controllers (PLC) concepts and application to Nuclear Reactor Control
- PID controllers tuning for dynamic systems
- Plant-wide control charts design and verification
- Control recipe design and verification

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Text:

Designing Processes and Control Systems for Dynamic Performance, Thomas E Martin, Mcgraw Hill, 2000
Process Dynamics, Modeling, and Control, Babatunde A. Ogunnaike, W. Harmon Ray, Oxford University Press, 1994
Process Measurement and Analysis (4th Ed.), Bela G. Liptak, CRC Press, 2003

Learning Outcomes:
Participants who successfully complete the course have reliably demonstrated the ability to:

- understand process control methods and application to nuclear power plants
- design process controllers for startup, shutdown, steady operation for selected process equipment and systems selected from nuclear power plants
- design and validate control programs that represent required process control functions, and implement in DCS, PLC, or PID
- control reactivity
- spatial flux control
- understand and practice human interface systems (HIS) as part of plant wide control systems
- design and validate equipment and plant wide control recipe for nuclear power plants
- use matlab / simulink / labview to design and simulate control system functions for selected cases from nuclear power plant
- demonstrate process control data analysis techniques and apply for fault diagnosis

Information about course designer/developer:
Course designed by: H.A. Gabbar, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement “faculty to be hired”:
Dr. H.A. Gabbar, PhD, Associate Professor, FESNS

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course:
PhD in control and safety with experience in process control and process systems engineering

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: Each student must have access to an IBM compatible personal computer to use Matlab/Simulink to perform Proportional Integral and Derivative (PID) control.

Course Title: NUCL 5290G – Advances in Nuclear Power Plant Systems

Prerequisite: undergraduate course in nuclear power plant systems

Course Description and Content Outline: A combination of lectures, self-paced interactive CD-ROM study and the use of power plant simulators imparts to students the advances in the key design and operating features of the main nuclear power plan types, including reactors using pressure vessels and pressure tubes, pressurized water, boiling water and gas cooled reactors; the use of natural versus enriched fuel, converters and breeders; overall plant control systems, load following capabilities, islanding operations; safety systems, responses to abnormal and emergency events. Nuclear plant simulators will be used throughout the course.

Topics include:

- Introduction to the key design & operating features of the main nuclear power plan types
- Advances in the design features of reactors using pressure vessels and pressure tubes
- Operating characteristics of pressurized water, boiling water and gas cooled reactors
- Use of natural versus enriched fuel – design and operating aspects
- Design of reactors that are fuel converters or breeders
- Overall plant control systems and load following capabilities of the various reactor types
- Frequency and voltage control under islanding operations
- Evolution of safety system design
- Simulated responses to abnormal and emergency events in real time

Delivery Mode and Teaching Method: 3 hours of class lectures per week

Student Evaluation: Assignments, Exams, Oral Presentations, Projects.

Textbook Requirements: Course pack available from International Atomic Energy Agency.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- specify the desired operating characteristics of a nuclear-electric generating unit to meet electric power system requirements
- define the key design parameters for pressurized or boiling water reactors, and the criteria for selecting light or heavy water as coolant and/or moderator
- demonstrate, using real time simulators, the normal operation of nuclear-electric power plants using various types of reactors
- explain the responses of various reactor types to malfunction conditions
- identify the conditions under which fast breeder reactors would be cost effective to construct and operate, and define the key reactor design parameters
- explain the improvements in the reliability of reactor safety systems, emphasizing the key characteristics of passive systems
- demonstrate, using real time simulators, the responses of nuclear-electric power plants using various types of reactors to design-basis emergency events

Information about course designer/developer:
Course designed by G. Bereznai, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course:
Dr. G. Bereznai.

Faculty qualifications required to teach/supervise the course:
Ph.D. degree in engineering or science, and relevant experience in teaching and research.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: each student must have access to an IBM compatible personal computer to execute reactor plant simulations.

Course Title: NUCL 5300G – Advanced Topics in Radioactive Waste Management

Prerequisite(s): undergraduate course in radioactive waste management

Course Description and Content Outline: This course will examine the various international approaches used for the development of publicly acceptable radioactive waste disposal facilities. Particular emphasis will be placed on the technical aspects of geologic disposal systems, used/recycled fuel disposal, and the assessment of radioisotope release. The influence of public acceptance on the selection and implementation of technical solutions will also be considered.

Topics include:

- Performance factors and requirements for engineered barrier systems
- Environmental modelling of waste release
- Geologic barrier systems
- Used fuel behaviour

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Text:
The geological disposal of nuclear waste: N. A. Chapman and I. G. McKinley. J. Wiley & Sons Limited, 1987

Literature:

B.W. Goodwin et al., "The Disposal of Canada's Nuclear Fuel Waste: Postclosure Assessment of a Reference System", AECL-10717, 1994.

L.H. Johnson et al., "The Disposal of Canada's Nuclear Fuel Waste: The Vault Model for Postclosure Assessment", AECL-10714, 1994.

C.C. Davison et al., "The Disposal of Canada's Nuclear Fuel Waste: The Geosphere Model for Postclosure Assessment", AECL-10719, 1994.

"Model summary report for the safety assessment SR-Can", SKB TR-06-26, 2006

"Project Opalinus Clay: FEP Management for Safety Assessment –Demonstration of disposal feasibility for spent fuel, vitrified high-level waste and long-lived intermediate-level waste", NTB 02-23, 2002.

Barbara Pastina, and Pirjo Hellä, (eds), "Expected Evolution of a Spent Nuclear Fuel Repository at Olkiluoto", POSIVA 2006-05, 2006.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand the strength and weakness of environmental modeling
- understand the limitations and advantages of geologic systems for retarding waste release
- understand the interrelationship between the various barrier systems, the geologic media, and the required dose release criteria
- perform estimates of local site performance based on international data

Information about course designer/developer:
Course designed by B.M. Ikeda, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. B.M. Ikeda

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course:
PhD in engineering or science with experience in teaching and research in the managing or

disposal of nuclear fuel waste.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5310G – Transmutation of Nuclear Waste

Prerequisite(s): Knowledge of nuclear physics and reactor physics

Course Description and Content Outline: The course is a graduate-level treatment of nuclear waste. Topics covered include: Brief historical summary on nuclear energy, the problematic of nuclear waste, spent fuel classification and radio-toxicity, current proposed management of spent fuel, technical background on the concept of transmutation, transmuters and their capability, nuclear data and calculation methods for transmutation, example of facilities for nuclear transmutation, perspective an practical option of transmutation.

Topics include:

- Historical background on nuclear power
- Nuclear waste and classification
- Spent fuel content and radio-toxicity
- Transmutation as an approach for nuclear waste management
- Estimation parameters in transmutation
- Simulation codes and nuclear data for transmutation
- Light water reactor and transmutation
- Fast nuclear reactor and transmutation
- Accelerator driven system and transmutation
- Other techniques for transmutation
- Practical options of transmutation
- Transmutation and future perspective

Length in Contact Hours: 2.5 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 2.5 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Texts:

1. Series of papers in reference journals and technical reports are provided to students
2. Series of proceedings and technical meetings and NEA program on transmutation and nuclear data bank

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- Characterize nuclear waste
- Classify nuclear waste
- Understand different options of nuclear waste management
- Understand the physics of transmutation process and its technical approach
- Parameters involved in transmutation
- Understand the application of nuclear methods for waste transmutation
- Understand the components of different transmuters and their capabilities
- Use elements of nuclear reactions and radioactivity to calculate parameters used in nuclear transmutation
- Use nuclear data libraries used in transmutation
- Understand challenges facing the transmutation approach

Information about course designer/developer:
Course designed by R. Machrafi, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement “faculty to be hired”:
Dr. R. Machrafi

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but there will be no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in nuclear engineering or physics and experience in teaching waste management/radiation physics
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5400G – Advanced Radiation Science

Prerequisite: undergraduate course in radiation science

Course Description and Content Outline: This course introduces advanced concepts in radiation engineering, with an emphasis on how ionizing radiation interactions with matter may be modelled. The course reviews fundamental particle interaction mechanics, measurement and detection of radiation, evaluation of nuclear cross sections and various solutions to the Boltzmann transport equation. Pre-requisites: Undergraduate courses in nuclear physics, differential equations, and statistics. This course is cross-listed with ENGR 5181G Advanced Radiation Engineering.

Topics include:

- Charged and neutral particle interaction mechanics
- Elastic scattering kinematics
- Laboratory and Centre-of Mass co-ordinate system considerations
- Wave function operators and the Schrödinger equation
- Expectation values and the Hamiltonian
- Nuclear shell, optical and compound nucleus models for cross sections
- Asymptotic approximation to nuclear scattering cross sections
- Energy averaged cross sections and cross section libraries
- Boltzmann transport equation
- Spherical harmonics approximations to solve the transport equation
- Generation of the diffusion equation
- Discrete ordinates method to solve the transport equation
- Monte Carlo methods to solve the transport equation
- Basic nuclear radiation detection principles

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Textbook Requirements:
Lewis, E. and Miller, W., 1993, *Computational Methods of Neutron Transport*, ANS Publications: Illinois.
Custom Handouts

Literature:

Lux, I. and Koblinger, L., 1990, *Monte Carlo Particle Transport Methods: Neutron and Photon Calculations*, CRC Press: Boston.
Lewis, E. and Miller, W., 1993, *Computational Methods of Neutron Transport*, ANS Publications: Illinois.
Duderstadt, J. and Martin, W., 1979, *Transport Theory*, Wiley-Interscience: New York.
Schaeffer, N., 1974, *Reactor Shielding for Nuclear Engineers*, USAEC: Virginia.
Knoll, G., 1989, *Radiation Detection and Measurement – 3rd Edition*, Wiley: Toronto.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand how charged and neutral particles interact with materials
- understand how radiation may be used to determine material properties
- solve particle scattering problems in both the laboratory and centre-of-mass frames of reference
- derive cross sections from the Schroedinger equation
- understand the various models for nuclear cross sections
- understand how continuous and multi-group cross sections and generated and used in particle transport computations
- solve the Boltzmann transport equation using:
  - Spherical harmonics;
  - Discrete ordinates; and
  - Monte Carlo analysis

- understand the basic concepts of ionizing radiation detection

Information about course designer/developer:
Course designed by E. Waller, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. E. Waller, Dr. E. Nichita

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty qualifications required to teach/supervise the course:

PhD degree in physics, mathematics or engineering with experience in radiation transport.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5410G – Physics of Radiation Therapy

Prerequisite: NUCL 5060G Nuclear Concepts for Engineers and Scientists, or equivalent.

Course Description and Content Outline: A study of the uses of various types of radiation for therapeutic applications, including X-rays, gamma radiation, electrons, neutrons, lasers, UV, visible, infrared, radio-frequency, and microwaves. Topics include: production of radiation for therapeutic purposes; external beam radiotherapy, brachytherapy, electron beam therapy, boron neutron capture therapy, heavy ion therapy and photodynamic therapy; therapeutic dose calculation and measurement; dose calculation algorithms, treatment planning, optimization and verification; equipment calibration; dose impact on patients and workers. This course is cross-listed with RADI 4320 Therapeutic Applications of Radiation Techniques.

Topics include:

- Clinical Radiation Generators
- Interactions of Ionizing Radiation
- Measurement of Ionizing Radiation
- Quality of X-ray Beams
- Measurement of Absorbed Dose
- External Beam Radiation Therapy
- Treatment Planning
- Electron Beam Therapy
- Brachytherapy
- Radiation Protection
- Quality Assurance
- Total Body Irradiation
- Three-Dimensional Conformal Radiation Therapy
- Intensity-modulated Radiation Therapy

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Texts:

The Physics of Radiation Therapy, Faiz M Khan, ISBN: 0781730651

Radiation Oncology Physics: A Handbook for Teachers And Students, Intl Atomic Energy Agency (2005), ISBN: 978-9201073044

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- describe the main component of a clinical LINAC and teletherapy machine
- understand the main types of interactions of ionizing radiation with matter
- understand the dose units and measuring protocols for water phantoms
- understand the principles of external beam radiation therapy and basic field combinations
- apply simple correction methods for tissue inhomogeneity, patient shape, etc.
- understand clinical terms for treatment specification (CTV, PTV, etc.)
- understand the methods and equipment for treatment planning and verification
- be familiar with ancillary devices such as wedges, blocks, boluses and compensators
- understand the clinical uses and dose calculation for electron beam therapy
- understand the clinical uses and dose calculation for brachytherapy
- know the rules of radiation protection for patient and personnel
- describe the advantages of conformal therapy and Intensity-Modulated Radiation Therapy

Information about course designer/developer:
Course designed by E. Nichita, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired": Dr. E. Nichita, Dr. E. Waller
Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.
Faculty qualifications required to teach/supervise the course: PhD in nuclear engineering or physics with experience in teaching the medical/radiation physics.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5420G – Aerosol Mechanics

Prerequisite: undergraduate course in physics, chemistry, differential equations, and statistics. A working knowledge of the MATLAB code is required.

Course Description and Content Outline: Aerosols, or particles suspended in the air, are generated from numerous processes and used in numerous ways. Some examples of commonly encountered aerosols are smoke from power generation, cigarette, forest fire, atmospheric aerosols causing ozone depletion, reduced visibility, rain, snow, cloud, fog, and respiratory deposition or drug delivery through respiratory system. Some aerosols cause significant health and environmental problems while others improve the quality of life. To prevent the formation of undesired pollutants or to produce materials of desired properties, it is important to understand the mechanics of aerosols. This course explores the properties, behaviour and measurement of airborne particulate. Concepts related particle motion, particle size statistics, forces acting on particles, respiratory and mechanical filtration and physicochemical properties of particles will be discussed. Real-world examples of particle transport will be used to reinforce the issues being discussed.

Topics include:

- Properties of gases
- Particle motion
  - Uniform
  - Straight line acceleration
  - Curvilinear
  - Brownian motion
  - Diffusion
- Particle size statistics
- Adhesion
- Thermal forces
- Radiometric forces
- Particle sampling and concentration measurement
- Filtration
- Respiratory deposition
- Coagulation
- Condensation
- Evaporation
- Electrical properties
- Optical properties
- Atmospheric aerosols

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Modeling Project

Textbook Requirements:
W. C. Hinds, Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles, 2nd Ed, John Wiley & Sons, 1999.
Custom Handouts

Literature:
J. H. Seinfeld, Atmospheric Chemistry & Physics of Air Pollution, John Wiley and Sons, 1998
R. C. Flagan and J. H. Seinfeld, Fundamentals of Air Pollution Engineering, Prentice Hall
S. Friedlander, Smoke, Dust and Haze, John Wiley and Sons
K. Willeke and P. Baron, Aerosol Measurement: Principles, Techniques and Applications, John Wiley and Sons, 2001
Journals:
J. Aerosol Science
Aerosol Science & Technology
J. Air & Waste Management Assoc.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- explain and calculate the statistics of a given particle size distribution
- determine the movement of aerosols by a given transport mechanics (inertial movement, diffusion, electrical migration and thermophoresis) and analyze the important mechanisms for a given aerosol system
- calculate the optical properties of a given aerosol system
- derive expressions for a given aerosol system involving multiple aerosol mechanisms (nucleation, condensation, coagulation, diffusion) and analyze the dynamics of the particle size distributions
- design a system to generate, to collect aerosols and to measure particle size distribution
- explain the multi-disciplinary aspects of aerosol science & technology
- explain aerosol science & technology to the professional society and general public

Information about course designer/developer:
Course designed by E. Waller, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. E. Waller

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty qualifications required to teach/supervise the course:
PhD degree in physics or engineering with experience in teaching aerosol mechanics.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Course Title: NUCL 5430G – Advanced Dosimetry

Prerequisite: undergraduate course in dosimetry

Course Description and Content Outline: This course covers advanced concepts in radiation dosimetry linking fundamental radiation physics with metrological theory and practice for therapeutic, external and internal dosimetry. The course reviews basic radiation and charged particle interaction processes and the underlying quantities and units used in dosimetry and radiation monitoring. Cavity theory and the application of ionization chamber methods of dosimetry for photon and electron beams will be covered and a review of passive integrating dosimeters such as radiochromic film, chemical dosimeters and biological dosimetry given. The properties and role of various pulse-mode detectors in dosimetry and monitoring will be discussed along with the metrological relationship between measured quantities and effective dose. Internal dosimetry and dose assessment will be studied in terms of in-vitro and in-vivo monitoring methods along with the standard codes and methods used for assessing dose from bioassay data. The course will conclude with a survey of dosimetry practice under special circumstances and environments such as that encountered in space and in accident scenarios.

Topics include:

- Description of ionizing radiation fields
- Quantities for describing radiation interaction
- Charged particles and charged particle interactions
- Cavity theory and ionization chambers
- Dosimetry and calibration of photon and electron beams
- Passive dosimeters for photon and electron beams
- Pulse-mode detectors and radiation monitoring
- Neutron monitoring
- Radioactive decay and absorbed dose in radioactive media
- In-vitro and in-vivo bioassay methods
- Internal dose assessment
- Special case dosimetry and monitoring practice

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Textbook Requirements:
F.H. Attix – *Introduction to Radiological Physics and Radiation Dosimetry*, Wiley, 1986
Custom Handouts

Literature:
E.B. Podgorsak, *Radiation Physics for Medical Physicists*, Springer, 2006; F.M. Khan, *The Physics of Radiation Therapy*, Lippincott Williams and Wilkins, 2003; Miscellaneous ICRU and NCRP Reports

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand how radiation interacts with matter and the quantities used to describe this interaction
- understand how ionization chambers can be used to measure absorbed dose in photon, electron and neutron fields and how these instruments are calibrated against national standards for absorbed dose
- understand the principles and application of passive and biological dosimetry systems and their calibration
- understand the operation and application of pulse-mode detectors in dosimetry and dose monitoring
- understand radioactive decay and absorbed dose in radioactive media
- understand the bioassay methods used to quantify an intake of radioactive material
- understand and carry out dose assessments of internal dose using industry-standard procedures and codes

- understand the application of dosimetric principles and methods to special exposure situations and pathways

Information about course designer/developer:
Course designed by A.J. Waker, PhD, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. A.J. Waker, and Faculty to be Hired

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty qualifications required to teach/supervise the course:
PhD degree in physics or engineering with experience in radiation science and dosimetry

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

Course Title: NUCL 5440G – Advanced Radiation Biophysics and Microdosimetry

Prerequisite: undergraduate course in biophysics and/or dosimetry

Course Description and Content Outline: This course introduces advanced concepts in radiation biophysics with an emphasis on the stochastic nature of radiation interaction with biological systems and the microdosimetric analysis of radiation effects. The course reviews fundamental charged particle interaction processes and the measurement of radiation energy deposition on the microscopic and sub-microscopic scale and how this knowledge can be used to quantify radiation quality. Microdosimetric descriptions of radiation quality will also be discussed in terms of low-dose radiation protection, medical applications of low LET radiation and high LET radiation therapy as well as the special nature of radiation fields encountered in space. Pre-requisites: Undergraduate courses in nuclear physics; radiation detection and the interaction of radiation with matter; statistics.

