UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY | GRADUATE STUDIES

Proposal to offer:

Graduate Diploma

Nuclear Design Engineering

November 2012

1. INTRODUCTION

The Faculty of Energy Systems and Nuclear Science wishes to submit a proposal for a Type 3 Graduate Diploma program in Nuclear Design Engineering. The proposed program is designed to meet identified needs for post-graduate knowledge and skills in nuclear power plant design engineering, particularly for people already working in the industry.

The proposed diploma in Nuclear Design Engineering focuses on the design impacts of such topics as the regulatory concerns and worker protection in the nuclear industry, nuclear safety concepts, operating features and special safety components of nuclear-electric generating units. It is anticipated that graduates of the proposed program will have enhanced opportunities for professional advancement within the field of nuclear power plant design.

The Faculty of Energy Systems and Nuclear Science currently offers graduate diplomas in Nuclear Technology – Fuel, Materials, and Technology; Health Physics; Operation and Maintenance; Radiological Applications; Reactor Systems; and Safety, Licensing, and Regulatory Affairs. Furthermore, the Faculty offers the Master of Science, Master of Engineering with fields in Nuclear Power, and Radiological and Health Physics. The Faculty also offers the Doctor of Philosophy degree in Nuclear Engineering with the following two fields: Nuclear Power and Energy Applications; and Radiological and Health Physics. The proposed diploma in Nuclear Design Engineering complements the Faculty's other areas of expertise and research strengths, some of which are very closely linked to the topics of design, licensing, and safety of nuclear technology.

As will be explained in full detail in the program content section below, this program is in line with UOIT's Strategic Mandate Agreement (SMA) in that the delivery model is very flexible and hybrid. This program will be accessible to individuals who are currently employed in industry and seek further specialization of knowledge in the design and safe operation of nuclear reactors in Canada. Additionally, this program will also be available and of interest to current graduate students at UOIT. Students currently enrolled in other graduate programs may also wish to enroll in the two new courses to be offered as a result of this new program. The flexible delivery model will make it possible for graduate students in other programs to enroll without disrupting their ongoing programs of study. Furthermore, the presence of nuclear industry professionals in the same class as full-time graduate students is expected to result in significant peer-learning and the establishment of long-term working relationships.

2. DEGREE REQUIREMENTS

a. Program learning outcomes

This graduate diploma will be awarded to students who have demonstrated the ability to:

- Explain and apply the acquired knowledge of the design and operation of nuclear power plants

- Analyze and assess the design and safety of nuclear power plants based on established principles, codes and standards in the field of nuclear energy and apply this knowledge to formulate informed professional decisions

- Use knowledge of the design and safety of nuclear equipment and systems to guide the critical analysis and responses to unforeseen events in nuclear power plants
- Describe clearly and explain the design of equipment and systems in nuclear power plants, the management of human performance and quality systems, and the associated production and safety issues
- Evaluate planned and unplanned situations in the management of the nuclear power industry based on an understanding of the complex issues that underlie the design and safety features of nuclear power plants
- Utilize initiative, personal responsibility and accountability in work related to the design, reliable operation and safety of nuclear power plants
- Extrapolate the broader implications of the application of the knowledge acquired in the Graduate Diploma in Nuclear Design Engineering on a case by case basis.

b. Admission requirements

Applicants must hold a baccalaureate degree in the fields of engineering, science or mathematics with a grade point average of B- (GPA = 2.7 on a 4.0/4.3 scale), i.e. one grade below that for entry into a MEng degree program. In the case of mature students who do not meet the MASc/MEng academic requirements, UOIT's policy for the admission of mature students will apply.

As students applying to the Graduate Diploma in Nuclear Design Engineering are not required to prepare a thesis or major project, they are not required to find a supervisor. Their program advisor will be the Graduate Program Director of the Faculty of Energy Systems and Nuclear Science.

c. Program structure

To gain the Graduate Diploma in Nuclear Design Engineering, a student must complete four courses as defined below. Credit for the same course having been taken at UOIT, or for a similar course taken at another institution within the last three years, will require the approval of the FESNS Graduate Program Director, and will only be considered if the course for which a student is applying to gain credit has not been used to meet the degree or diploma requirements in another program. For example, a student may have successfully completed one or more of the courses listed below as part of his/her studies for a MEng degree, but instead of proceeding to complete the MEng requirements, the student transfers to the Nuclear Design Engineering diploma program. Similar transfer of credit may be possible for courses taken for another graduate diploma or degree, or taken as a stand-alone undergraduate course, as long as the course considered for credit transfer had not been used to satisfy the requirements for another degree or diploma.