Topics include:

- Charged and neutral particle interaction mechanics
- Linear Energy Transfer
- DNA strand breaks and chromosomal aberrations
- Cell survival
- Target and hit theory
- Relative Biological Effectiveness
- Microdosimetric quantities and the compound Poisson process in radiation energy deposition
- Measurement of microdosimetric quantities
- Dual radiation action and compound dual radiation action
- Microdosimetry and low-dose radiation protection science
- Microdosimetry and low-energy X-rays used in medical diagnosis and therapy
- Microdosimetry of high-LET radiation used in radiotherapy
- Microdosimetry and space radiation protection science

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Textbook Requirements:
Radiobiology for the Radiologist, Hall and Giaccia, sixth edition, Lippincott Williams and Wilkins, 2006; *Radiation Biophysics*, Alpen, 1997, Academic Press

Literature:
The Dosimetry of Ionizing Radiation, Volume I, Ed. Kase, Bjarngard and Attix, Academic Press, 1985; *Design, Construction and Use of Tissue Equivalent Proportional Counters,* Ed. Schmitz, Waker, Kliauga and Zoetelief, Radiat. Prot. Dosim, 64, No 4, 1995; *Proceedings of Micodosimetry Symposia*, 1967-2006; *Radiation Detection and Measurement – 3rd Edition*, Knoll, G., 1989, Wiley: Toronto.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand how charged and neutral particles interact with matter
- understand how radiation affects cellular and sub-cellular biological structures
- understand the concept and physical basis of Relative Biological Effectiveness
- understand the theoretical and experimental basis of microdosimetry and microdosimetric quantities
- understand the application of microdosimetry in medical applications of high and low LET radiation
- understand how microdosimetry can inform low-dose and space radiation protection

Information about course designer/developer:

Course designed by A.J. Waker, PhD, Faculty of Energy Systems and Nuclear Science
Identify faculty to teach the course and/or statement “faculty to be hired”: A.J. Waker, and Faculty to be Hired
Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.
Faculty qualifications required to teach/supervise the course: PhD degree in physics, mathematics or engineering with experience in radiation biophysics.
Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.
Equipment requirements: N/A

Course Title: NUCL 5450G – Non-Destructive Analysis

Prerequisite: N/A

Course Description and Content Outline: This course introduces a wide variety of non-destructive analysis techniques for use in research, design, manufacturing and industrial service. The course instructs how each technique works, how it can be applied, when and where it can be used and each technique's capabilities and limitations. The course describes how to take an industrial non-destructive analysis problem and determine which technique is best suited for the job, how to apply a given technique and which information the technique will provide. Laboratories will provide hands-on experience with non-destructive analysis equipment. Pre-requisites: Undergraduate courses in physics, differential equations, and statistics.

Topics include:

- Basic wave physics applied to non-destructive analysis
- Ultrasonic Testing methods
- Acoustic Emission techniques
- Magnetic Flux Leakage methods
- Eddy Current technique
- Radiography (photon and neutron)
- X-ray Fluorescence and Diffraction
- Microwave methods
- Thermography
- Advanced techniques

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week. Laboratories will be held every second week.

Student Evaluation: Assignments, Exams, Laboratories

Textbook Requirements:

D.E. Bray and R.K. Stanley, Nondestructive Evaluation, A Tool for Design, Manufacturing, and Service, McGraw-Hill, New York, 1989.

Custom Handouts

Literature:

L. Cartz, Nondestructive Testing, ASM Int., Materials Park, OH, 1995

D.E. Bray and D. McBride, Nondestructive Testing Techniques, John Wiley & Sons, New York, 1992

R.V. Williams, Acoustic Emission, Adam Hilger, Bristol, 1980

J.R. Matthews, Ed., Acoustic Emission, Gordon and Breach, 1983

J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer-Verlag, Berlin, 1983

A.J. Bahr, Microwave Nondestructive Testing Methods, Gordon and Breach, New York, 1982

H.L. Libby, Introduction to Electromagnetic Nondestructive Test Methods, Willey-Interscience, New York, 1971

ASNT, Non-Destructive Testing Handbook, second edition, in nine volumes

H.L. Libby, Introduction to Electromagnetic Nondestructive Test Methods, Wiley-Interscience, New York, 1971

M.G. Silk, et al., The Reliability of Non-destructive Inspection, Adam Hilger, Bristol, 1987

J.J. Burke, and V. Weiss, Eds., Nondestructive Evaluation of Materials, Plenum Press, New York, 1976

P. Holler, Ed., New Procedures in Nondestructive Testing, Springer-Verlag, 1983

H.S. Lew, Ed., Nondestructive Testing, American Concrete Institute, Detroit, 1988

R.C. McMaster, Ed., Nondestructive Testing Handbook, Ronald Press, New York, 1959

Journals:

Int. Advances in Nondestructive Testing, W. G. McGonnagle, Ed., Gordon and Breach, New York.

Materials Evaluation

British J. Nondestructive Testing.

Non-destructive Testing Int.

J. Testing and Evaluation
Non-Destructive Testing
Soviet J. Nondestructive Testing
Research Techniques in Nondestructive Testing; Academic, New York

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand the theory of energy waves and how they may be used to inspect and analyze materials
- understand how radiation may be used to determine material properties
- analyze and solve problems of significance to non-destructive analysis
- design simple non-destructive analysis systems
- understand the theory and operation of common non-destructive analysis instruments
- understand the types of materials flaws that may be detected, and the best technique to detect them with
- learn about complex failure attributed to material flaws
- explore how non-destructive analysis techniques are used to improve the reliability of complex systems

Information about course designer/developer:
Course designed by E. Waller, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. E. Waller, Dr. A. Waker.

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty qualifications required to teach/supervise the course:
PhD degree in physics or engineering with experience in non-destructive analysis

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: Ultrasonic (A-scan), x-ray radiography set, Eddy current probe, Magnetic yoke, x-ray fluorescence analyzer

Course Title: NUCL 5460G – Industrial Radiography

Prerequisite(s): no prerequisites

Course Description and Content Outline: The course will describe the fundamental physics of neutron, X-ray, Gamma Ray, and Infra-Red radiography. Traditional and modern techniques currently in practice will be discussed as well as discussing recent advances in the technology. Applications of radiography to industrial environments will be presented. Considerations for radiography system design will be discussed.

Topics include:

- X-ray Imaging and Radiography
- Gamma-Ray Imaging and Radiography
- Neutron Imaging and Radiography
- Infra-Red Imaging and Radiography
- Film Based Techniques
- Digital Techniques
- Image Processing and Image Enhancement
- X-Ray and Gamma Ray Sources
- Neutron Sources
- Industrial Applications of Radiography

Length in Contact Hours: 3 hours/week, 3 credits

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Representative Texts:
No specific textbook. Students will be required to perform literature searches in texts, handbooks, and journal papers.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- identify the mechanisms of neutron, X-ray, and Gamma-Ray interaction with materials for radiography applications
- identify the mechanisms of Infra-Red and other electromagnetic wave interactions with materials for radiography applications
- identify and explain neutron, X-ray, and Gamma-Ray sources
- understand film and digital (electronic) techniques of radiography
- apply basic image processing techniques for image enhancement and image analysis
- identify Industrial applications of radiography and the known strengths and weaknesses
- discuss the current state of the art of Industrial Radiography

Information about course designer/developer:
Course designed by G. Harvel, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. G. Harvel

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, but no on-line instruction.

Faculty qualifications required to teach/supervise the course:
Ph.D. in science or engineering, with experience in radiography, neutron, X-Ray, or Gamma interaction with matter, and imaging technologies.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements:

For the laboratory, some or all of the following equipment is required:

1. Neutron source and neutron imaging equipment
2. Gamma Source, appropriate shielding
3. X-ray source with appropriate shielding
4. Film and Film Processing Equipment
5. Dynamic Imaging Systems for X-Rays and Gamma-Rays
6. Infrared Camera
7. Computers with image acquisition hardware and image processing software

Course Title: NUCL 5470G – Nuclear Forensic Analysis

Pre-requisites: Undergraduate courses in nuclear physics, radiation detection, chemistry (preferably organic chemistry), differential equations, and statistics.

Course Description and Content Outline: There are many techniques available to forensic investigators to investigate suspect criminal activity. In addition, there are many times when forensic techniques are required to investigate nuclear-related events. This course will explore nuclear and chemical techniques related to the nuclear technology and forensics. Both radiation and analytical chemistry techniques will be introduced. Risks and hazards associated with nuclear forensic investigations will be reviewed, and mitigation strategies developed. Data integrity and communication of results will be emphasized.

Topics include:

- Threats
  - Radiological dispersal devices forensics
  - Improvised nuclear weapons forensics
  - Weapons of mass destruction forensics
  - Trans-Uranium Elements
  - Fission Products
  - Identification
  - Trauma Accidents (including mass casualty)
  - Violent crime (gunshot; abuse; human rights violations)
  - Non-violent crime (smuggling; theft; forgery)
- Techniques
  - Rapid Screening Measurements
  - Non- Destructive Assay
  - Neutron Activation Analysis and radiography
  - Alpha, Beta and Gamma Spectrometry
  - Neutron Counting, Portal Counting, Liquid Scintillation Counting, Gas Flow Proportional Counting
  - X-ray radiography and radiology
  - TLD/OSL/ESR/NMR
  - Methods and strategies for separation chemistry
  - Introduction to chemical analytical techniques
- Data integrity, risk assessment and communications
  - Reliability, data quality objectives and reporting
  - Sample integrity and contamination control
  - Risk and hazard assessment of field and laboratory work
  - Communication of results

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Textbook Requirements:

K. Moody, I. Hutcheon and P. Grant, Nuclear Forensic Analysis, CRC Press, 2005.
Custom Handouts

Literature:

B. Brogdon, Forensic Radiology, CRC Press, 1998
R. Jensen, Mass Fatality and Casualty Accidents: A Field Guide, CRC Press, 1999

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- discuss the various types of radiological threats that exist
- discuss the applications of radiation-based techniques (primarily radiography, radiology and radioscopy) used in forensic investigations
- determine appropriate forensic techniques for given scenarios of interest
- understand the complexities involved in determining origin of radioactive material
- understand basics of analytical chemical techniques used in forensics

- understand the requirements for chain of custody, data quality objectives and reporting of results in nuclear forensics
- analyze and mitigate potential hazards while performing nuclear forensic analysis
- communicate concepts of nuclear forensics to the professional society and general public

Information about course designer/developer:
Course designed by E. Waller, PhD, PEng, Faculty of Energy Systems and Nuclear Science

Identify faculty to teach the course and/or statement "faculty to be hired":
Dr. E. Waller, Dr. S. Forbes (Faculty of Science)

Are there any plans to teach all or portions of this course on-line? A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty qualifications required to teach/supervise the course:
PhD degree in physics, chemistry or engineering

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: N/A

ELECTIVE GRADUATE COURSES FROM THE FACULTY OF ENGINEERING AND APPLIED SCIENCE

Course Title: ENGR 5010G – Advanced Optimization

Year and Semester: N/A

Course Description and Content Outline: The objective of this course is to understand the principles of optimization and its application to engineering problems. Topics covered include: the steepest descent and Newton methods for unconstrained optimization; golden section, quadratic, cubic and inexact line searches; conjugate and quasi-Newton methods; the Fletcher-Reeves algorithm; fundamentals of constrained optimization theory; simplex methods for linear programming; modern interior-point methods; active-set methods and primal-dual interior-point methods for quadratic and convex programming; semidefinite programming algorithms; sequential quadratic programming and interior-point methods for nonconvex optimization. In addition, implementation issues and current software packages/algorithms for optimization will be covered. Global optimization, including genetic algorithms and simulated annealing, will be introduced.

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: The principal form of assessment will be two major research projects, one counting for 30% and the other counting for 50% of the course mark. Assignments will count for the remaining 20%. The exact weighting of the various components will be presented to the students in the first week of lectures.

Textbook Requirements (sample):

Antoniou, A. and Lu, W.-S., (In-Press), *Optimization: Methods, Algorithms, and Applications*, Kluwer Academic.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- formulate and solve unconstrained and constrained optimization problems
- understand how the major unconstrained, constrained, and global optimization techniques work
- use optimization as a tool for solving engineering design problems

Information about course designer/developer:
Course designed by S. Nokleby, PhD, PEng, Faculty of Engineering and Applied Science

Identify faculty to teach the course and/or statement "faculty to be hired":
S. Nokleby and D. Zhang

Faculty qualifications required to teach/supervise the course:
PhD degree in engineering and relevant experience in teaching and research. Faculty members will normally be registered Professional Engineers.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: Software requirements include MATLAB with both the Optimization Toolbox and the Genetic Algorithm and Direct Search Toolbox.

Course Title: ENGR 5121G – Advanced Turbo Machinery

Year and Semester: N/A

Course Description and Content Outline: Basic Thermodynamics and Fluid Mechanics equations and definitions of efficiencies in turbomachines. Two-dimensional cascades (cascade analysis, performance of cascades and cascade correlations). Axial flow turbines. Radial flow turbines. Axial flow compressors. Centrifugal compressors and fans. Applications of turbomachinery to engineering problems. Design, analysis and performance analyses of turbomachines. Transport phenomena aspects. Software use and tests.

Content Outline by Topic:

- Basic Thermodynamics and Fluid Mechanics equations and definitions of efficiencies in turbomachines.
- Two-dimensional cascades (cascade analysis, performance of cascades and cascade correlations).
- Axial flow turbines.
- Radial flow turbines.
- Axial flow compressors.
- Centrifugal compressors and fans.
- Applications of turbomachinery to engineering problems.
- Design, analysis and performance analyses of turbomachines.
- Transport phenomena aspects.
- Software use and tests.

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Mid-term exam (20%), project and presentation (25%), weekly homework assignments (15%), and final exam (40%).

Textbook Requirements:

Wilson, G. and Korakianitis, T., 2002, *The Design of High-Efficiency Turbomachinery and Gas Turbines – 2nd Edition*, Pearson: New York, NY.

Learning Outcomes: It is aimed to teach students the principles used in analyzing/designing compressors and turbines. Students will be expected to design a gas turbine to meet specific mission requirements. Upon completion of the course, students will be able to understand the design systems and techniques used in the aeropropulsion and gas turbine industries.

Information about course designer/developer:
Course designed by I. Dincer, PhD, Faculty of Engineering and Applied Science

Identify faculty to teach the course and/or statement "faculty to be hired":
M. Rosen

Are there any plans to teach all or portions of this course on-line? Course materials and details will be available on WebCT. Numerical and analytical methods will be used.

Faculty qualifications required to teach/supervise the course:
PhD degree in engineering and relevant experience in teaching and research. Faculty members will normally be registered Professional Engineers.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: Engineering Equation Solver (EES) and MATLAB will be provided to the students.

Course Title: ENGR 5122G – Computational Fluid Dynamics

Course Description and Content Outline: Introduction to CFD modelling and mesh generation software. Basic equations of fluid flow and commonly used approximations. Turbulence modelling (one and two equation models, and higher order models). Iterative solution methods and convergence criteria. Practical analysis of turbulent pipe flow / mixing elbow and turbomachinery blade problems. Software use and tests.

Topics include:

- introduction to CFD modelling and mesh generation software.
- basic equations of fluid flow and commonly used approximations.
- turbulence modelling (one and two equation models, and higher order models).
- iterative solution methods and convergence criteria.
- practical analysis of turbulent pipe flow / mixing elbow and turbomachinery blade problems.
- software use and tests.

Delivery Mode and Teaching Method(s): This one-term course will be delivered using 3 hours of lectures per week.

Student Evaluation: Mid-term exam (20%), project and presentation (25%), weekly homework assignments (15%), and final exam (40%).

Textbook Requirements:

Chung, T. J., 2002, *Computational Fluid Dynamics*, Cambridge University Press: Oxford, UK.

Ferziger, J. H., and Peric, M., 2003, *Computational Methods for Fluid Dynamics*, Springer: New York, NY.

Learning Outcomes: The aim of this course is to develop practical skills in Computational Fluid Dynamics and the use of FLUENT, the most widely used commercial CFD code available. Students are expected to apply these skills to relevant Engineering applications and gain an appreciation of the limitations and advantages of CFD modelling. On completion of the course a successful student should be able to: (i) Set up a numerical model (including mesh generation) using FLUENT. (ii) Identify and define the correct boundary conditions and most appropriate turbulence model. (iii) Interpret the results and validate them using experimental and theoretical data.

Information about course designer/developer:
Course designed by I. Dincer, PhD, Faculty of Engineering and Applied Science

Identify faculty to teach the course and/or statement "faculty to be hired":
G. Naterer

Are there any plans to teach all or portions of this course on-line? Course materials and details will be available on WebCT. Numerical and analytical methods will be used.

Faculty qualifications required to teach/supervise the course:
PhD degree in engineering and relevant experience in teaching and research. Faculty members will normally be registered Professional Engineers.

Classroom requirements: Standard computer enabled UOIT classroom equipped with VCR, DVD, data projectors, and wired and wireless internet access.

Equipment requirements: Special CFD software (e.g., FLUENT) will be provided to the students.

Course Title: ENGR 5740G – User Interface Design

Course Description: This course is an introduction to user interface design and implementation on a wide range of hardware platforms. It covers the basic techniques used in user interface design, how users behave, implementation tools and techniques and the evaluation of user interface designs. It covers both desktop and mobile environments, including the design of user interfaces for cell phones, PDAs and mobile games.

Topic Outline:

- User behaviour: Basic cognitive psychology, Types of users, Usage patterns
- Design methodologies
- Prototyping
- Design and implementation tools: Prototyping systems, Software libraries, GUI builders
- Evaluation of user interface designs: Mathematical models, User studies, Experimental techniques
- User interfaces for mobile and embedded devices: Design challenges with limited devices: Mobile devices: cell phones, PDAs, and mobile entertainment, Appliances and consumer devices

Delivery Mode and Teaching Method: 3 hours of lectures per week.