ENGR 4520U Nuclear Plant Safety Design

NUCL 5100G Nuclear Plant Systems and Operation

NUCL 5120G Design of Nuclear Plant Systems

NUCL 5130G Nuclear Design Processes and Techniques

Subject to the approval of the FESNS Graduate program Director, one elective graduate course may be substituted for one of the three graduate level courses, or a senior (4xyzU) undergraduate course may be substituted for ENGR 4520U.

These four courses must be completed within a three year period with a minimum passing grade of B- for each course.

The courses will typically be offered so that the requirements for the diploma can be completed in two years.

The courses are planned to be offered in three hour blocks once a week. Initial discussions indicate that some employee groups will be permitted to attend the courses during regular working hours, although UOIT is prepared to schedules these courses to be delivered after 4 pm Monday to Friday. In addition, these courses will be supported by distance learning technology, giving students the option of face-to-face, web-based or hybrid (i.e. a combination of face-to-face and web-based) delivery options. The web-based component will be available both synchronously and asynchronously.

d. Program content

The proposed program is designed to meet identified needs for post-graduate knowledge and skills in nuclear design engineering, particularly for people already working in the industry. Given the multidisciplinary nature of work in the nuclear industry, most of the engineers hired into the industry have a degree in one of the traditional disciplines, such as mechanical, electrical, chemical or civil engineering. Nuclear-specific design experience is typically acquired via industry courses and on-the-job training, professional courses and post-graduate education. UOIT is uniquely suited to provide post-graduate education in many aspects of nuclear technology, as evidenced by the current offer of a suite of six graduate diploma programs in nuclear technology, as well as MEng, MASc and PhD programs in nuclear engineering. However, as was recently identified during a competency review in the industry, there is a significant shortfall of expertise in the nuclear design engineering area. This situation is in part the result by demographic changes, as well as changes in the relative roles of the various companies and institutions in the industry.

The courses in the proposed graduate diploma program have been designed in collaboration with key industry stakeholders to meet the identified needs, as well as to comply with graduate level standards. Students are expected to achieve learning outcomes which emphasize higher level skills in such areas as application, analysis, advanced communication, and professional autonomy and growth.

e. Assessment of teaching and learning

Combination of quizzes, tests, assignments, case studies, simulator-based discussion of system design and operational behaviour, and written examinations. The use of nuclear power plant simulator software made available to UOIT by industry partners provides a significant level of experiential learning in the proposed program.

Detailed description of each course in the program is given in Appendix A.

3. RESOURCE REQUIREMENTS

The proposed program adds two new graduate level courses. Typically graduate courses are offered once every two years. The relatively large number of students who will be supported by their companies to enrol in the proposed program will imply that some of the courses may be offered annually, depending on the total number of students. While graduate classes are typically limited to a maximum of 30, the average level of enrolment in the four courses comprising the proposed program is expected to be in the 20-25 range.

The teaching resources for these courses are within the capability of the Faculty. There is no laboratory component to these courses other than the nuclear plant simulator software and display systems that have already been installed in two laboratory classrooms, and these have the capacity for scheduling the courses needing the simulator into these rooms. All other resources have already been acquired in sufficient numbers as part of the previously approved graduate programs in the nuclear area (GDip. MEng, MASc, PhD) to support the delivery of these two new courses.

A graduate committee and a graduate program director with administrative resources have already been established. To the extent that this new program requires further administrative resources, these can be funded from the increase in revenue resulting from the higher graduate enrolment.