Student Evaluation: assignments: 30%, final project: 25% and final examination: 45%.

Textbook Requirements: Alan Cooper and Robert Reimann, *About Face 2.0: The Essentials of Interaction Design*, Wiley, 2003, 0764526413.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- apply in-depth knowledge of the important properties of users and how they impact user interface design
- design and implement user interfaces for desktop, mobile and embedded environments
- illustrate the importance of evaluating user interface designs both before and after they are implemented
- follow a formal user interface design and implementation methodology
- select the appropriate tools for the design and implementation of a user interface and be able to use them in a competent manner
- apply in-depth understanding of the important difference between user interfaces for a desktop environment and user interfaces for mobile and embedded environments

Information about course designer/developer:

Course designed by M. Green, PhD, Faculty of Science

Identify faculty to teach the course and/or statement "faculty to be hired":

M. Green and additional faculty will be hired.

Faculty qualifications required to teach/supervise the course:

PhD degree in engineering or computer science with relevant experience in teaching and research. Faculty members may normally be registered Professional Engineers.

Course Title: ENGR 5750G – Software Quality Management

Course Description and Content Outline: An intensive investigation into software quality engineering issues, including testing techniques, defect detection and prevention, reliability engineering, examination of maintenance issues and configuration management. Software evolution issues, including planning for evolution, round out the course. Students will do a major team project examining issues in defect reduction. The course will have a strong industrial flavour.

Topic Outline:

- Introduction to software quality engineering
- Software Quality Standards
- Testing: concepts, issues and techniques
- Life cycle testing
- Coverage and usage testing
- Software quality metrics
- Defect reduction, defect classification
- Software inspection
- Developing a software quality plan
- Safety and quality Issues
- Software reliability engineering
- Software evolution
- Maintenance issues

Delivery Mode and Teaching Method: 3 hours of lectures per week.
Student Evaluation: Mid-term exam: 10%, research project and presentation: 20%, assignments: 30%, and final exam: 40%.
Textbook Requirements: J. Tien, *Software Quality Engineering,* John Wiley 2005
Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- apply in-depth understanding of the importance of good quality in software
- explain and use the basic Quality Life Cycle
- use the 7 basic tools of quality control
- write a software quality management plan
- use software quality metrics
- implement defect reduction programs
- manage safety-software issues
- plan for the evolution of software
- manage software maintenance
- analyze case studies in software quality

Information about course designer/developer:
Course designed by J.M. Bennett, PhD, Faculty of Engineering and Applied Science

Identify faculty to teach the course and/or statement "faculty to be hired":
J.M. Bennett, R. Liscano, C. Martin

Faculty qualifications required to teach/supervise the course:
PhD degree in engineering/computer science & relevant experience in teaching & research. Faculty members may be registered Professional Engineers.

Course Title: ENGR 5910G – Embedded Real-Time Control Systems

Course Description and Content Outline: This course focuses on the design and implementation techniques for embedded real-time control systems. It covers embedded system design, instruction sets for microprocessor architecture, I/O, interrupts, hardware and software of embedded systems, program design and analysis, practical issues, multi-tasking operating systems, scheduling and system design techniques.

Topic Outline:

- Embedded system design process
- Instruction sets for microprocessor architecture
- Mechanisms for input, output, and interrupts
- Basic hardware and software platforms and Embedded computing
- Program design and analysis
- Practical issues related to computer based control systems
- Multi-tasking operating systems for embedded applications
- Real-time programming in high-level languages
- Priority scheduling and System design techniques

Delivery Mode and Teaching Method: 3 hours of lectures per week.

Student Evaluation: mid-term exam: 20%, research project and presentation: 25%, homework assignments: 15%, and final exam: 40%.

Textbook Requirements: Wittenmark, K.J. 2000, *Principles of Embedded Computing System Design,* Wayne Wolf, Morgan Kaufmann Publishers. ISBN 1-55860-541-X

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- articulate the characteristics of embedded and real-time systems in terms of functionality, time constraints, power consumption, cost and development environment
- become familiar with the design process in real-time applications; use UML modeling language to design real-time applications
- describe architecture features of ARM RISC processor and SHARC processor; understand the difference between the two processors; and use instruction sets of these processors to accomplish simple operations
- understand and illustrate major challenges in embedded computing system design.
- apply knowledge of practical issues related to computer based control systems: PID tuning, anti-aliasing filters, integrator saturation and windup, switch de-bouncing, selection of sampling rates
- write simple programs with multi-tasking operating systems
- design, build and integrate hardware and software for simple real-time embedded applications
- use industry-grade tools & development environment for embedded applications

Information About Course Designer/Developer: Course designed by J. Ren, PhD, Faculty of Engineering & Applied Science and L. Lu, PhD, Faculty of Energy Systems & Nuclear Science and Faculty of Engineering & Applied Science

Identify faculty to teach the course and/or statement "faculty to be hired":
J. Ren, L. Lu,

Faculty qualifications required to teach/supervise the course:
PhD degree in engineering and relevant experience in teaching and research. Faculty members will normally be registered Professional Engineers.

Course Title: ENGR 5920G – Analysis and Control of Nonlinear Systems

Course Description and Content Outline: Introduction to nonlinear systems, phase plane analysis, stability determination by Lyapunov direct method, advanced stability theory, existence of Lyapunov functions, describing function analysis, nonlinear control system design by feedback linearization, sliding control, variable structure control, adaptive control of linear and nonlinear systems, control of multi-output systems, control of multi-input multi-output systems.

Topic Outline:

- Introduction to nonlinear systems
- Planar systems and their phase space
- Lyapunov stability theory
- Input-output stability
- Absolute stability
- Passivity
- Perturbed systems
- Feedback linearization
- Sliding mode control
- Back-stepping control
- Lyapunov based adaptive control
- Nonlinear observers

Delivery Mode and Teaching Method: 3 hours of lectures per week.

Student Evaluation: mid-term exam: 20%, research project and presentation: 25%, homework assignments: 15%, and final exam: 40%.

Representative Textbook: Khailil, H.K. *Nonlinear Systems – 3rd Edition*. Prentice Hall, 2002.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- apply knowledge of the basic fundamentals of nonlinear phenomena: multiple equilibria, limit cycles, complex dynamics, bifurcations
- identify second order nonlinear systems: phase plane techniques, limit cycles- Poincare-Bendixson theory, index theory
- understand Input-output analysis and stability: small gain theorem, passivity, describing functions
- understand and apply Lyapunov stability theory: basic stability and instability theorems, LaSalle's theorem, indirect method of Lyapunov
- linearize a system by state feedback: input-output and full state linearization, zero dynamics, inversion, tracking, stabilization
- apply basic software tools to the analysis of nonlinear systems

Information about course designer/developer:

Course designed by L. Lu, PhD, Faculty of Energy Systems and Nuclear Science and Faculty of Engineering and Applied Science

Identify faculty to teach the course and/or statement "faculty to be hired":

L. Lu and E. Esmailzadeh

Faculty qualifications required to teach/supervise the course:

PhD degree in engineering and relevant experience in teaching and research. Faculty members will normally be registered Professional Engineers.

Course Title: ENGR 5930G – Adaptive Control

Course Description and Content Outline: This is a course on the general principles of adaptive control and learning. This course will cover real-time parameter estimation, deterministic self-turning regulators, stochastic & predictive self-tuning regulators, model reference adaptive systems, gain-scheduling, properties of adaptive systems, robust adaptive control schemes, adaptive control of nonlinear systems, practical issues and implementation.

Topic Outline:

- Real-time parameter estimation
- Deterministic self-turning regulators
- Stochastic & predictive self-tuning regulators
- Model reference adaptive systems
- Gain-scheduling
- Properties of adaptive systems
- Robust adaptive control schemes
- Adaptive control of nonlinear systems
- Practical issues and implementation

Delivery Mode and Teaching Method: 3 hours of lectures per week.

Student Evaluation: mid-term exam: 20%, research project and presentation: 25%, homework assignments: 15%, and final exam: 40%.

Textbook Requirements: K. J. Astrom and B. Wittenmark, *Adaptive Control*, 2nd , Addison-Wesley, 1995

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- utilize the fundamental concepts of adaptive control and learning
- understand and apply the concepts of convergence, stability, and robustness to analyze control systems
- estimate parameters and learn models from empirical data
- understand and analyze the behavior of adaptive control schemes such as model reference, adaptive control and self tuning regulators
- articulate perturbation and averaging theory
- use advanced stability theory to analyze adaptation schemes
- design gain-scheduling controllers
- be familiar with practical issues in implementation of adaptive controllers

Information about course designer/developer:
Course designed by J. Ren, PhD, Faculty of Engineering & Applied Science

Identify faculty to teach the course and/or statement “faculty to be hired”:
J. Ren, L. Lu

Faculty qualifications required to teach/supervise the course:
PhD degree in engineering and relevant experience in teaching and research.
Faculty members will normally be registered Professional Engineers.

Course Title: ENGR 5940G – Intelligent Control Systems

Course Description and Content Outline: With the advance of increasingly faster computing hardware and cheaper memory chips, computational intelligence, also known as a part of “soft computation”, is becoming more and more important in control engineering. This course will equip the student with the essential knowledge and useful resources to solve some of the systems control problems not easily solved using conventional control methods. This course will cover: fundamentals of fuzzy set theory, structures of fuzzy logic controllers, structures of neural networks, learning algorithms, genetic algorithms.

Topic Outline:

- General characteristics of intelligent control systems.
- Fundamentals of fuzzy set theory.
- Application of fuzzy logic in control.
- Basic and complex structures of fuzzy logic controllers.
- Automated design and self-organization of fuzzy controllers.
- Basic structures of neural nets.
- Static and dynamic neural nets.
- Learning algorithms.
- Application of neural nets in modeling, identification and control of systems.
- Optimization by using genetic algorithms.
- Examples of intelligent control systems in industry.

Delivery Mode and Teaching Method: One-term, 3 hours of lectures per week.

Student Evaluation: mid-term exam: 20%, research project and presentation: 25%, homework assignments: 15%, and final exam: 40%.

Textbook Requirements: C.T.Lin, C.S.G.Lee (1996): *Neural Fuzzy systems - A Neuro-Fuzzy Synergysm to Intelligent Systems*, Prentice Hall, New York.

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- understand fundamental concepts of fuzzy logic (FL), neural network (NN) and genetic algorithm (GA)
- use NN/FL to model the complex static/dynamic systems
- use NN/FL as a tool to construct the complex nonlinear controller to better control the complex dynamics systems
- use GA to solve global optimization problem
- gain hands-on experience on MATLAB toolboxes for NN and FL to solve practical control design problems
- explore and utilize the Internet resources on computational intelligent related to control engineering

Information about course designer/developer:

Course designed by J. Ren, PhD, Faculty of Engineering & Applied Science

Identify faculty to teach the course and/or statement “faculty to be hired”:

J. Ren

Faculty qualifications required to teach/supervise the course:

PhD degree in electrical engineering and relevant experience in teaching & research.
Faculty members will normally be registered Professional Engineers.

Course Title: ENGR 5960G – Power System Operations, Analysis and Planning

Course Description and Content Outline: Transmission lines. Steady state transmission capacity; network compensation; voltage management; load flow simulation; transient stability simulation; system security; system planning; symmetric operation of power systems.

Topic Outline:

- Introduction to single-phase, three-phase systems and the per unit system
- Transmission line models and steady-state transmission capacity
- Concepts of network compensation: impedance, voltage, angle and power
- Voltage management and effect on transmission capacity
- Load flow simulation: admittance matrix, problem structure, numerical simulation by the Newton-Raphson method
- Transient stability simulation: deriving the swing equation, complex generator models, complex component control models, numerical simulation techniques
- Reliability and security: criteria, deterministic concepts, transfer limits, security limits, contingencies, limit determination
- Power system planning: operations versus planning; planning processes and criteria
- Asymmetric operation of transmission systems

Delivery Mode and Teaching Method: 3 hours of class lectures per week.

Student Evaluation: Homework assignments: 50%; final exam: 50%.

Textbook Requirements: Marceau, R.J., *Notes on Power System Operation, Analysis and Planning*

Learning Outcomes: Students who successfully complete the course have reliably demonstrated the ability to:

- determine steady-state transmission line capacity employing all the possible compensation strategies; choose an appropriate compensation strategy according to circumstances; explain the operation of the different compensation technologies
- derive the equations which describe steady-state network operation; explain how these equations can be solved. Develop load flow software; analyze the result of simulations describing different operating conditions; make recommendations concerning compensation strategies required to solve network operating problems
- explain how power systems react to unforeseen circumstances; derive the swing equation
- explain how transient conditions are represented and solved; develop appropriate software for transient stability simulation. Integrate complex generator models and network component control system models; determine whether a system is stable or unstable; determine a transient stability transfer limit
- explain the difference between reliability and security. explain such concepts as: i) operations and planning criteria; ii) transfer limit; iii) security limit; iv) steady-state security; v) dynamic security; determine a security limit; explain how security limits are employed in system operation
- plan a transmission corridor using traditional three-phase AC transmission concepts
- explain how asymmetric operation can increase: i) reliability, ii) security and iii) economics of power system operation and planning; plan a transmission corridor employing asymmetric operation and planning concepts

Information about course designer/developer:

Course designed by R. J. Marceau, PhD, Faculty of Engineering and Applied Science

Identify faculty to teach the course and/or statement "faculty to be hired":

R. J. Marceau.

Faculty qualifications required to teach/supervise the course:

PhD degree in electrical engineering and relevant experience in teaching and research. Faculty members will normally be registered Professional Engineers.

ELECTIVE GRADUATE COURSES FROM THE FACULTY OF SCIENCE

Course Title: MCSC 6010G – Mathematical Modelling

Pre-requisite(s): Satisfaction of admission requirements for the program.

Course Description and Content Outline:

The Mathematical Modelling course is a core course and forms an essential part of the MSc program. The student will get familiar with the fundamental principles and techniques in mathematical modelling, showcased through the use of classical and advanced models in physics, biology and chemistry. Several analytical techniques will be introduced through the study of the mathematical models presented.

Topics include:

- **Procedures of modelling:**
    - stochastic vs deterministic models
    - discrete vs continuous models
    - conservation laws
    - compartmental models
    - symmetries and other structures
- **Simplification procedures:**
    - non-dimensionalization
    - reduced models
    - toy models.
- **Analytical methods:**
    - asymptotic approximations
    - regular and singular perturbation methods
    - multiple scales
    - Methods to find: traveling wave solutions, shock waves and solitons.
    - relaxation dynamics
    - Steady-state, Hopf and Turing bifurcation.
- **Applications**
    - Population models and epidemiology
    - Neuron and cell dynamics
    - Nonlinear waves in biological, chemical and physical systems
    - Fluid Dynamics
    - Pattern formation (in fluid experiments, animal coat patterns, chemical reactions, visual cortex)
    - Coupled systems (neurons, traffic flows, lattice systems)

Length in Contact Hours: 3 hours/week, 3 credits.

Delivery Mode and Teaching Method(s): Lecture

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Literature:

- C M Bender and J A Orszag, *Advanced mathematical methods for scientists and engineers* McGraw Hill, 1978
- F B Hildebrand, *Methods of Applied Mathematics*, Dover, 1992
- A B Tayler, *Mathematical Models in Applied Mechanics*, OUP, 1985
- A C Fowler, *Mathematical Models in The Applied Sciences* CUP, 1997
- J Kevorkian and J D Cole, *Perturbation Methods in Applied Mathematics*, Springer, 1981
- J Kevorkian and J D Cole, *Multiple Scale and Singular Perturbation Methods*, Springer, 1996
- E J Hinch, *Perturbation Methods*, CUP, 1991

- M H Holmes, *Introduction to Perturbation Methods*, Springer, 1998
- J. Murray. *Mathematical Biology, Springer,*
- J. Keener and J. Sneyd. *Mathematical Physiology, Springer, 2002*

Proposed textbook requirements: None

Learning Outcomes:

Students who successfully complete the course have reliably demonstrated the ability to:

- formulate a model of an observable phenomenon using the most suitable mathematical procedure subject to the desired level of accuracy of the model and the choice or availability of techniques of mathematical analysis.
- analyze scientific data and determine whether the data is better modeled using stochastic or deterministic modelling.
- determine whether an observable phenomena is better modeled using discrete time models of continuous time models.
- identify properties of observable phenomena which can be abstracted into modelling hypotheses for the mathematical model. For instance: symmetry, time-reversibility, conserved quantities, coupled system structure, compartmental structure, etc.
- use various procedures, such as nondimensionalisation or linearization, to simplfy the analysis of the mathematical model.
- formulate toy models which are more easily analyzable in order to model only some specific features of the observable phenomena. Be able to compare the results with the actual data in order to validate or not the toy model. Iterate the formulation or the analysis of the toy model in order to improve the accuracy of the mathematical modelling.
- use various analytical methods to perform the mathematical analysis of models: asymptotic approximations, regular and singular perturbation methods, multiple scales, traveling wave solutions, shock waves and solitons, relaxation dynamics, elementary bifurcation theory for ordinary and parabolic partial differential equations, and discrete mappings , Turing bifurcations in reaction-diffusion equations.
- formulate mathematical models of various degrees of complexity and accuracy for phenomena arising in biology, chemistry, physics, finance, engineering using the mathematical procedures acquired in the course to obtain models. Analyze the mathematical models using the techniques acquired in the course.
- analyze the results of the mathematical analysis of models of observable phenomena, compare the results to the known data, identify predictions that the mathematical model makes about the phenomenon and identify the positive and negative features of the model.

Information about course designer/developer: Pietro-Luciano Buono and Peter Berg, Ph.D Mathematics, Faculty of Science, UOIT.

List faculty eligible to teach the course and/or statement of “faculty to be hired":

Dhavide Aruliah, PhD Computer Science
Peter Berg, PhD Mathematics
Pietro-Luciano Buono, PhD Mathematics
Anatoli Chkrebtii, PhD Physics
Greg Lewis, PhD Mathematics
Fedor Naumkin, PhD Physics
Eleodor Nichita, PhD Engineering
William Smith, PhD Applied Mathematics
Ed Waller, PhD Engineering

Are there any plans to teach all or portions of this course on-line?

A WebCT course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty Qualifications to teach/supervise the course:
PhD in physical science (mathematics, computer science, physics, chemistry) or engineering.

Classroom requirements: Technology-enhanced classroom with data projector, VCR and DVD and internet access.

Equipment requirements: See Classroom requirements

Course Title: MCSC 6030G – High-Performance Computing

Pre-requisite(s): MCSC 6020G Numerical Analysis or equivalent.

Course Description and Content Outline:

The goal of this course is to introduce students to the tools and methods of high-performance computing (HPC) using state-of-the-art technologies. The course includes an overview of high-performance scientific computing architectures (interconnection networks, processor arrays, multiprocessors, shared and distributed memory, etc.) and examples of applications that require HPC. The emphasis is on giving students practical skills needed to exploit distributed and parallel computing hardware for maximizing efficiency and performance. Building on MCSC 6020G, students will implement numerical algorithms that can be scaled up for large systems of linear or nonlinear equations.

Topics include:

- Survey of high-performance computer architectures: interconnection networks, processor arrays, multiprocessors, multicomputers, Flynn's taxonomy
- Basic efficiency guidelines for high-performance computing
- Parallel algorithm design
- Programming tools for high-performance computing
    - Message Passing Interface (MPI)
    - BLAS, LAPACK, PBLAS, ScaLAPACK, BLACS
- Timing, profiling, and benchmarking
- Optimisations: floating point operations, memory accesses
- Case studies: parallelel programs from some scientific computations

Length in Contact Hours: 3 hours/week, 3 credits.

Delivery Mode and Teaching Method(s): Lecture.

Student Evaluation: Assignments, Exams, Oral Presentations, Projects

Resources:

- E. Anderson, Z. Bai, C. Bischoff, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorenson. LAPACK Users' Guide (3rd Ed). SIAM, 1999
- R. Barrett, M. Berry, T.F. Chan, J. Demmel, J. Donato, J. Dongarra, V. Eijkhout, R. Pozo, C. Romine, and H. Van der Vorst. Templates for the Solution of Linear Systems. SIAM, 1994
- S. Goedecker and A. Hoisie. Performance Optimization of Numerically Intensive Codes. SIAM, 2001
- G.H. Golub and C. Van Loan. Matrix Computations (3rd Ed). John Hopkins, 1996
- W. Gropp, E. Lusk, and A. Skjelluj. Using MPI. MIT Press, 1994
- M. Overton. Numerical Computing with IEEE Floating Point Arithmetic. SIAM, 2001

Proposed Textbook Requirements:
M.J. Quinn. Parallel Programming in C with MPI and OpenMP. McGraw-Hill, 2004
Learning Outcomes:
Students who successfully complete the course have reliably demonstrated the ability to:

- use Foster's design methodology to design parallel algorithms by analysing sequential algorithms for simple applications (e.g., summing data vectors, computing N-body interactions, solving two-point boundary-value problems, etc.)
- formulate and code a parallel implementation of a matrix-free matrix-vector product for matrices with block or band structure for use with an iterative Krylov-subspace solver for linear equations.

- formulate and code a parallel implementation of the Jacobi method for the iterative solution of a system of linear equations.
- formulate and code a parallel implementation of the conjugate gradient method for the iterative solution of a banded symmetric positive definite system of linear equations.

Information about course designers/developers: Dhavide Aruliah, Greg Lewis and William Smith.

List faculty eligible to teach the course and/or statement of "faculty to be hired":

Greg Lewis, PhD Mathematics
Dhavide Aruliah, PhD Computer Science
William Smith, PhD Applied Mathematics

Are there any plans to teach all or portions of this course online?
A course website will play an integral role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.

Faculty Qualifications to teach/supervise the course:
PhD in mathematics, computer science or physics with experience in numerical methods and/or high performance computing.

Classroom requirements: Technology-enhanced classroom with data projector, VCR and DVD and internet access.

Equipment requirements:
See Classroom requirements

Course Title: MCSC 6120G – Numerical Methods for Ordinary Differential Equations

Pre-requisite(s): MCSC6020G Numerical Analysis or equivalent

Course Description and Content Outline:
Differential equations are an indispensable tool for the modelling of physical phenomena. However, most often in practice, analytical solutions to model equations cannot be found, and numerical approximations must be made. In this course, practical computational techniques for the numerical solution of ordinary differential equations will be covered, with an emphasis on their implementation and the fundamental concepts in their analysis.

Topics include:

- Review of ordinary differential equations
- Initial value problems
  - Forward Euler
  - Convergence, accuracy, consistency, and 0-stability
  - Absolute stability
  - Stiffness: Backward Euler
  - A-stability, stiff stability
  - Trapezoidal scheme
- One-step methods
  - Basic Runge-Kutta methods and general formulation
  - Convergence and order for Runge-Kutta methods
  - Error estimation and control
  - Implicit Runge-Kutta and collocation methods
  - Runge-Kutta software
- Linear multistep methods
  - Adams-Bashforth, Adams-Moulton, Backward Differentiation Formulae (BDF)
  - Order, 0-stability and convergence
  - Absolute stability and stiff decay
  - Implementation issues: error estimation, predictor-corrector techniques, step selection and modification, nonlinear systems solution
  - Multistep software
- Boundary Value Problems
  - Simple and multiple shooting
  - Difference schemes
    - Midpoint and Trapezoidal
    - Convergence, accuracy, consistency and stability
    - Solving linear problems: elimination for block matrices, stability
    - Solving nonlinear problems: Newton’s method
    - Scalar, second order ODEs
    - Collocation and Runge-Kutta
    - Convergence acceleration techniques
    - BVP software

Length in Contact Hours:
3 hours/week, 3 credits.
Delivery Mode and Teaching Method(s): Lecture.

Student Evaluation:
The mark will be determined from 4 assignments, which will require the implementation of various numerical methods to a variety of problems, and a term project, which will provide the student with experience of the implementation of a numerical method to a more in-depth problem.

Literature:

- U.M. Ascher, R.M. Mattheij, and R.D. Russell. Numerical Solution of Boundary Value Problems for Ordinary Differential Equations. SIAM, 1995.
- K.E. Brenan, S.L. Campbell, and L.R. Petzold. Numerical Solution of Initial Value Problems in Differential-Algebraic Equations. North-Holland, 1989.
- E. Hairer, S.P. Norsett, and G. Wanner. Solving Ordinary Differential Equations I. Springer-Verlag, second edition, 1993.
- E. Hairer and G. Wanner. Solving Ordinary Differential Equations II. Springer-Verlag, 1991.
- J.D. Lambert. Numerical Methods for Ordinary Differential Systems. Wiley, 1991.
- L.F. Shampine. Numerical Solution of Ordinary Differential Equations. Chapman & Hall, 1994.

Proposed Textbook Requirements:
U.M. Ascher and L.R. Petzold. Computer Methods for Ordinary Differential Equations and Differential-Algebraic Equations SIAM, 1998

Learning Outcomes:
Students who successfully complete the course have reliably demonstrated the ability to:

- choose and implement the appropriate numerical technique when presented with an ordinary differential equation requiring a numerical solution, and to understand the limitations of this approximation
- state the advantages and disadvantages of implicit versus explicit methods, single step versus multi-step methods, high-order versus low-order methods
- state definition of stability, accuracy, convergence
- state definition of stiffness and recognize the numerical consequences
- derive a multi-stage Runge-Kutta method
- design and implement codes for the solution of ordinary differential equations using a variety of methods
- be familiar with existing software packages and the issues involve in implementing them

Information about Course Designer/ Developer:
Greg Lewis, PhD Mathematics, Faculty of Science, UOIT.
List faculty eligible to teach the course and/or statement of "faculty to be hired": Greg Lewis, PhD Mathematics, Faculty of Science, UOIT, Dhavide Aruliah, PhD Mathematics, Faculty of Science, UOIT.
Are there any plans to teach all or portions of this course online?
A course website will play a role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc.
Faculty Qualifications to teach/supervise the course:
PhD in mathematics, computer science or related field, with background in numerical analysis and scientific computing, and research experience in the development and/or implementation of numerical methods for ODEs.
Classroom requirements: Technology-enhanced classroom with data projector, VCR and DVD and internet access.
Equipment requirements:
See Classroom requirements

Course Title: MCSC 6125G – Numerical Methods for Partial Differential Equations

Pre-requisite: MCSC 6020G Numerical Analysis or equivalent.

Course Description and Content Outline:
This course is an introduction to the mathematical concepts needed to develop accurate, reliable, and efficient numerical methods for the approximate solution of partial differential equations (PDEs). Partial differential equations constitute a vital modelling tool in science and a rich field of applied mathematical research. Essential model problems of elliptic, parabolic, and hyperbolic type are examined with corresponding numerical approximation techniques. This course includes a study of various discretisation frameworks: finite-difference methods, finite-element methods, finite-volume methods, and spectral collocation methods. Approximation schemes are compared and contrasted with an emphasis on error estimation, consistency, stability, and convergence as well as availability and convenience of existing software. There will be discussion of elements of iterative methods used for solving linear algebraic and nonlinear systems that arise from discretisation of PDE problems.

Topics include:

- Classification and well-posedness of PDE problems
    - Elliptic, parabolic, and hyperbolic model problems
    - Initial-boundary and boundary-value problems
- Finite difference discretisation schemes
- Finite element discretisation schemes
- Finite volume discretisation schemes
- Spectral collocation discretisation schemes
- Von Neumann analysis
- Accuracy, stability, and convergence
- Time-stepping algorithms and the method of lines
- Dissipation and dispersion
- A priori and a posteriori error estimates
- Iterative methods for systems of linear and nonlinear equations
- Possible applications: electromagnetics, fluid mechanics, solid mechanics, gas dynamics, semiconductor drift-diffusion models, chemical engineering applications

Length in Contact Hours: 3 hours/week, 3 credits.

Delivery Mode and Teaching Method(s): Lecture.

Student Evaluation: Assignments, Oral Presentation, Project
References:

U. Ascher and L. Petzold. Computer Methods for Ordinary Differential Equations and Differential-Algebraic Equations. SIAM, Philadelphia. 1998

D. Kincaid and W. Cheney. Numerical Analysis: Mathematics of Scientific Computing. Brookes/Cole. 3rd ed. 2002

J. Demmel. Applied Numerical Linear Algebra. SIAM, Philadelphia. 1997

P.G. Ciarlet. The finite element method for elliptic problems. SIAM, Philadelphia. 2nd ed. 2002

M. Gockenbach. Partial Differential Equations: Analytical and Numerical Methods. SIAM, Philadelphia. 2002

C.A. Hall and T.A. Porsching. Numerical Analysis of Partial Differential Equations. Prentice-Hall. 1990

R. Mitchell and D. F. Griffiths. The Finite Difference Method in Partial Differential Equations. Wiley, New York. 1980

Quarteroni, R. Sacco, and F. Saleri. Numerical mathematics. Springer, New York. 2000

L.N. Trefethen. Spectral Methods in MATLAB. SIAM, Philadelphia. 2000

Proposed textbook requirements:

K.W. Morton and D.F. Mayers. Numerical Solution of Partial Differential Equations.Cambridge. 1996

Learning Outcomes:
Students who successfully complete the course have reliably demonstrated the ability to:

- derive the symbol of a linear differential operator from a linear or nonlinear PDE or system of PDEs to classify according to type (elliptic, parabolic, hyperbolic)
- derive finite-difference schemes and develop computer codes for the numerical solution of standard scalar model PDE problems (first-order wave equation, heat equation, Schrodinger equation) in one or two spatial dimensions on regular grids
- derive the symbol of the linearisation of a nonlinear PDE (or PDE system) to classify it according to type (elliptic, parabolic, hyperbolic) for the purpose of selecting appropriate numerical solution approaches
- apply von Neumann analysis to finite-difference schemes for standard model PDEs to determine the associated amplification factors
- derive dispersion relations for standard model PDEs and corresponding finite-difference schemes
- analyse finite-difference schemes for standard model PDEs to determine their constistency, stability, and CFL condition
- derive and code finite-difference implementations of standard boundary conditions (Dirichlet, Neumann, Robin) for PDEs in one, two or more dimensions on regular grids
- implement spectral collocation and Galerkin finite element schemes for the solution of second-order elliptic PDE problems in one spatial dimension

Information about Course Designer/Developer:
Dhavide Aruliah, PhD Computer Science, Faculty of Science, UOIT

List faculty eligible to teach the course and/or statement of “faculty to be hired":
Dhavide Aruliah, PhD Computer Science
Peter Berg, PhD Mathematics
Greg Lewis, PhD Mathematics

Are there any plans to teach all or portions of this course online
A course website will play an integral role in the delivery of resources for this course: syllabus, schedule, assignments, solutions to homework and exams, handouts, supplementary notes, etc

Faculty Qualifications to teach/supervise the course:
PhD in mathematics or computer science with experience with partial differential equations and numerical analysis.

Classroom requirements: Technology-enhanced classroom with data projector, VCR and DVD and internet access.

Equipment requirements: See Classroom requirements. Students should have access to programming environments such as Matlab for the purpose of completing assignments and projects.

4.4. Collateral and supporting departments

The Faculty of Engineering and Applied Science, the Faculty of Science, and the Faculty of Business and Information Technology at UOIT are supporting the proposed programs, in part by providing faculty members who contribute their expertise and time to teach and co-supervise students and by sharing resources where mutually beneficial.

5. OUTCOMES

5.1 Enrolment and Graduations

As this is an application for a new program, this section is not applicable.

5.2 Employment

Employment records of the graduates from the program will be maintained on an ongoing basis.

5.3 Publications

Publication records of the graduates from the program will be maintained on an ongoing basis.

5.4 Projected Graduate Intake and Enrolments

Table 5-1 shows the projected graduate student enrolment (both full-time and part-time students) over the next seven years. As additional faculty are hired over the next few years, the planned enrolment in the program is expected to increase.

Table 5-1 Projected Intake and Enrolments

YEAR	FULL-TIME		PART-TIME		TOTAL ENROLMENT
	Intake	Enrolments	Intake	Enrolments	
2009	3-5	3-5	1-2	1-2	4-7
2010	5-7	8-12	1-2	2-4	10-16
2011	4-6	12-18	1	3-5	15-23
2012	4-6	16-23	1	4-6	20-29
2013	4-6	18-24	1	5-7	23-31
2014	4-6	18-24	1	6-8	24-32
2015	4-6	18-24	1	6-8	24-32

APPENDIX A: LIBRARY SUBMISSION

LIBRARY SUBMISSION TO ONTARIO COUNCIL OF GRADUATE STUDIES (OCGS) FOR: THE DOCTOR OF PHILOSOPHY (PHD) IN NUCLEAR ENGINEERING

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

Compiled by: Carol Mittlestead, B.A. (Hon), M.L.S., Associate Librarian

Introduction:

This document outlines the resources and services provided by the Library in support of the University of Ontario Institute of Technology's Doctor of Philosophy (PhD) in Nuclear Engineering.
In the first section, an overview of the Library from an "all users" perspective is provided. The second section details collections and services that specifically support the research endeavours of those teaching or enrolled in the PhD program. In this report, the term "collections" is used to describe both paper and electronic resources – books, indexes, periodicals (journals, magazines, newspapers), librarian recommended web sites, and data sets. The term "accessibility" addresses the physical presence of the Library, onsite reference assistance, the Library web page www.uoit.ca/library as a 24/7 portal, and interlibrary loan and document delivery.

The Library: An Overview

Facilities:

The Library is an American Library Association (ALA) award winning building designed by Toronto architects Diamond & Schmitt. Opened in late 2004, the Library boasts several noteworthy features:

- 75,000 square feet
- 500 seats
- 10 group study rooms
- 2 library orientation classrooms
- Round reading room with fireplace (2nd floor)
- Silent study and special collections room (3rd floor)
- *Graduate Student Quiet Study Zone (4th floor) – Swipe card access ONLY*
- *Graduate Student Lockers*
- Special needs adaptive technology area
- 160 public computers – wired and wireless
- Microsoft Office Suite
- Photocopiers and printers

Collections:

The Library's acquisition plan is based on evolving pedagogical needs as determined by the academic faculties. In close liaison with the deans and professors, subject specialist librarians define collection development strategies for the ongoing curriculum-based purchase of resources as well as for the evaluation and review of existing material.

"Traditional" (largely paper based) Resources

While the majority of the library's acquisition budget is devoted to electronic resources in accordance with new technology, customer service demands and UOIT's laptop university mandate, there is a small but comprehensive print collection. The plan is to increase paper book holdings by at least 5,000 volumes annually for several successive years with a current projected cost of $400,000 to $450,000 per annum. Similarly, the paper periodical collection is expected to remain constant with an investment of about $50,000 per year excluding costs (e.g. binding) incurred through donations. It is realized that not all current and archival holdings have moved to electronic format. As noted below, other "traditional" resources are also being maintained.

- 88,000 volumes (160,000 volume capacity)
- 400 paper copy journals
- 4,200 audiovisuals (Media Services)
- 877 microfilm reels
- Special Collections e.g. Nuclear, Law
- Leisure reading paperback collection
- Archives including Dissertations &Theses (see also below)

Digital Resources

Just as the availability of digital resources increases substantially from year to year so does their use as UOIT enrolment increases. Currently over $1.7 million or approximately 77% of the acquisitions budget is devoted to purchasing and maintaining electronic subscriptions.

There are primarily three categories of online publications – electronic books or e-books, electronic journals or e-journals (also includes electronic transactions, conference proceedings, standards, etc.) and data sets. The "explosion" of the technical document is reflected by the Library statistics recorded below:

- 47,000 e-books

  $63,000 in both 2004-5 and 2005-6; $116,000 in 2006-7; $150,000 in 2007-8; $175,000 anticipated in 2008-9

- Indexing and abstracting for over 75,000 electronic journals through various multidisciplinary and subject specific databases; 46,000 journals available immediately in full text

  $450,000 in 2005-6; $550,000 in 2006-7; $1.3 million in 2007-8; $1.7 million anticipated in 2008-9

Access to statistics is provided through the Library's subscriptions to four data sets – E-Stat, DLI (Data Liberation Initiative), ICPSR (Inter-University Consortium for Political and Social Research) and ODESI (Ontario Data Documentation Extraction Service and Infrastructure Initiative). E-Stat is Statistics Canada's educational database including census data and

CANSIM (Canadian Socio-economic Management System). The DLI is a far more expansive and comprehensive collection of statistical sets assimilated and maintained by Statistics Canada and offered through the IDLS (Internet Data Library System) hosted by the University of Western Ontario's Social Science Computing Laboratory. ICPSR is the international equivalent of DLI and is hosted by the University of Michigan. ODESI is a new project funded by the Ontario Council of University Libraries and Ontario Buys that assimilates much of the government data described above as well as including information from polling companies and public domain files such as the Canadian National Election Surveys. Given the interdisciplinary nature of the PhD in Nuclear Engineering, data sets from any of the four platforms that relate to energy, health care, education and public safety will be of particular value to this cohort.