The majority of the students expected to enrol in this program will have financial support from their employers.

a. Faculty members

Table 3.1 Faculty Rank

Name	Faculty rank	Home unit	Teaching/research interests
George Bereznai	Professor and Dean	FESNS	Nuclear plant systems and operations; real time simulation and its use in experiential learning
John Froats	Associate Professor and Nuclear Engineer in Residence	FESNS	Nuclear plant system design, use of standards, application and mitigation of risk, safety in design and operation of nuclear plants
Glenn Harvel	Associate Professor	FESNS	Nuclear plant design and simulation, modular reactors, equipment ageing, multiphase flow, instrumentation for multiphase flow, neutron radiography
Eleodor Nichita	Associate Professor	FESNS	Neutronic design and analysis methods for advanced nuclear reactors, reactor kinetics and control, neutron and radiation transport, mathematical modeling and numerical methods
Igor Pioro	Professor, Graduate Program Director	FESNS	Thermalhydraulics of nuclear reactors and Generation IV reactor concepts, boiling and forced convection including supercritical pressures, two-phase thermosyphons, heat exchangers, and heat recovery systems

Table 3.2 Faculty supervisory experience

Name	Number of master's thesis supervised (including current)	Number of PhD theses Supervised (including current)
John Froats	0	0
Glenn Harvel	16	4
Eleodor Nichita	4	2
Igor Pioro	15	5
George Bereznai	5	1

b. Additional academic and non-academic human resources

The additional administrative work load resulting from the proposed program will increase the duties of the graduate program assistant, but can be accommodated via planned realignment of administrative duties in the Faculty.

c. Physical resource requirements

The existing courses are already supported in terms of physical resources, including laboratory, classroom and the library. The new courses, and some additional projects associated with the current courses, will make use of the existing Simulator Laboratory in the OPG Engineering Building. The nuclear power plant simulator already installed in ENG 3035 provides excellent experiential learning opportunities for the students in the proposed program. No new physical or teaching/learning resources are required.

4. BUSINESS PLAN

Typically the diploma program is a subset of an existing program at UOIT, and students in the diploma program take the same courses at the same time as other graduate students in UOIT's Graduate Nuclear Engineering programs. The introduction of the proposed GDip in Nuclear Design Engineering requires the addition of one new course to the list of graduate courses, and the addition of some content to create a graduate version of an undergraduate course that was already listed as available to graduate students. With the relatively large numbers of students that OPG has identified as needing the four core courses in the proposed GDip program, these courses will need to be offered more frequently, with the maximum additional teaching load being two courses per year.

The expected enrolment of OPG employees in each of the four courses making up the proposed GDip is 15, with some of the classes approaching the maximum 30 that can be accommodated in the OPG building's simulator laboratory. The average class size is projected to be at least 20, given the expected level of interest in these courses from MEng and MASc students in addition to employees of OPG and other industry partners.

Tuition revenue per course at $1375 per student will be at least $27,500, plus BIU, for which no credit is taken at this time. No new core faculty is planned to be hired to deliver these two additional courses per year, however the reassignment of teaching duties will require the hiring of additional sessional lecturers either to teach some of the GDip courses or to take over the class for which the core faculty would have been scheduled in the absence of the additional students in the GDip program. The cost of the additional sessional instructor is $9,000. The capability for administrative and technical support exists in the Faculty. The delivery of the four courses making up the proposed GDip is expected to take place in the simulator lab in the OPG Engineering building, which is equipped with the nuclear plant simulator, and which can seat 30 students. The resources for developing the one new course and adding graduate content to the other courses is within the assigned work load of core faculty.

FESNS CALENDAR 2012-2013

10.2 Graduate programs offered

The following graduate programs are offered by the Faculty of Energy Systems and Nuclear Science:

Nuclear Engineering

• Master of Applied Science (MASc);

• Master of Engineering (MEng) – regular program;

• Master of Engineering (MEng) – UNENE administered program; and

• Doctor of Philosophy (PhD).