The Library obtains its electronic resources by both approaching the vendor directly and by participating in consortium negotiations. This is largely dependent on subject content and company or organization specifications. UOIT is a member of both OCUL (Ontario Council of University Libraries) and CRKN (Canadian Research Knowledge Network) – the provincial and national university library consortia, respectively, that provide for the effective group purchase and distribution of electronic resources.

Resource Accessibility & Assistance:

The Library constantly strives to make its resources and services more readily available to faculty, staff and students. Despite the increasing demand for electronic resources with off campus access, the Library is still valued for its sense of place and study facilities. Opening hours have been extended each academic year and this will again be the case for 2008-9 for an increase to 94 hours per week.

General inquiries or requests for specific assistance are handled in person, by phone or by e-mail. The Reference team including Subject Specialist Librarians offers class orientations, workshops and individual reference appointments.

The UOIT Library web site www.uoit.ca/library is available 24 hours per day, 7 days a week. It is both the portal for accessing resources and for discovering a multitude of procedural and instructional information. For guidance in navigating and assessing the collection in relation to one's research interest, it is recommended that all library users consult the tabs entitled "Research a Topic" and "Search Collections". Librarian Prepared Subject Guides are included here. For each topic a list of recommended books, e-books, media resources, electronic indexes and full text databases is provided along with links to statistics, data, government information and "free" but academically sound websites. A "special notes" or "need to know" section prefaces the Subject Guide if there are unique collections or lending conditions associated with a given topic. Help Sheets are available under the "Get Help" tab on the Library web page if the patron needs further research or technical assistance.

In addition to the Subject Guides mentioned above that emphasize pertinent indexes and databases, there are also other ways to effectively access electronic journals, magazines, and newspapers. Scholars Portal and E-Journals at Scholars Portal are OCUL platforms that allow an individual to access a number of databases simultaneously. The Library also provides a searchable alphabetical list of all indexes and databases, a searchable alphabetical list of all periodical (journal, magazine and newspaper) titles, and a citation locator that checks for either journal or article availability. Further, cross-referencing amongst databases is provided by a federated search engine or linking software called "Find It @ UOIT". If a patron is searching one database, but the article is available in another, he/she will be redirected to this resource. If the article is not available at UOIT, the option to request an ILL (interlibrary loan) is displayed.

Refworks is a software tool that allows for citations to be "harvested" from various periodical databases or imported directly so bibliographies can be easily prepared. The user selects the appropriate bibliographic format (e.g. MLA, APA) and Refworks applies it to the references that have been assimilated. The complementary component is Refshare; it allows for bibliographies to be shared amongst colleagues and/or to be used as electronic reserve listings. Students may be directed to an article by their professor and simply authenticate into the Library system. The Library also provides information and assistance in creating durable links or persistent URLs as permitted by database licensing agreements and copyright law. This is yet another method of sharing resources amongst colleagues and/or creating reserve reading lists.

Interlibrary Loan (ILL) is currently free to all UOIT staff, students and faculty. Patrons are directed to an online request form available on the library's web site. Borrowing and lending occur through RACER (rapid access to collections by electronic requesting) a VDX (Virtual Document Exchange) interlibrary loan system implemented in OCUL member libraries. Searches are primarily performed throughout Ontario universities, but items are obtained from other Canadian universities, CISTI (Canada Institute for Scientific and Technical Information) and international institutions too.

Faculty and students from UOIT may visit most other Canadian university libraries and borrow books (Reciprocal Borrowing Agreement) directly upon presentation of their UOIT photo identification card. Materials may be returned directly to the lending library or may be left at the UOIT Library where they will be returned to the appropriate lending library.

The Library: Program Specifics

Collections:

As noted in detail below, the Library acknowledges that nuclear engineering encompasses a broad spectrum of professional expertise that reflects upon energy, industrial, environmental, and health care issues; the Program has an interdisciplinary focus. Similarly, the Library has responded to the research intensity that is an essential component of any PhD program.

"Traditional" (largely paper based) Resources:

From its inception, UOIT has been building its reputation on science and technology based programming; Library collection has echoed this. At present, approximately 11,200 engineering volumes are available for circulation. For example, there are books on reactor physics, fuel cycles, power plant design and operation, facilities decommissioning, risk analysis, dosimetry and radiation therapy. Following the move to the new Library in late 2004 and the availability of more space, investment in engineering books has increased steadily -- $72,000 in 2005/6; $90,000 in 2006/7; $120,000 in 2007/8. Despite the increased availability and popularity of e-books, it is expected this expenditure will continue to rise by 4-5% for several successive years.

The volume count given above does not include the 1,750 international nuclear engineering reports acquired through donations and housed in the Library's Special Collections room as reference or non-circulating works. Most of these reports were published in the 1970 to 1990 time frame, but some date as far back as the early 1950s. While Canada is well-represented through national reports such as those published by the Canadian Nuclear Association and Canadian Nuclear Society, materials from the United States, United Kingdom, France, Italy, Sweden, Australia and other countries and international bodies are available too. The Library will continue to solicit for further donations to this Special Collection.

Approximately 12,500 supporting science --mathematics, chemistry, physics, biology,—books are also available. Over the last three years, investment has averaged at $128,000 per annum. It is expected that this expenditure will remain constant for several years.

The practical information needs of post graduate students are addressed by the Library as well. Books that focus on topics such as qualitative and quantitative research methods, the drafting of research proposals, intellectual property, grant writing, presentation techniques, technical communications, and university teaching are available. Engineering management books including professional ethics and project management as well as other business texts addressing issues such as market share, networking and leadership will also prove valuable to this PhD group. To facilitate greater user accessibility, the preference is to acquire industrial standards in electronic format (see below), but if this is not possible, the Library will purchase paper copies.

Borrowing privileges for Faculty and Graduate Students are quite generous given the limited size of the collection:

- Limit of 50 regular loan items
- 30 day loan period with 2 renewals (i.e. 90 day total)
- Semester loan by REQUEST

<u>Digital Resources:</u>

<u>*E-books*</u>

As mentioned above, the Library is investing heavily in e-books. While some are yearly subscriptions, others are individual titles or publisher groupings by subject or date release (e.g. titles published in 2007) purchased on a one time basis. E-books most likely to interest Nuclear Engineering PhD candidates include:

- *Access Science* (McGraw-Hill Encyclopedia of Science & Technology Online)

- *Books 24 x 7* - 1,400 e-books in *Engineering Pro* subset; 2,000 e-books in *IT Pro* subset with 400 for Software Engineering

- *CRC netBase* series – 980 e-books in *Engineering netBase*

  Examples of other *netBase* e-book databases include: *Bioscience, ChemLib, Forensics, Electrical Engineering, Mechanical Engineering, Materials, Polymers*

- *Encyclopedia of Materials Science & Technology* (EMSAT)

- *Kirk-Othmer Encyclopedia of Chemical Technology*

- *Springer* (various subject collections e.g. 2,600 engineering titles)

- *Synthesis Digital Library* (225 lecture series – ASEE (American Society for Engineering Education) award winner

- *Ullmann's Encyclopedia of Industrial Chemistry*

Journals, Transactions, Conference Proceedings and Standards

Patrons can search for journals through an abstracting or indexing tool such as Inspec or Science Citation Index Expanded for a comprehensive subject overview (linking to full text through Find It @ UOIT and interlibrary loan provided as described above) or they can choose to search more directly for full text. The UOIT Library presently provides access to over 4,300 full text science journals and 12,000 full text technology/engineering journals. They are available as traditional paper subscriptions, single electronic titles (e.g. Science, Nature, Fusion Science & Technology) or as one of several titles within an electronic database. These resources are not only a venue for periodicals; many also offer technical reports, conference proceedings and standards.

Below is an overview of journal holdings information pertinent to the Nuclear Engineering PhD program. First, a listing of electronic indexes and databases is provided. While these tools do allow for searching by specific journal title, their intrinsic value lies in their ability to perform subject searches across all content held within the database; the user starts with a concept and pulls articles from numerous journals simultaneously. Secondly, a select list of journal titles is provided based of their impact factors and thus relevancy to nuclear engineering research.

Indexes and Databases

Extremely Relevant:

Annual Reviews – Physical Sciences – Nuclear & Particle Science
ASTM Digital Library (American Society of Testing & Materials – handbooks, transactions, etc.)
ASTM Standards
CCOHS (Canadian Centre for Occupational Health & Safety)*
Compendex
CSA (Canadian Standards Association) Online
E-Journals @ Scholars Portal (OCUL portal for simultaneous access to multiple publishers e.g. Elsevier/Science Direct, Springer, Kluwer, Wiley)
IEEE (Institute of Electrical and Electronics Engineers – journals, transactions, conference proceedings, standards (approved and draft))
INIS (International Nuclear Information System)
Inspec (IEE – Institution of Electrical Engineers)
NTIS (National Technical Information Service)
Science Citation Index Expanded (Part of ISI Web of Science)
Scopus

Very Relevant:

ACM (American Computing Machinery)
BioOne
Biosis Previews
Computer Science Index
Environment Complete
IOP (Institute of Physics)
Materials Science – Sage Full text
MathSciNet
Proquest Science
PubMed

RSC (Royal Society of Chemistry)
Scitation (AIP – American Institute of Physics, SPIE –Society for Optical Engineering, ASME – American Society of Mechanical Engineering)
SIAM (Society for Industrial & Applied Mathematics)
SciFinder Scholar with SSM (Substructure Molecule)
Wilson Applied Science & Technology Abstracts

Relevant (multidisciplinary databases):

Academic One File
Academic Search Premier
JStor (Journal Storage – Archives)

* includes MSDS (Material Safety Data Sheets) and associated Ontario and federal legislation and standards

When a key journal is not available through a database package, the Library negotiates directly with the publisher for title-by-title access. This has been the case for journals issued by ANS (American Nuclear Society).

Postgraduate students are directed to *JCR (Journal Citation Reports),* an electronic resource that ranks journals by impact factor and indicates which journals are most frequently cited in each field. The Library scores exceedingly well under the JCR category of Nuclear Science and Technology. Examples of high impact titles that are available through the UOIT Library include:

Annals of Nuclear Energy
Applied Radiation & Isotopes
Fusion Engineering & Design
Fusion Science & Technology
Health Physics
IEEE Transactions on Nuclear Science
International Journal of Energy Research
International Journal of Radiation Biology
Journal of Fusion Energy
Journal of Nuclear Materials
Journal of Radioanalytical & Nuclear Chemistry
Journal of Radiation Protection
Nuclear Engineering & Design
Nuclear Instruments & Methods in Physics Research: Section A, Accelerators, Spectrometers, Detectors & Associated Equipment
Nuclear Instruments & Methods in Physics Research: Section B, Beam Interactions With Materials & Atoms
Nuclear Technology
Plasma Devices and Operations
Progress in Nuclear Energy
Radiation Effects & Defects in Solids
Radiation Measurements
Radiation Physics & Chemistry
Radiation Protection Dosimetry

Acutely aware of UOIT's "youth", the Library strives to obtain full text electronic archives of key journals as well as current issues whenever possible. The following serves to illustrate:

IEEE (journals, transactions, conference proceedings)	1913-present
International Journal of Radiation Biology	1959-present
Journal of Radioanalytical & Nuclear Chemistry	1968-present
Radiation and Environmental Biophysics	1963-present
Radiation Effects & Defects in Solids	1969-present
Radiation Research	1954-present
Nature	1869-present
Science	1880-present

The library also operates a very active donation program searching for specific back run titles in paper format as necessary.

Data Sets (see comment in general section)

Thesis Databases and Digilog

The Library provides access to *PQDT (Proquest Dissertations and Theses)* and *Theses Canada Portal.* PQDT is a multidisciplinary international database of more than 2 million theses. Indexing and abstracting is provided from 1861 to the present with fulltext provided from 1998 to the present. The mission of the Theses Canada Portal is to digitize and consolidate Canadian theses documents into one database. Each product offers interlibrary loan and purchase options for items not yet available in electronic format. As well as housing a paper copy of each UOIT postgraduate thesis in its Archives, the Library posts an electronic copy on Digilog, its own tailored version of D-Space or institutional repository software. Faculty and graduate students are also invited to post their research findings on Digilog.

The Library is preparing for UOIT's initial PhD programs and is committed to supporting the resource and research needs of both faculty and students.

CM – 08/18/08

APPENDIX B: GRADUATE POLICIES

GENERAL POLICIES AND PROCEDURES FOR GRADUATE STUDIES

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

June 1, 2006

Preamble:

As a young and dynamic institution, the University of Ontario Institute of Technology (UOIT) continues to develop policies and procedures for matters related to graduate studies. The new policies in this paper are based on the best practices of leading institutions across Canada, while recognizing UOIT's unique mission, principles and dynamics.

The main purpose of this document is to consolidate proposed new graduate studies policies with existing ones, thus creating a comprehensive set of conventions for all UOIT students, faculty members and staff pursuing graduate-level study, teaching or administration.

To clarify any information in these policies, please contact the Dean of Graduate Studies. The General Policies and Procedures for Graduate Studies will be reviewed no later than fall 2010.

The following current UOIT policies and guidelines also apply to graduate studies:

- Student Conduct;
- Protection of Privacy and Access to Information;
- Research Guidelines;
- Intellectual Property; and
- Use of Turnitin.com's Plagiarism Detection System.

GRADUATE STUDIES

Dean of Graduate Studies: Brian Campbell, BA, BPhil, PhD

UOIT is an innovative research intensive university with modern state-of-the-art facilities. Graduate students at UOIT benefit from innovative instructors, progressive research and academic tools unique to UOIT. We are focused on high quality programs in high demand areas of study. Our faculty members are dedicated professionals, who have acquired their considerable skill by working on some of the most advanced projects in Canada and around the world. Students who accept the challenge of graduate studies at UOIT are equipped with the tools needed to succeed in today's global marketplace.

The first part of this section outlines a comprehensive set of policies relating to graduate level study, teaching and administration. The second part outlines specific details of the graduate programs offered at UOIT. This information is organized as follows:

1. Administration of Graduate Studies

1.1 Dean of Graduate Studies

The role of the Dean of Graduate Studies is central to all major academic and administrative graduate study activities.

1.1.1 Responsibilities

The responsibilities of the Dean of Graduate Studies include:

- providing leadership, strategic planning and vision, particularly in the growth and development of graduate programs and activities;
- administering all regulations relating to graduate studies;
- chairing the Graduate Studies Committee of Academic Council;
- representing graduate studies at Academic Council; and
- representing the university's graduate studies to internal and external individuals and groups.

1.2 Graduate Program Directors

Each program will have a Graduate Program Director. This role is of critical importance to ensuring the success of the program and its students.

Graduate Program Directors should have a strong interest in students and their success, thoroughly understand UOIT's policies and procedures for graduate studies, and be available on a regular basis to assist students seeking advice on issues related to their studies.

The Graduate Program Director is accountable to the Dean of the Faculty and, with respect to graduate activities, to the Dean of Graduate Studies.

1.2.1 Appointment

The Graduate Program Director is appointed by the Dean of the home Faculty, in consultation with the Dean of Graduate Studies. The duration of the appointment may be two or three years at the discretion of the home Faculty Dean with opportunity for re-appointment.

1.2.2 Responsibilities

Each Graduate Program Director has a formal role and responsibilities relating to the Graduate Studies Committee of Academic Council, including nominations, Supervisory Committees, student awards and similar matters.

The main duties of the Graduate Program Director are to:

1. ensure that all graduate studies policies and procedures are administered fairly and correctly and are communicated to students in their program;
2. chair the Academic Committee for the program and make recommendations to the Dean of Graduate Studies regarding the admission of applicants;
3. approve a program of studies for each student and provide advice regarding changes to a student's status or program;
4. appoint a faculty advisor or research supervisor for each student;
5. where applicable, work with the student and research supervisor to form a Supervisory Committee and appoint a committee Chair;
6. recommend external examiners to the Dean of Graduate Studies;
7. consider requests from students to defer an examination;
8. consider for approval changes to a student's grade;
9. liaise regularly with the Dean of Graduate Studies and, as needed, with the Registrar;

10. maintain student records and forward to the appropriate UOIT office(s), as required;
11. provide advice, as needed, to units and bodies such as the Graduate Studies Committee of Academic Council;
12. help ensure that graduate students have the necessary resources, facilities and support;
13. co-ordinate financial assistance (including assistantships and fellowships) for graduate students;
14. help monitor the progress of graduate students;
15. provide input and assistance as requested for the creation and review of graduate programs;
16. mediate as needed in conflicts or disputes between a graduate student and his or her research supervisor; and
17. co-ordinate graduate student recruitment activities for the program.

2. Graduate Faculty Appointments

Faculty members who are eligible to participate in the supervision of graduate students and teach graduate courses must have an academic appointment at UOIT. This may be a core or definite-term appointment, or that of an Adjunct Professor or Professor *Emeritus/Emerita*. Individuals wishing to teach at the graduate level are nominated by the Dean of the Faculty through which the program is delivered. Once approved by the Dean, the nomination is forwarded to the Graduate Studies Committee of Academic Council for final approval.

All faculty members who are currently involved in any aspect of graduate education, including acting as a research supervisor and/or member of a Supervisory Committee and who are listed in the Ontario Council of Graduate Studies (OCGS) briefs, automatically become eligible to teach graduate courses and supervise graduate students. The category of membership will be determined by the criteria set out in section 2.1.

Membership is effective from the date of introduction of a graduate program until the program is scheduled for a periodic appraisal by OCGS. At this point all faculty members will be re-evaluated for graduate teaching and supervision privileges. In effect, the normal renewal of graduate teaching and supervision privileges is synchronous with OCGS periodic program appraisal.

The updated faculty list will be printed annually in the paper and electronic versions of the graduate section of the *Academic Calendar*. It is the responsibility of the Graduate Program Director to keep an up-to-date list of eligible faculty members who participate in a graduate program.

2.1 Categories of Graduate Teaching and Supervision Privileges

Graduate studies at UOIT offers two categories of eligibility: Graduate Faculty and Special Graduate Faculty.

Graduate Faculty are UOIT faculty members who are authorized to participate in all aspects of a graduate program on a regular and sustained basis. These privileges are renewable every seven years at the time of the OCGS periodic appraisal of the graduate program in which the faculty member participates. Graduate Faculty are authorized to perform a variety of activities including: serving as a research supervisor or co-supervisor or as a member of a student Supervisory Committee, participating in an Examining Committee, teaching graduate-level courses, acting as a faculty advisor, and mentoring and advising graduate students in all aspects of their program. Graduate Faculty have a research program that includes externally refereed publication.

Special Graduate Faculty status is intended for non-core faculty members who have temporary appointments at UOIT (in certain cases where qualifications warrant) and who provide a limited graduate educational activity for a limited time (i.e., two to three years). Faculty members in this category may be appointed to serve on a Supervisory Committee and/or as external examiners. They may also be allowed to teach graduate courses for a limited time and participate on an Examining Committee. Permission for such appointments must be obtained from the Dean of the host Faculty with a memo to the Dean of Graduate Studies and an up-to-date curriculum vitae.

In no case may a non-core faculty member serve as the sole research supervisor of a graduate student. Individuals with special graduate teaching and supervision privileges may assist with the direction of a graduate student's research, following approval by the Dean, through appointment as a co-supervisor. In this case, however, one of the co-supervisors must be a member of the Graduate Faculty for that graduate program.

3. Program Format

Some Master's programs require students to write a thesis, while other programs require a project, major paper or other work. The thesis, project or major paper is a central part of the student's program and helps fulfill one of UOIT's mandates: to promote the generation of knowledge through scholarly research of the highest quality.

In some UOIT programs, students may choose between one or more formats such as a thesis, project or a course work option. The program format and options are specified in the program description in the graduate section of the *Academic Calendar* and in other program information.

A graduate thesis is an original work that is overseen by a research supervisor and a Supervisory Committee. Theses are worth at least nine credits and involve an oral examination that includes an assessment by an external examiner. A project or major paper is an original work that is supervised by a research supervisor and includes a second reader. Projects and major papers are worth at least six credits and do not require an oral examination or an external examiner.

4. Student Supervision

Each Master's student will have a faculty advisor or research supervisor to provide guidance throughout the program. In programs that do not require a thesis, project or major paper, the student will be guided by a faculty advisor throughout the program.

A student registered in a program that requires a thesis, project or major paper may initially have a faculty advisor, but will be assigned a research supervisor when the student begins his or her research. In some cases a student may have co-supervisors, with the terms established through an agreement for co-supervision and made clear at the outset to all involved.

4.1 Faculty Advisor Appointment

The Graduate Program Director is responsible for assigning faculty advisors.

4.2 Faculty Advisor Responsibilities

The faculty advisor will be a member of the student's home Faculty. The main responsibilities of the faculty advisor are to:

1. consult with the student, recommend a program of study, and submit it to the Graduate

Program Director for approval;
2. help the student choose an appropriate area of research, if applicable;
3. ensure that the student understands all degree requirements and regulations, as well as applicable policies;
4. be knowledgeable about, and inform the student of, key deadlines and related information;
5. be reasonably available to the student to discuss the program of study, as well as any academic concerns;
6. if requested, advise the student on academic or personal student services or resources; and
7. monitor the student's academic progress.

4.3 Research Supervisor Appointment

The relationship between the student and the research supervisor is most important to the student's successful completion of a graduate degree. The Graduate Program Director will seek input from the student before assigning a research supervisor.

All research supervisory appointments must be approved in the first instance by the Dean of the primary Faculty in which the student is registered. Except in extraordinary circumstances, approved on an individual basis by the Dean of Graduate Studies, research supervisors must be members of the UOIT core faculty. Associate members and Adjunct Professors may serve as co-supervisors with the approval of the Dean of the Faculty.

Before approving the appointment of a research supervisor, the Dean should give careful consideration to the faculty member's research activities, supervisory experience and training, previous performance in graduate student supervision, the number of graduate students already being supervised, any imminence of leave (i.e., research, maternity or administrative) or retirement, and any other relevant factors.

Since continuity of supervision is important in all graduate work, a change of research supervisor may be made only for strong reasons and after extensive consultation with all involved. A request for a change may come from the student, the research supervisor, the Graduate Program Director or the Dean. It should normally be sent, in writing, to the Graduate Program Director accompanied by the reasons for the proposed change. If the home Faculty Dean concurs with the request, the recommendation for change should be sent to the Dean of Graduate Studies for final approval.

4.4 Research Supervisor Responsibilities

Specific responsibilities of the research supervisor include:

1. being sufficiently familiar with the field of research to provide guidance and/or be willing to gain that familiarity before agreeing to act as a research supervisor;
2. being accessible to the student for consultation and discussion of the student's academic progress and research;
3. helping the student select and plan a suitable, timely and manageable research topic;
4. co-operating with the student and Graduate Program Director to establish a Supervisory Committee to convene meetings, normally at least once annually, to evaluate the student's progress;
5. responding in a timely, consistent and thorough manner to written work submitted by the student, with constructive and well-informed suggestions for improvement and continuation;
6. providing a research environment that is safe, healthy, tolerant and free from harassment, discrimination and conflict;

7. within the norms appropriate to the discipline, providing financial support and/or helping the student obtain financial support from all reasonable sources;
8. endeavouring to achieve consensus and resolve differences in the best interests of all involved when there is conflicting advice, or when there are different expectations on the part of co-supervisors or members of a student's Supervisory Committee;
9. acknowledging appropriately the contributions of the student in presentations and published material, in many cases via joint authorship;
10. being sensitive to cultural factors which may influence the individual student's learning and research behaviour and experience; and
11. making arrangements for continuity of the student's supervision before beginning an extended leave of absence.

4.5 Student Responsibilities

Student responsibilities include:

1. making a commitment and showing substantial effort, initiative and dedication to gain the background knowledge and skills needed to pursue the research project successfully;
2. working with their research supervisor to develop a plan and a timetable for completion of all stages of the research project, and working assiduously to adhere to a schedule and to meet appropriate deadlines;
3. meeting regularly with their research supervisor and reporting fully and regularly on progress and results;
4. keeping their Graduate Program Director fully informed regarding any matter relevant to their status in the program and seeking advice from their research supervisor, as appropriate;
5. meeting agreed-upon performance standards and deadlines of funding organizations to the extent possible when financing has been provided by UOIT or a funding agency, or through a contract or grant; and
6. adhering to the standards of research ethics, health and safety, and respecting the requirements of academic integrity, honesty and professionalism (this includes, but is not limited to, acknowledging and crediting any source of ideas, assistance, materials and/or data provided by others).

4.6 Student-Research Supervisor Conflicts

It is the responsibility of UOIT and its Faculties to ensure that all graduate students receive appropriate and fair supervision. Due to the nature of the relationship between the student and research supervisor, conflicts may arise. In such instances, the first step must be to attempt to resolve the conflict informally between the student and research supervisor. It is the responsibility of the Graduate Program Director to act as a mediator.

A student who believes the conflict has not been resolved should contact the Dean of the student's home faculty. If the conflict persists, the student may pursue appropriate resolution through the Dean of Graduate Studies.

5. Supervisory Committee

Each graduate student in a program that requires a thesis will have a Supervisory Committee. Early formation of a Supervisory Committee, along with regular meetings and formal meeting records, will help ensure higher completion rates.

5.1 Appointment

The Supervisory Committee will be appointed by the Graduate Program Director, after consultation with the research supervisor and the student. The appointment will be made once the research supervisor is satisfied that the student has made adequate progress in the chosen research area.

5.2 Composition

Master's Candidates

Normally, each Supervisory Committee for a Master's level candidate consists of the candidate's research supervisor(s) and at least one other UOIT faculty member. The Chair, who may be someone other than the candidate's research supervisor, is appointed by the Graduate Program Director of the candidate's home Faculty.

Doctoral Candidates

The Supervisory Committee for a doctoral candidate consists of the candidate's research supervisor(s) and at least two other UOIT faculty members. The Chair, who may be someone other than the candidate's research supervisor, is appointed by the Graduate Program Director of the candidate's home Faculty.

5.3 Responsibilities

The Supervisory Committee's main responsibilities are to:

1. advise the student and help define the course of study;
2. assess and approve the student's research proposal;
3. provide support to the student and research supervisor by broadening and deepening the range of expertise and experience available;
4. be reasonably accessible to the student to discuss and suggest other sources of information;
5. offer comments when requested on written work submitted by the student;
6. review the student's progress toward successful completion of the thesis with scheduled meetings at least once per year;
7. provide constructive feedback and provocative discussion of the student's program of study, thereby exposing the student to a wider range of expertise and ideas than can be provided by the research supervisor alone;
8. report progress to the Graduate Program Director and recommend continuation in the program based on satisfactory performance (in the case of reports of unsatisfactory progress, the student may be required to withdraw from the graduate program); and
9. recommend to the Graduate Program Director and the Dean of Graduate Studies whether a thesis should move to oral examination (this stage must be completed no less than three months prior to the date set for examination).

5.4 Chair's Responsibilities

The main responsibilities of the Chair of the Supervisory Committee are to:

- convene and run Supervisory Committee meetings;
- keep the Graduate Program Director informed of the student's progress;
- recommend potential External Examiners to the Dean of Graduate Studies; and
- forward a copy of the student's thesis to members of the Examining Committee at least four weeks before the oral examination.

6. Thesis, Project or Major Paper

Many Master's programs require students to write a thesis or major paper, or produce a project. All written work must be in English and in correct, concise and scholarly language.

6.1 Permission to Begin

Permission to begin the thesis is given by the student's Supervisory Committee when there is general agreement that sufficient research has been done. If the student's program requires a project or major paper, the student's research supervisor will authorize the student to begin the project or major paper.

Students should seek guidance from their research supervisor regarding the use of a style manual appropriate to the academic discipline in which they are working, as well as other available guides to assist in effective writing. Also, students are expected to be aware of and observe copyright requirements, and follow other standards as outlined in the UOIT policies on Research Ethics (http://www.uoit.ca/EN/main2/about/14057/14152/Academic_Policies_and_Procedures/research_ethics.html) and Research Involving Animals (http://www.uoit.ca/EN/main2/11246/13525/14057/14152/research_guidelines.html).

6.2 Use of Copyright Material in Student Work

When preparing a thesis, major paper or other program work, students may include some copyright material, typically in the form of excerpts from books or articles, charts, diagrams or similar previously published materials. It is the student's responsibility to acknowledge properly any copyright materials used, strictly following the citation guidelines and rules of their Faculty and/or program.

As well, students who use extensive selections of copyright work may need to seek advance written permission from the author, and must append the letter to their work. Students should contact the copyright holder well in advance of their deadline, as obtaining permission to use copyright materials may take considerable time. In addition, students may be required to pay a fee to obtain such permission. Questions regarding the use of copyright materials should be discussed with the faculty advisor or research supervisor, as appropriate.

Students may be required to submit their work to Turnitin.com. Further information can be obtained from UOIT's policy on the Use of Turnitin.com's Plagiarism Detection System (http://www.uoit.ca/EN/main/11259/11265/150328/196937/turnitin_policy.html).

6.3 Oral Examination

Master's candidates whose programs require a thesis and doctoral candidates are required to defend their completed thesis/dissertation orally in front of an Examining Committee. Candidates are expected to follow the advice of their research supervisor(s) and their Supervisory Committee in establishing when their work is ready for examination. In exceptional circumstances students may request that the Dean of Graduate Studies arrange for an examination of the thesis/dissertation or other work without the support of the research supervisor(s) and Supervisory Committee.

It is the candidate's responsibility to ensure that all materials are prepared and assembled appropriately. Students should consult their research supervisor(s) for specific regulations on the preparation and presentation of thesis/dissertation materials.

6.3.1 Examining Committee

The Examining Committee evaluates the academic merit of the candidate's thesis/dissertation who defends a thesis/dissertation and decides whether the candidate has satisfactorily passed the oral examination.

Master's Candidates

For Master's candidates, the Examining Committee consists of all members of the Supervisory Committee plus one external examiner (see Section 6.3.2). The committee is chaired by the Graduate Program Director or designate.

Doctoral Candidates

For doctoral candidates, the Examining Committee consists of the external examiner, one university examiner (see Section 6.3.2) and all members of the candidate's supervisory committee (including the research supervisor(s). The committee is chaired by the Graduate Program Director or designate.

6.3.2 External Examiner

Master's Candidates

An external examiner is typically a faculty member outside the student's program. The external examiner for a Master's oral exam <u>can not</u> be an Associate or Adjunct member of the student's home Faculty, nor have had any direct or indirect contact with the candidate as either a course instructor or supervisor supervision of the candidate's thesis. This person will have considerable direct knowledge in the field of study of the subject matter.

The external examiner is appointed by the Dean of Graduate Studies, upon recommendation of the Graduate Program Director. When an external examiner from outside the university is recommended, a curriculum vitae and written rationale for the choice must be provided to the Dean of Graduate Studies.

Conflicts of interest must be avoided when recommending the names of external examiners to the Dean of Graduate Studies. External examiners must not be teaching or supervising family members or relatives of the candidate, must not be closely linked in a personal or research capacity, nor shall they have shared financial interests with either the candidate or the research supervisor(s). Should the candidate's thesis contain chapters or sections of previously published works, the external examiner shall not have been involved in the review or editing of this material in any capacity.

Doctoral Candidates

The university examiner is a core faculty member at UOIT who has not been involved with the candidate in any teaching or supervisory capacity.

External examiners should hold the rank of Full or Associate Professor (or equivalent) if they are at a university, or of comparable expertise and standing if not at a university. An external examiner for a PhD dissertation is a well-qualified, objective and experienced individual who has not had any direct contact with the candidate as either a course instructor or supervisor of the candidate's dissertation and who is not associated or affiliated with UOIT. This person will have considerable direct knowledge in the field of study of the subject matter.

The university and external examiners are appointed by the Dean of Graduate Studies, upon recommendation of the Graduate Program Director. A curriculum vitae of the recommended external examiner and written rationale for the choice must be provided to the Dean of Graduate Studies.

Conflicts of interest must be avoided when recommending the names of university or external examiners to the Dean of Graduate Studies. University and external examiners must not be teaching or supervising family members or relatives of the candidate, must not be closely linked in a personal or research capacity, nor shall they have shared financial interests with either the candidate or the research supervisor. Should the candidate's dissertation contain chapters or sections of previously published works, the university and external examiners shall not have been involved in the review or editing of this material in any capacity.

External Examiner’s Report for Master’s and Doctoral Candidates

The external examiner shall prepare a report of his/her assessment of the candidate’s thesis and send it to the Dean of Graduate Studies or designate no less that one week before the scheduled exam date. The Dean or designate will distribute copies of the report to all other members of the Examining Committee. The content of the report is confidential and must not be discussed with the candidate prior to the final examination. Depending on the content of the report, the Examining Committee and the Dean of Graduate Studies may meet to determine whether or not to proceed with the final examination.

The Dean of Graduate Studies reserves the right to postpone the final examination if the External Examiner's report is not received three days prior to the scheduled exam date.

6.3.3 Approval for Oral Examination

Before an oral examination can be held, the Supervisory Committee must approve the thesis for examination (no more than one negative vote and/or abstention). The work must be submitted at least four weeks prior to the proposed oral examination.

6.3.4 Examination Procedure

Once the work has been deemed ready for examination, the Chair of the Examining Committee shall make all necessary arrangements for sending the thesis to the external examiner, setting the examination date, and preparing the relevant documents needed at the time of the examination.

If a member of the Examining Committee finds that he or she is unable to attend the oral examination, the Graduate Program Director should secure a suitable replacement. Should a suitable replacement not be found, the member is asked to submit his or her questions or concerns, to be read by the Examining Committee Chair at the defence. In extraordinary circumstances, the examination will be rescheduled if one or more members of the Examining Committee are unable to attend.

The oral examination consists of a short presentation (15-20 minutes) by the candidate summarizing the main findings of the work. The presentation is an open event that can be attended by all interested parties at the discretion of the Chair, but visitors may not remain for the rest of the proceedings.

Once the presentation has concluded, the student answers questions from members of the Examining Committee, including the committee Chair. Questions must be related to the work done by the student for the thesis and be based on knowledge directly related to the material.

When the question period is over, the student is asked to leave the room and members of the Examining Committee will determine the outcome of the oral examination. The Examining Committee Chair is a non-voting member, unless the Chair’s vote is needed to break a tie.

6.3.5 Outcomes of Completion of the Oral Examination

The Examining Committee will render one of the following four decisions:

1. acceptable without change;
2. acceptable with minor change;

3. acceptable with major change; or
4. not acceptable.

<u>1. Acceptable Without Change</u>
A grade of pass is given if there is acceptance of the student's work with no required revisions by the committee as a whole.

<u>2. Acceptable with minor change</u>
A grade of pass is given if there is acceptance of the student's work with minor revisions to be completed within four weeks; revisions must not alter or drastically change the content of the thesis.

<u>3. Acceptable with major change</u>
A thesis which is not acceptable as a pass but not deemed a fail is referred for major revision. A thesis cannot be referred for a major revision and a second oral examination more than once; no further defence is permitted. In order to qualify for a decision of major revision, the work must meet one of the following requirements:

a) the committee agrees that the work requires considerable change in order to be deemed a pass; or
b) there is a majority vote in favour of major revision.

In the case of a major revision, the Examining Committee will reconvene within six months to continue the examination including the revisions. The revised thesis will be distributed within four to six weeks prior to the meeting to all members of the committee for review and assessment.

<u>4. Not Acceptable</u>
A thesis is deemed failed if:

a) there is a majority vote to fail it; or
b) the thesis is deemed unacceptable after major revisions.

Detailed reasons for failure must be submitted by the Chair of the Examining Committee to the Dean of Graduate Studies, the Graduate Program Director, and the candidate within two weeks.

6.4 Project or Major Paper Evaluation
The research supervisor or co-supervisors, and at least one other reader appointed by the Graduate Program Director from among the Graduate Faculty or Special Graduate Faculty for that program, shall submit a grade for the project or major paper. All grades must be accompanied by a report that outlines the reasons for the grade.

Each of the submitted grades will be one of the following.

1. acceptable without change;
2. acceptable with minor change;
3. acceptable with major change; or
4. not acceptable.

In cases where all the submitted grades are acceptable without change, a grade of pass will be given.