Graduate diplomas in Nuclear Technology

• Graduate Diploma in Nuclear Technology - Fuel, Materials and Chemistry;

• Graduate Diploma in Nuclear Technology - Health Physics;

• Graduate Diploma in Nuclear Technology - Operation and Maintenance;

• Graduate Diploma in Nuclear Technology - Radiological Applications;

• Graduate Diploma in Nuclear Technology - Reactor Systems; and

• Graduate Diploma in Nuclear Technology - Safety, Licensing and Regulatory Affairs; and

• Graduate Diploma in Nuclear Design Engineering10.2.1 Affiliated programs

The following graduate programs are affiliated with the Faculty of Energy Systems and Nuclear Science:

• Master of Engineering Management (MEngM) (offered in collaboration with the Faculty of Business and Information Technology and the Faculty of Engineering and Applied Science. See Section 11 for program information); and

• Graduate Diploma in Engineering Management (offered in collaboration with the Faculty of Business and Information Technology and the Faculty of Engineering and Applied Science. See Section 11 for program information).

10.3 Graduate faculty

Dhavide Aruliah, BSc, MS, PhD

Emma Bartfay, BSc, MMath, PhD

Wally Bartfay, RN, MN, PhD

Michael Bennett, BS, MA, PhD

George Bereznai, BE, MEng, PhD, PEng

Peter Berg, DiplPhys, PhD

Pietro-Luciano Buono, BSc, MSc, PhD

Ibrahim Dincer, BSc, MSc, PhD

Shari Forbes, BSc, PhD

John Froats, BEng, PEng

Hossam Gaber, BSc, PhD, PEng

Kamiel Gabriel, BSc, MSc, MBA, PhD, PEng

Mark Green, BSc, MSc, PhD

Julia Green-Johnson, BSc (Hons), MSc, PhD

Glenn Harvel, BEng, MEng, PhD, PEng

Douglas Holdway, BSc (Hons), MSc, PhD

Brian Ikeda, BSc, MSc, PhD

Holly Jones-Taggart, BSc, (Hons), PhD

Matthew Kaye, BASc, MSc, PhD

Greg Lewis, BSc, MSc, PhD

Lixuan Lu, BESc, MESc, PhD, PEng

Rachid Machrafi, BSc, MSc, PhD

Richard Marceau, BEng, MScA, PhD, PEng, FCAE

Greg Naterer, BMath, MASc, PhD, PEng, FCSME

Eleodor Nichita, BSc, MSc, PhD, PEng

Scott Nokleby, BEng, MASc, PhD, PEng

Igor Pioro, MSc, PhD, Dr. Tech Sc., PEng

Jing Ren, BA, MSc, PhD

Marc Rosen, BASc, MASc, PhD, PEng, FCSME, FEIC, FASME, FIEF

Anthony Waker, BSc, PhD

Edward Waller, BSc, MScE, PhD, PEng

10.4 Program information

The University of Ontario Institute of Technology (UOIT) offers graduate programs leading to the degrees of Master of Applied Science (MASc), Master of Engineering (MEng) and Doctor of Philosophy (PhD) in Nuclear Engineering. In addition, six graduate diploma programs are offered in Nuclear Technology. The Nuclear Engineering graduate programs encompass the nuclear power industry, from fuel manufacture to radioactive waste disposal, and the many and varied applications of radiation in industrial and medical disciplines, with a strong emphasis on health physics. Typical workplace activities include fundamental and applied research, design and development of new equipment, systems and procedures, maintenance and modifications, commissioning and decommissioning of equipment and complete facilities, operation, analysis, and regulatory affairs.

The master's programs in Nuclear Engineering are comprised of the following two fields:

• Nuclear Power; and

• Radiological and Health Physics.

Graduates of a master's level degree program in Nuclear Engineering must be competent in a wide range of disciplines that impinge on the safe and reliable operation of the many and varied systems that comprise radiological equipment, nuclear power plants, and related facilities. They must understand the complex interrelationships between humans, non-human biota and the physical, chemical, economic, and social components of the environment. The program provides the depth and breadth of knowledge necessary for practicing professionals in nuclear engineering. Under the guidance of a research supervisor and a multidisciplinary team of scientific and engineering faculty, each student has the opportunity to engage in in-depth study of particular problems that emphasize theory and/or experimentation.