In cases where at least one grade is "acceptable with minor change" and there are no "acceptable with major change" or "not acceptable" grades, the research supervisor will ensure that the student's work is revised to respond to the recommended minor changes. Normally, these revisions must be completed within four weeks. Revisions must not alter or drastically change the content of the project or major paper. Upon the satisfactory completion of the revisions, a grade of pass will be submitted for the student.

In cases where at least one grade is "acceptable with major change" and there are no "not acceptable" grades, the research supervisor will ensure that the student's work is revised to respond to the recommended changes. These revisions must be completed within six months. After these revisions are complete the student's project or major paper will be circulated a second time for evaluation by the research supervisor or co-supervisor and at least one other reader appointed by the Graduate Program Director. Any grade of "acceptable with major change" or "not acceptable" from the second reading will result in a grade of fail. Any evaluations of "acceptable without change" or "acceptable with minor change" will be processed accordingly and the student will be given a grade of pass.

In cases where there are at least two "not acceptable" grades, the student will be given a grade of fail.

In cases where there is only one "not acceptable" grade, the Graduate Program Director will meet within two weeks with the research supervisor and the student. The Graduate Program Director has two options after this consultation:

1. The Graduate Program Director sends the project or major paper to another reader within four weeks. The project or major paper may incorporate only minor revisions. If the new reader determines that the project or major paper is either "acceptable without change," "acceptable with minor change" or "acceptable with major change," the assessment of the student's work will continue with the appropriate level of response as outlined above for the evaluation that requires the greatest revision. If the new reader assigns a grade of "not acceptable," the student will have then received a second "not acceptable" and will be given a grade of fail.

or

2. The Graduate Program Director follows the procedures associated with "acceptable with major revision."

6.5 Thesis, Project or Major Paper Notation

Upon acceptance of the student's thesis, project or major paper, the title of the work and date of approval will be recorded on the transcript.

6.6 Permission to withhold dissertation/thesis from public domain

If, at the time of submitting his/her thesis, the student elects to protect any rights to immediate commercial publication, or to obtain a patent which may arise from his/her research, or to keep his/her dissertation/ thesis out of circulation for other reasons, he/she may apply in writing to the Dean of Graduate Studies requesting that the dissertation/thesis be withheld from the public domain for a period of up to 12 months from the date of successful defence.

The student must submit any request for extension of the restriction of circulation one month prior to the termination of the previous period. The student and his/her supervisor will be required to justify the extension of the restriction. Subsequent requests must follow the same procedure.

This request must be made when the dissertation/thesis is first submitted to the Office of Graduate Studies.

7. Submission of Student Work

Once a student's thesis, project or major paper has been approved, the student must submit the work formally. The following procedures and conditions apply:

1. one bound copy and one electronic copy of the original thesis, project or major paper become UOIT property;
2. the student grants UOIT a royalty-free, non-exclusive licence to make copies of the work for academic purposes at UOIT, and upon request from other universities or bona fide institutions;
3. the international copyright symbol (©) is displayed prominently on the title page of the thesis (or displayed with similar prominence on other types of work);
4. the site licence, signed by the student at the start of the program, takes effect; the site licence permits the UOIT library to circulate as part of its collection and/or copy the work for academic purposes only (the university's copyright notice is placed on all copies made under the authority of the licence);
5. while the site licence excludes the sale of authorized copies for profit, UOIT may recover duplication costs through a fee;
6. every copy made available under the licence clearly states that the copy is being made available in this form with full consent of the copyright owner and only for the purposes of private study or research; and
7. UOIT may submit the work to the National Library of Canada, which is permitted to reproduce and lend copies for educational or research use only.

8. Intellectual Property

Intellectual property (IP) comprises original work which often takes various forms such as research data, books, journal papers, theses, projects, photographs, computer programs, websites, equipment, devices, or audio recordings.

8.1 Students and Ownership of Intellectual Property

Students, as well as faculty members and researchers, may create intellectual property. This may be done individually or in collaboration with one or more students, the student's research supervisor or faculty advisor, or other faculty members.

UOIT's Intellectual Property policy generally states that creators own their work. As a result, student rights are treated as equivalent to those of all other academic personnel, including faculty members. When a student works collaboratively with other students, the student's research supervisor, or other UOIT faculty members or researchers, credit for the work is generally shared among the research collaborators. To be considered for joint authorship, all collaborators must:

- have made a significant contribution to the concept, design, collection, analysis or interpretation of the data; and
- have helped write and revise the draft publication for intellectual content.

In addition, as the Student Contributors section of UOIT's Research Guidelines states:

> "A student should be granted due prominence on the list of co-authors for any multiple-authored article or report that is based primarily on the student's own work, according to the commonly accepted practice in the field."

8.2 Students and Ownership of Externally Funded Research

While jointly created intellectual property (IP) is owned jointly, other ownership rules may apply when a student participates in a project that is funded by externally sponsored contracts or grants. In such cases, the sponsoring organization or any contractual agreement with UOIT may determine ownership and control of IP.

Students should discuss with their research supervisor or faculty advisor whether any such conditions apply to the student's work. Nevertheless, an external organization or agency may not delay completion of a student's thesis, project or major paper. Only in special circumstances may an outside organization or agency be permitted to temporarily delay public dissemination of such student work.

If the work has commercial value, the student, in conjunction with other co-creators of the work, may wish to apply for a patent or other IP protection. Upon request, UOIT will assess the commercial value of the work and may agree to pay for these costs and manage the IP commercialization process on behalf of the creators. In all cases, commercialization activities require authorization from the Associate Provost, Research to confirm that obligations to UOIT and any research sponsors have been met and will continue to be satisfied.

9. New Graduate Programs and Review of Existing Programs

When developing new graduate programs or reviewing existing ones, UOIT will follow the policies and procedures of the Ontario Council on Graduate Studies (OCGS). OCGS policies and procedures can be found at http://ocgs.cou.on.ca/.

10. Admission Policies and Regulations

10.1 Application Procedure

Applications for admission to graduate studies programs are normally submitted online at http://www.uoit.ca/. Where paper applications are required, they shall be submitted to:

Office of Graduate Studies

University of Ontario Institute of Technology (UOIT)
2000 Simcoe St. North
Oshawa, Ontario L1H 7K4
Canada
Website: http://gradstudies.uoit.ca

10.2 Application Deadline Dates

Prospective students should refer to the Graduate Studies website for application deadlines.

10.3 Admissions

To be eligible for admission to any graduate degree program at UOIT, applicants must normally meet the following requirements:

a) Hold a four-year honours degree or equivalent from a recognized institution in the area of graduate study or a closely related subject.
b) Have an overall academic standing of at least a B (GPA = 3.0 on a 4.0/4.3 scale), with a minimum B in the last two full-time years (four semesters) of undergraduate work or equivalent.
c) Provide a minimum of two letters of reference from persons having direct knowledge of the applicant's academic competence. Some Faculties may require three letters. Academic references are preferred; however professional references will be accepted. Letters of reference should come from individuals under whom the applicant has worked closely or studied.
d) Provide proof of English proficiency if the first language is not English (see current policy on English proficiency on the Graduate Studies website).
e) Submit one official copy of each previous undergraduate and graduate transcript directly from the granting institute. It is the student's responsibility to provide a certified English translation of the transcript if the original is in another language.
f) As part of the application form, provide a one-page statement of interest outlining their objectives in undertaking graduate study. Applicants may describe career aspirations/plans, specific research interests (if known), and experience relevant to their interests. If a potential thesis supervisor has been contacted, he/she must be identified in the statement of interest.
g) If required, submit a brief description of the courses listed on the official transcripts or provide a copy of the relevant calendar where they are listed.

The aforementioned requirements are the minimum required for entry into graduate studies at UOIT. Some Faculties may have additional requirements for entry into a specific program.

10.3.1 Offers of Admission

All offers of admission are based on the recommendation of the Graduate Committee of the graduate program in question. Regular student offers of admission may include, but are not limited to, pre-admission or post-admission conditions. Preadmission conditions may include, but are not limited to, requirements for full official documentation, or the completion of a previous degree or other requirements before the student is admitted. Offers of admission with post-admission conditions may include, but are not limited to, taking additional courses to make up for deficiencies or meeting other requirements or standards of performance. Post-admission conditions may have time limits. Meeting post-admission conditions is required for successful completion or continuation in a program. In the latter case the offer of admission will be rescinded if conditions are not met.

10.3.2 Refusal of Admission

Due to enrolment limitations and additional requirements in some programs, meeting the minimum requirements does not guarantee admission to the program. UOIT may, at its sole discretion, refuse admission to an applicant even if the above minimum admission criteria have been met.

10.3.3 Appeal of Admission Decisions

Individuals may appeal their admission decision in writing within 10 working days to the Registrar's office. There may be a charge assessed for such appeals. Admission appeals are directed to the Dean of Graduate Studies who will refer the appeal to the Graduate Studies Committee of Academic Council.

10.3.4 Letters of Permission (students from other universities)

Students completing graduate programs at other Ontario universities may register under the Ontario Visiting Graduate Student Plan (see section 13.8). Students completing graduate programs at Canadian universities outside of Ontario may register through the Canadian University Graduate Transfer Agreement. (See section 13.8)

Students completing graduate programs at universities outside Canada can apply to complete individual courses on a Letter of Permission (LOP) from their home university. Such students shall be admitted to UOIT as non-degree students.

LOP students will still be required to complete the UOIT Application for Admission form, as well as submit a letter from the dean of Graduate Studies at the student's home university to the Office of Graduate Studies at UOIT, outlining the expectations of work to be completed while at UOIT.

10.4 Description of Graduate Students

Regular student: Applicants meeting the minimum admission requirements are considered for admission as a regular student.

Probationary student: Applicants who do not meet the minimum admissions requirements may be considered for admission to a probationary year. Applicants must be approved by the Graduate Program Director who will prescribe a program of studies to meet the admission requirements for a Master's program. During this time, the student will be admitted as a non-degree student until the qualifications outlined have been met and the student can be moved into regular student status.

Special student: Applicants who are non-degree-seeking students may apply to take graduate-level courses for professional upgrading or personal interest. Applicants will apply through the Registrar's office and successful students must receive Faculty consent prior to registering for the course.

11. Student Status

11.1 Classification of Graduate Students

Full-time*:* Graduate students are considered full time if they meet the following criteria:

a) pursue their studies as a full-time occupation;
b) formally identify themselves as full-time students on all documentation;
c) maintain regular contact with their faculty advisor or research supervisor, if applicable, and be geographically available and visit the campus regularly; and
d) If employed by UOIT, work no more than an average of 10 hours per week at diversionary employment while they are registered as a full-time student. Diversionary employment is work that takes a student's time away from his/her program of study and research. For example, Teaching Assistant positions are diversionary employment while most Graduate Research Assistantships are not, if they directly support students in their programs of study and research. In calculating this diversionary work average it is recognized that employment opportunities for full-time students may fluctuate throughout the year. Students have a diversionary work allocation of 510 hours in any 12 month period and no more than 255 in any of each of 3 terms: fall (September to December), winter (January to April) and spring/summer (May to August).

Part-time*:* Graduate students who do not meet the above criteria are deemed part-time students. Part-time students may have course load restrictions. Students should consult the individual Faculty with regard to the availability of part-time studies within their program.

11.2 Absences from Studies

Graduate students are expected to be uninterruptedly registered in their designated program of study in order to support the timely completion of their degree. However, the university recognizes that under certain circumstances a student may need to absent themselves from regular study while maintaining their relationship with UOIT. Such circumstances must have sufficient cause and an official leave of absence must be requested through the Office of Graduate Studies and approved by the Dean of Graduate Studies.

Acceptable circumstances include:

a) exceptional circumstances: medical, extraordinary demands of employment, compassionate circumstances;
b) maternity leave: available to students during or following a pregnancy; and
c) parental leave: available to students who face extraordinary demands in parental responsibilities, or whose duties require that they be absent from their studies for a period of time.

A leave will normally begin on the first day of term, for a period of 1, 2 or 3 academic terms. During the period of leave, the following conditions apply:
Students are not registered or required to pay fees
Students may not undertake any academic or research work or use any of the University's facilities.
Students are not eligible to receive UOIT scholarships or assistantships. (In the case of other graduate student awards, the regulations of the particular granting agency apply.)

Except for parental leave or in exceptional circumstances, it is not expected that a student will be granted more than one leave under the terms of this policy. The time limits for completing the degree program will be extended by the duration of the leave taken (i.e. one, two, or three terms as appropriate).

Leave of absence forms will not be processed for students who have outstanding fees.

Students must inform the university immediately upon return.

11.3 Deferral of Offers

Applicants who are offered admission may apply to defer their application or their offer of admission by one year. Where an application is deferred, the applicant will not have to re-apply but will be reassessed for admissibility on a competitive basis in the relevant admission period. Where an offer is deferred, the applicant may register in a subsequent session within the one-year period without re-application. The deferral must be requested before the start of the term in which the student is scheduled to begin. A request for deferral of application or deferral of offer must be made in writing to the Office of Graduate Studies.

12. Financial Aid

UOIT endeavours to help support graduate students in their programs by offering teaching assistantships, research assistantships, scholarships and bursaries. The Office of Graduate Studies and individual Graduate Program Directors have the most up-to-date information on external and internal awards and other financial support.

For further details regarding scholarships, awards and bursaries, visit www.uoit.ca.

13. Registration Policies and Regulations

13.1 Session Dates

Graduate students normally register for three academic semesters per year: fall (September to December), winter (January to April) and summer (May to August).

13.2 Registration

Students must be registered in all terms commencing with the term specified in their letter of acceptance and continuing until graduation. Failure to register in all terms will result in withdrawal from the program. If a student does not register within one term of acceptance, readmission to the program is required. All courses in the student's program must be approved by the Graduate Program Director.

Students will be automatically registered in a graduate continuance course until graduation, withdrawal or program termination. Students must actively register for all other program courses.

13.3 Changes in Course Registration

Students may add courses with the approval of the Graduate Program Director within the first two weeks of lectures in any given semester. Students may drop courses without academic penalty within the first 75 per cent of the semester, with the approval of the Graduate Program Director. Students should see the academic timetable for specific add and drop deadlines. Financial deadlines may differ from these dates.

13.4 Residency Requirement

At least half of a graduate student's courses must be from the UOIT course offerings in order to meet the residency requirements for graduation.

13.5 Program Changes

Changes to a graduate student's program must be approved by the Graduate Program Director.

13.6 Provision for Waiver of Regulations

Waivers of course prerequisites/co-requisites may be granted by the Graduate Program Director. Waivers of Faculty, degree or general regulations may be granted by the Dean of Graduate Studies.

13.7 Transfer Credits

All course credit transfers into graduate programs require the approval of the Graduate Program Director of the Faculty delivering the equivalent course. Transfer courses may not have been used to satisfy other degree requirements. Graduate courses will not be considered for transfer credit if they were completed more than eight years prior to admission or if the grade received in the course is below B- (70%). Transfer credits are not included in the calculation of the GPA at UOIT.

13.8 Visiting Students

The Ontario Visiting Graduate Student Plan (OVGSP) permits a graduate student to take courses at other Ontario universities while remaining a registered student at his or her home institution. UOIT students must complete the OVGSP form (available from the Office of Graduate Studies) and provide an outline of the course, desired term, and the reasoning for requesting such permission. The course must be a requirement of the student's program and must be formally approved by the Graduate Program Director as well as the student's faculty advisor or research supervisor before submission to the Registrar's office. Students from other universities wishing to register for graduate-level courses at UOIT should contact the Office of Graduate Studies at their home institution for more information regarding the process.

Similarly, UOIT students wishing to take courses at institutions outside Ontario but within Canada may do so through the Canadian University Graduate Transfer Agreement (CUGTA). This Agreement provides students in good standing enrolled in a graduate degree or diploma program at a CAGS member university the opportunity to avail themselves of courses offered at another member institution (host) for transfer credit to the program at their institution (home). The conditions for eligibility, documentation and process are similar to those of the OVGS Plan. Details and forms are available from the Office of Graduate Studies. The CUGTA Agreement requires students to pay tuition for the course(s) concerned and applicable incidental fees at the host institution.

UOIT students wishing to take courses at universities outside Canada may do so on a letter of permission. Such a course must be approved in advance by the student's graduate program director, in consultation with the student's faculty advisor or research supervisor, as applicable. A letter of permission ensures that the courses to be taken at the host institution will be recognized for credit at UOIT and are applicable to the student's program of study. This allows the student to attend the host institution without formal admission. If the student is in clear academic standing and has the necessary prerequisite courses, the student shall complete a Letter of Permission Request form and submit the course outline(s) to the Registrar's office. Students are responsible for having copies of the final transcript from the host institution forwarded to the UOIT Registrar's office for award of transfer credit. The minimum mark a student must achieve to have the course transferred is B- (70 per cent). The grade from the transfer credit will not be included in the calculation of the GPA at UOIT.

UOIT students must apply for a letter of permission before taking a course elsewhere.
Failure to do so could result in revocation of admission.

Only students who have been admitted without conditions or who have fully satisfied any conditions specified at the time of admission will be approved to apply for graduate courses at other universities through the Ontario Visiting Graduate Student (OVGS) Plan, the Canadian University Graduate Transfer Agreement (CUGTA) or a letter of permission.

13.9 Repeating Courses

Students who fail one required course may be permitted to continue their program with permission of their graduate program director. If the failed course is designated as a mandatory course in the program, students may re-take the same course with the approval of the Graduate Program Director. If the failed course is an elective course, students may be able to take an alternative elective approved by the Graduate Program Director. The approved alternative course or the second attempt of the failed course must be completed within 12 months of receipt of the failing grade. Students who have a second failure will be dismissed from the university.

All instances of a course will appear on the academic transcript. The highest grade earned will be used to calculate the student's grade point average.

Students approved to continue in the program will be assigned probationary status and will remain on probation until such time as they have successfully completed the required course (within a maximum period of 12 months). They will be required to maintain good standing (minimum B- grade) in all coursework and satisfactory performance in all project/thesis work undertaken during this probationary period. The Graduate Program Director or designate will provide progress reports to the Office of Graduate Studies each term for the duration of the probation. Once the course in question has been completed successfully, the probationary status will be removed. Students who fail to maintain clear academic standing or earn a second failing grade will be dismissed from the university.

13.10 Deferral of Course Examinations

Students whose religious obligations conflict with a scheduled final examination will be permitted to write a deferred examination. Such students are required to give three weeks' notice to their graduate program director and to document the religious obligations involved.