An alternate to the regular program of studies that leads to the MEng in Nuclear Engineering is also available at UOIT. This program is administered by the University Network of Excellence in Nuclear Engineering (UNENE), a Canadian-based alliance of universities, nuclear power utilities, research and regulatory agencies for the support and development of nuclear education, research and development capability in Canadian universities. UNENE was created through the partnership of five Ontario universities including McMaster University, Queen's University, UOIT, University of Waterloo and University of Western Ontario.

The UNENE MEng program was designed for the working professional, providing engineers the enhanced knowledge, tools, technology as well as business and management skills necessary to keep them at the forefront of their profession. Courses are offered on alternate weekends, usually over a seven-week period, versus the semester-based weekly delivery of lectures given typically in three-hour evening sessions. Courses can also be delivered using distance education tools to accommodate those students working at sites remote from the Greater Toronto Area. Additional details on the UNENE program are available at www.unene.ca.

The PhD program in Nuclear Engineering comprises the following two fields:

• Nuclear Power and Energy Applications; and

• Radiological and Health Physics.

The main objective of the PhD program is to prepare graduates for a career that includes research and/or teaching in academia or industry; 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 seven graduate diplomas in Nuclear Technology and Nuclear Design Engineering are based on areas of specialization within the fields of Nuclear Power, and Radiological and Health Physics. The programs have been designed to accommodate the needs of personnel working in the nuclear industry and to promote an orientation toward lifelong learning as students may choose to complete a number of these diplomas over the course of their careers. Students in the graduate diploma programs will upgrade their knowledge and skills and position themselves for transfer and/or advancement within their industry. Diplomas are offered in the areas of Fuel, Materials and Chemistry; Health Physics; Operation and Maintenance; Radiological Applications; Reactor Systems; Safety, Licensing and Regulatory Affairs; and Nuclear Design Engineering.

10.5 Admission requirements

In addition to the general admission requirements for graduate studies at UOIT described in section 4.4.2, applicants must meet the following program-specific requirements.

Master of Applied Science (MASc) and Master of Engineering (MEng) in Nuclear Engineering

• Completion of a four-year honours undergraduate science or engineering degree from a Canadian university, or its equivalent from a recognized institution; and

• Overall academic standing of at least a B (GPA: 3.0 on a 4.3 scale), with a minimum B in the last two years (four semesters) of full-time undergraduate work or equivalent, although a B+ is preferred for MASc applicants.

Close technical contact with a faculty member is an essential part of graduate education in engineering and science. Prior to being accepted into the MASc program, applicants must find a professor who specializes in their desired area of research and who is willing to act as a supervisor. In the event the applicant cannot find a thesis supervisor, the applicant may be considered for admission into the MEng-Course option.

Master of Engineering (MEng) in Nuclear Engineering – UNENE administered program UNENE requires an honours or four-year degree in engineering, science or mathematics and a B-minus average or better. UNENE also considers any relevant work or research history. Meeting the minimum requirements does not guarantee acceptance.

Individuals who choose to apply for admission to UOIT will, once their application is approved, be registered within the Faculty of Energy Systems and Nuclear Science. The master's degree awarded by UOIT will be a MEng with a Nuclear Engineering designation.

Doctor of Philosophy (PhD) in Nuclear Engineering

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.

Prior to being accepted into the program, PhD applicants must also find a professor who specializes in their desired area of research and who is willing to act as a supervisor. 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.

3. Approval of the direct transfer by the thesis supervisor(s) and the supervisory committee. The transfer must also be approved by the graduate program director and the dean of Graduate Studies. The faculty will usually require up to 12 additional credits of course work in the PhD program. See section 4.4.2.1 for additional information.

Graduate diplomas in Nuclear Technology

To be considered for admission into any of the graduate diploma programs, applicants must hold a bachelor's degree in the fields of engineering, science or mathematics, with a grade point average of B-minus (GPA: 2.7 on a 4.3 scale). This is one grade below that for entry into a MEng degree program.

Individuals without an undergraduate degree and who have extensive experience relevant to the chosen field of diploma studies may be considered on a case-by-case basis. For more information, see section 4.4.8 for UOIT's policy on non-standard applicants.