Graduate program directors may grant deferred examinations on medical or compassionate grounds where sufficient documentation exists. A request for deferral on medical or compassionate grounds, along with supporting documentation, must be provided to the graduate program director within four days after the scheduled writing of the examination.

A graduate program director may also grant a deferred examination to a student who is scheduled to write three examinations in a 24-hour period. In this case, the exam in the middle of the three is normally the one that will be considered for deferral.

Scheduling is conducted in such a way as to minimize the instance of consecutive examinations for students.

If a technical difficulty prevents the writing of a computer-based examination, the graduate program director may arrange for a deferred examination for all students in the class. Such an examination will be scheduled no later than the end of the first week of classes in the following semester.

13.11 Supplemental Examinations

In some circumstances students may be allowed to write one supplemental examination. The mark from a supplemental examination may replace or otherwise augment a mark previously obtained in an examination in the same course. Students should contact their Graduate Program Director for regulations concerning supplemental examinations.

13.12 Grading Scheme

Grade	Percentage	Grade Points	Description
A+	90-100	4.3	**Very Good to Excellent**— Student demonstrated mastery of the course material
A	85-89	4.0	
A-	80-84	3.7	
B+	77-79	3.3	**Acceptable to Good**— Student demonstrated adequate knowledge of course material
B	73-76	3.0	
B-	70-72	2.7	
F	0-69	0	**Inadequate**— Student did not perform to academic expectations

Courses designated for pass/fail grading will be assigned a grade of PAS or FAL. For such courses, only failing grades will be included in the calculation of grade point average. The grade of FAL has a weighting of 0.0 grade points.

Academic standing

Academic standing is calculated and recorded on academic transcripts at the end of each semester for every full-time student.

Academic standing is determined by the semester and cumulative grade point averages and the student's academic standing in the previous semester. The minimum cumulative grade point average required for graduation is 2.7.

Clear Standing	Students are required to maintain a minimum cumulative grade point average of 2.7 to remain in clear standing.
Probation	Students are placed on probation if they receive a failing grade in a course and receive approval from the Graduate Program Director to continue in the program. Students will remain on probation until such time as they have successfully completed the failed course or an approved alternate course. This must be done within a maximum period of 12 months. Students will be required to maintain good standing (minimum B-grade) in all coursework and satisfactory performance in all project/thesis work undertaken during the probationary period. Term reports on student progress will be provided to the Dean of Graduate Studies by the Graduate Program Director or designate for the duration of the probation. Once the course in question has been completed successfully and the student has clear standing, the probationary status will be removed.
Dismissal	Students who fail to maintain the academic requirements for clear standing during a probationary period or earn two failing grades will be dismissed from the university.

13.13 Minimum Average

In order to continue in a prescribed program of study at the graduate level, a student must maintain a minimum B- average overall.

13.14 Grade Changes

After grades have been officially approved and released, any grade changes must be submitted in writing to the Registrar. Grade changes may result from the submission of course work, the writing of a deferred examination, clerical errors, or an approved examination reread. All grade changes must be approved by the course instructor and the Graduate Program Director or designate.

If a student's grade is not available when final grades are approved at the end of the term because of special circumstances, a special designation will be temporarily added to the student's record. If a deferred examination has been granted, a grade of DEF will be assigned. If a portion of the work required for the course is incomplete, a grade of INC may be recorded. These grades may satisfy prerequisites for further courses on a temporary basis, but not beyond the end of the subsequent term after which these grades revert to "F."

Graduate continuance courses will be assigned a grade of CO (continuance) and will not be included in grade point average calculations.

13.15 Grade Appeals
Students may, with sufficient academic grounds, request that a final grade in a course be appealed (which will comprise only the review of specific pieces of tangible but not oral work). Grounds not related to academic merit are not relevant for grade appeals.

Students are normally expected to contact the course instructor first to discuss the grade received and to request that their tangible work be reviewed. Students should be aware that a request for a grade appeal may result in the original grade being raised, lowered or confirmed. The deadline for submitting grade appeals is three weeks after the release of final grade reports in any term.

If the student wishes to formally appeal the grade, the student shall lodge a request with the Office of Graduate Studies, which will contact the graduate program director and collect any fees incurred for the appeal. Students must specify the rationale for their appeal by making clear the component of the final grade upon which they seek appeal. The graduate program director will be responsible for ensuring that the work is reappraised by an appropriate faculty member, ensuring anonymity of both the student and the reappraiser, and for communicating the result of the appeal (including the reappraiser's comments) and the route of appeal to the student and the course instructor. The reappraiser will be given the nature of the assignment and the rationale for the original grade. It is expected that every effort will be made to render the decision within 30 days of the reviewer having received the work.

In the event that a student feels that the appeal procedures have not been followed appropriately, a student may submit, in writing, a formal request for a grade appeal to the Graduate Studies Committee of Academic Council. Such appeals can only be considered on the grounds of procedural irregularity.

Appeals must be submitted within 15 working days of notification of the decision. Appeals shall be heard by a panel of a minimum of three committee members, as determined by the dean of Graduate Studies, including at least one student and at least two faculty members. The appeal hearing shall be chaired by the dean of Graduate Studies or designate, who shall be counted as a panel member.

At the discretion of the relevant appeals panel, the student and/or the faculty member may be invited to meet with the panel to present their case(s) orally. The panel's decision will be taken in camera and it is expected that parties will be informed of the decision in writing within 20 working days of the filing of the appeal.

13.16 Conferral of Degrees
Students expecting to graduate in any given term are required to contact the Registrar's office to complete the necessary forms. All applications must be received no later than February 4 for June graduation.

Degrees will be conferred at the time of Academic Council approval and notation of the degree awarded will be entered on the student's record. All students who are awarded a degree are eligible to attend the session of Convocation that immediately follows the date of conferral.

14. Degree Requirements

All candidates pursuing a Master's degree shall enroll in an advanced course of study approved by the Graduate Program Director of the program in which the graduate student is registered. Each student must meet the program requirements laid out by the host Faculty, while maintaining the required average to qualify to graduate in a timely manner.

14.1 Time Limits

The minimum time allowed for full-time students to complete all requirements for a Master's program is one year, and the maximum time is three years from the time of initial registration as a full-time student. Students registering on a part-time basis have a maximum of six years to complete the degree. Terms for which a student is granted a leave of absence shall not be included in these time limits.

Students needing to exceed the normal allotted time for completion of their program must formally request an extension to their program. Extension requests are to be made after the normal program length to the Dean of Graduate Studies.

Students who do not complete degree requirements within the allotted time and have not been granted an extension may be required to withdraw from the program. Under exceptional circumstances and on the recommendation of the Chair of the Supervisory Committee, a student who did not complete the degree requirements within the allotted time may be readmitted for one semester only to complete those requirements. Final approval for readmission must be granted by the Dean of Graduate Studies.

15. Academic Conduct

15.1 Code of Academic Conduct

Faculty members and students share an important responsibility to maintain the integrity of the teaching and learning relationship. This relationship is characterized by honesty, fairness, and mutual respect for the aims and principles of the pursuit of education. Academic misconduct impedes the activities of the university community, and is punishable by appropriate disciplinary action.

UOIT and its members have the responsibility of providing an environment which does not facilitate the inadvertent commission of academic misconduct. Students and faculty should be made aware of the actions which constitute academic misconduct, the procedures for launching and resolving complaints, and the penalties for commission of acts of misconduct.

15.1.1 Academic Misconduct: Offences

Academic misconduct includes, but is not limited to:

- unreasonable infringement on the freedom of other members of the academic community (i.e., disrupting classes or examinations, or harassing, intimidating or threatening others);
- violation of safety regulations in a laboratory or other setting;
- cheating on examinations, assignments, reports or other work used to evaluate student performance (cheating includes copying from another student's work or allowing one's own work to be copied, submitting another person's work as one's own, fabrication of data, consultation with an unauthorized person during an examination, and use of unauthorized aids);
- impersonating another student or allowing oneself to be impersonated for purposes of taking examinations, or carrying out laboratory or other assignments;

- plagiarism, which is the act of presenting the ideas, words, or other intellectual property of another as one's own (the use of other people's work must be properly acknowledged and referenced in all written material);
- obtaining by improper means examination papers, tests or similar materials, or the use or distribution of such materials to others;
- falsifying academic records, including tests and examinations, or submitting false credentials for the purpose of gaining admission to a program or course, or for any other purpose;
- misrepresentation of facts, whether written or oral, which may have an effect on academic evaluation; this includes making fraudulent health claims, obtaining medical or other certificates under false pretences, or altering certificates for the purposes of misrepresentation;
- submission of work when a major portion has been previously submitted or is being submitted for another course, without the express permission of all instructors involved; and
- professional unsuitability, such as behaviour inconsistent with the norms and expectations of the profession.

15.2 Procedure for Resolution

With respect to all accusations of academic misconduct, students are presumed innocent until the contrary has been established. Decisions regarding the commission of academic misconduct are based on the balance of probabilities. A record of all allegations of misconduct, along with details of the resolution, will be entered into the central academic records kept by the Registrar's office.

Faculty, staff, or students who have reason to believe that an academic offence has been committed should report the matter promptly to the appropriate dean. A written report of the alleged offence shall be prepared, together with any relevant evidence.

The dean must decide promptly whether an attempt is to be made to resolve the matter informally; otherwise, the dean shall follow the procedures for formal resolution.

In either case, a student will not be permitted to withdraw from the course in which the offence was alleged to have been committed until the matter is resolved and penalty imposed, if applicable.

15.2.1 Informal Resolution

The Dean must inform the student of the accusation of academic misconduct. The student will have five working days in which to respond to these allegations. If the alleged offender responds with an admission of guilt and agrees to the terms of a resolution as set out by the Dean, the matter will be considered closed. The terms of the resolution shall be detailed in writing and signed by the Dean and the student in question. A copy of this document will be sent to the Dean of Graduate Studies.

Informal resolution may not result in the expunging of grades, the revoking of degrees, or in the student being suspended or expelled.

15.2.2 Formal Resolution

When an attempt at informal resolution fails or is deemed inappropriate, the dean must inform the student in writing of the charge, the possible penalties, and provide a copy of the pertinent policy statement. The student will be given five working days to prepare a response. The dean will then meet with the student to hear the response.

Both the dean and the student are entitled to be accompanied by up to two advisors at this meeting, provided the identity of the advisors is given no less than 48 hours before the meeting.

The dean shall then conduct a thorough investigation of the allegations and response, to be concluded within 10 further working days, and notify the parties of the decision in writing. A copy of the decision will be provided to the dean of Graduate Studies and, on a need to-know basis, to administrative units (i.e. the graduate program director, other faculties, the registrar).

15.3 Penalties

If a student is deemed to have committed academic misconduct, one or more of the disciplinary penalties in the following list may be imposed. The severity of the penalty will be determined by the nature of the offence and the student's past record of conduct. Students found guilty of successive acts of misconduct will receive increasingly severe penalties.

The disciplinary penalties are:

- Resubmission of the piece of academic work in respect of which the misconduct was committed, for evaluation.
- A written reprimand, warning the student that the behaviour was unacceptable and that further misconduct will lead to additional penalties. A copy of the reprimand will be placed in the student's file, but no notation will appear on the academic record.
- Submission of a failing grade in an examination, test, assignment or course.
- Disciplinary probation for the remainder of the student's registration in his current program of study. A note to this effect will be placed in the student's file, but no notation will appear on the academic record. Any further offence will lead to a more severe penalty.
- Expunging of grades or revoking of degrees.
- Restraining orders or monetary restitution where appropriate in the case of threats, harassment, or damage to property.
- Suspension from attendance in a course, program, Faculty or UOIT itself, for a period not exceeding three years as deemed appropriate. While suspended, a student may not register, and loses the right to attend lectures, write examinations, and receive payment from UOIT sources. Courses taken elsewhere during the period of suspension are not eligible for transfer credit. Notice of suspension will be placed in the student's file and will appear on the student’s academic record. The conditions of suspension will specify the length of time such notice will remain on the student's academic record.
- Permanent expulsion from UOIT. A note to this effect will be placed in the student's file and will remain on his academic record.
- Such other penalty as deemed appropriate.

15.4 Termination of Student Enrolment

UOIT may terminate a student's enrolment in a graduate program on any of the following grounds:

- failure to achieve the required grades to continue as outlined in the degree regulations;
- failure to achieve the required grade on a comprehensive exam or project;
- failure to successfully complete a thesis, project or major paper;
- failure to register in any semester;
- failure to report, in advance, courses being taken at another institution;
- lack of progress toward completion of the program;
- recommendation of termination from the Supervisory Committee;

- failure to meet the conditions of admission;
- academic misconduct;
- professional unsuitability as defined by the program; or
- research misconduct and/or non-compliance with UOIT's research ethics guidelines or policies.

15.5 Academic Appeals

All decisions of the university relating to academic conduct or program termination may be appealed to the Graduate Studies Committee of Academic Council. The student will be given 10 working days to gather new evidence and to submit a letter of appeal to the dean of Graduate Studies. Under normal circumstances, disciplinary penalties will not be imposed before an appeal is decided; however, official transcripts will not be issued during this period. Formal registration may be revoked where warranted. In the case of suspected professional unsuitability, a student may be withdrawn from classes, practica, work placements or other program-related activities pending resolution of the case.

A student may apply to the dean of Graduate Studies for continued attendance in classes and related activities while the appeal is being heard. In order for such a request to be granted, the dean of Graduate Studies must be satisfied that there would be no detrimental effect of such continued attendance. If the appeal is granted, formal registration will be reinstated.

15.5.1 Graduate Academic Appeals Procedures

1. Appeals shall be heard by a panel of a minimum of three committee members, as determined by the Dean of Graduate Studies, including at least one student and at least two faculty members.
2. The appeal hearing shall be chaired by the Dean of Graduate Studies or designate, who shall be counted as one of the panel members.
3. Decisions with respect to the final disposition of an appeal will be carried by a simple majority of panel members hearing the appeal.
4. An appellant must have completed any prior levels of appeal open to him or her before filing a Notice of Appeal with the committee.
5. An appeal to the committee shall be commenced by filing a Notice of Appeal in the required form no later than 4 p.m. on the 10th working day after the date of the decision which is being appealed.
6. The chair may refuse to give a hearing to an appeal on the grounds that it is not within the jurisdiction of the committee.
7. The panel of the committee hearing an appeal may dismiss an appeal by unanimous decision after considering the written submissions notwithstanding a request for an oral hearing on the grounds that there is no real case for an appeal (i.e., the appeal is frivolous or vexatious and without merit).
8. In the Notice of Appeal, the appellant shall elect whether an oral hearing is requested. If no election is made, the appeal shall be determined in writing.
9. Where an appeal is to be determined in writing:

    i. As soon as reasonably practicable the panel shall provide a copy of the Notice of Appeal to the responding Faculty;
    ii. The responding Faculty has 10 working days to deliver to the panel a written response to the Notice of Appeal, attaching any documents relevant to the decision under appeal. A copy of the written response and attached documents shall be mailed to the appellant; and
    iii. The appellant shall have 10 working days from the mailing date of the responding Faculty's response to provide any final written response. A copy of this shall be

mailed to the Faculty.

10. Where the appeal is to be determined by oral hearing:
    a. Upon receipt of the Notice of Appeal, the panel, in consultation with the appellant and the responding Faculty, will schedule a date for the oral hearing;
    b. No less than 10 working days prior to the hearing, the appellant shall deliver to the panel (three copies) and the responding Faculty (one copy) of:
        i. Any written submissions to be relied upon at the hearing;
        ii. Copies of all documents to be referred to at the hearing; and
        iii. A list of persons attending as witnesses and a brief summary of each witness's intended evidence.
    c. No less than five working days prior to the hearing, the responding Faculty shall deliver to the panel (three copies) and the appellant (one copy) of the material listed at paragraph 10.1(b), (i) to (iii), above.
11. Where the appeal is to be determined in writing, the members of the panel may convene in person or via teleconference.
12. For an oral hearing, the following procedures shall apply:
    i. At the commencement of the hearing, the chair shall identify the parties and the members of the panel;
    ii. The appellant or a representative shall briefly describe the case to be presented, and provide factual support for the case through documentary evidence and testimony of the appellant and any witnesses, if relevant;
    iii. The responding Faculty or a representative shall briefly reply to the appellant's case and provide facts in opposition to the case through documentary evidence and the testimony of witnesses, if relevant;
    iv. Panel members may ask questions at the conclusion of each person's statement or testimony, or at the conclusion of the appellant's or responding Faculty's case;
    v. Normally, neither the appellant nor the responding Faculty may ask questions of the other's witnesses. Where facts important to the decision of the appeal are in dispute, however, either party may ask permission and, if appropriate, the panel may grant permission for the cross-examination of some or all witnesses;
    vi. Following the presentation of the appellant's and the responding Faculty's cases, the appellant and the responding Faculty may each make brief closing statements to summarize the main points of their respective positions;
    vii. Following the foregoing steps, the parties will withdraw and the panel will move in camera for its deliberations;
    viii. The decision of the panel will be in writing and shall include the names of the panel and all who appeared, a brief summary of the issues on the appeal, the panel decision and reasons in support of the decision.
13. The time limits specified under these procedures may be extended by the chair at the request of the appellant or responding faculty, if reasonable grounds are shown for the extension.

    The following UOIT policies and guidelines also apply to graduate studies:
    • Student Conduct;
    • Protection of Privacy and Access to Information;
    • Research Guidelines;
    • Intellectual Property; and
    • Use of Turnitin.com's Plagiarism Detection System.

These can be found at www.uoit.ca.

16. Fees and Financial Assistance

16.1 Tuition and miscellaneous service fees

To view current tuition and miscellaneous service fees, visit http://gradstudies.uoit.ca.

16.2 Financial assistance

Various types of financial support are available from the university, government or other sources. All are offered on a competitive basis except bursaries and OSAP assistance; these are awarded on the basis of financial need. Tuition and accommodation costs are the student's responsibility. Canadian students are strongly encouraged to apply to provincial and federal granting agencies for graduate scholarships and foreign students are encouraged to apply to granting agencies in their own countries.

Qualified full-time students are eligible for financial support through research assistantships funded by their faculty supervisor's research grants, government scholarships such as NSERC, SSHRC, and OGS, or other merit scholarships and/or teaching assistantships. Further details can be found on www.uoit.ca.

Appendix C: Key Professional Skills

- **Tri-agency Statement of Principles on Key Professional Skills for New Researchers**
- **NSERC: Professional Skills Development – From Ideas to Action**