As graduate diploma program applicants are not required to prepare a thesis or major project, they are not required to find a supervisor. Their program advisor would be the graduate program director of the Faculty of Energy Systems and Nuclear Science.

10.6 Part-time studies

To facilitate access to all potential students, part-time studies are permitted. Engineers in local industries, in particular, may wish to pursue the MEng program or a graduate diploma program through part-time studies. The UNENE program is offered on a part-time basis only.

10.7 Degree requirements

10.7.1 Master of Applied Science (MASc) in Nuclear Engineering

The objective of the MASc program is to prepare students for a career as engineers in fields that require specialized knowledge and skills. It is expected that graduates of the program will be able to work as engineers in industry, companies, and government agencies with strong R&D programs, or to continue their education by pursuing a PhD degree. The objective of the MASc program is achieved through a combination of course work, supervised research, a research seminar, and a research thesis. Students must complete five courses for a total of 15 credits, a non-credit seminar course and a thesis worth 15 credits.

10.7.2 Master of Engineering (MEng) in Nuclear Engineering

The objective of the MEng program is to provide the opportunity for engineers in industry to upgrade and expand their skills, including developing research skills. Graduates of the program will be able to use what they have learned in a variety of applications in industry, government and academia. All MEng students are required to engage in research activities as part of projects in many of the courses.

The MEng degree program has three options:

• MEng-Course, which consists of only courses;

• MEng-Graduate Research Project, which consists of a combination of courses and a project; and

• MEng-Industrial Research Project, which consists of a combination of courses and a project.

For the MEng-Course option, students must complete 10 courses worth a total of 30 credits.

For the MEng-Graduate Research Project option, students must complete seven courses worth a total of 21 credits and a graduate research project worth nine credits. Under the supervision of a faculty member, students have the opportunity to integrate and synthesize knowledge gained throughout their program of study. The chosen topic is dependent on the area of specialization of the student, using resources normally available on campus. Students are required to write a report and give a presentation on their completed project.

Students in the MEng-Industrial Research Project option must complete eight courses (24 credits) and an industrial project worth six credits. Students enrolled part-time in this program option may designate a period of approximately four months in an industrial laboratory to carry out an industry-oriented project under the supervision of a suitably qualified staff engineer or scientist, as well as a university co-supervisor. The faculty works with the students and their employers to arrange suitable projects. A satisfactory project topic and appropriate arrangements are required for the project to be approved by the faculty. However, it is possible that in some cases, this may not be feasible. Upon completion, students are expected to submit a substantial report and conduct a presentation about the project at the university. The industrial research project can only be undertaken after at least half the required courses have been completed.

Students in the MASc or MEng programs may take no more than one third of their courses from the undergraduate courses listed in section 10.8 or other 4xxx courses specifically approved by the graduate program director, provided the students did not take similar courses during their undergraduate degree programs.

Students must take at least half of their graduate courses from the list of NUCL 5xxxG courses in section 10.8. Courses not listed and offered by other faculties at UOIT or other universities can only be taken for credit if first approved by the graduate program director.

Courses are offered on the basis of demand with the expectation that courses will be offered at a minimum of once every two years.

10.7.3 Master of Engineering (MEng) in Nuclear Engineering – UNENE administered program

Students in the UNENE program must complete ten UNENE courses or eight courses and an industrial project. Three of the courses can be business courses from the Advanced Design and Manufacturing Institute (ADMI). The project is normally co-sponsored by the student's employer and one of the universities. Students have a maximum of five years to complete the required number of courses.

10.7.4 Doctor of Philosophy (PhD) in Nuclear Engineering

Students in the PhD program must complete four courses worth a total of 12 credits and a dissertation worth 40 credits (NUCL 6001G PhD Thesis). In general, the PhD dissertation involves intensive research and requires determination and enthusiasm to deliver a new contribution to the field of study. The duration of the PhD program is normally three to four years and financial support for the student must be secured.

In addition to the four courses and dissertation, the student must successfully complete NUCL 6002G Workshop and Professional Development and NUCL 6003G Doctoral Seminar. These are graded on apass/ fail basis. Courses in other graduate programs at UOIT may be taken provided students have not taken similar courses during their undergraduate or master's degrees and the courses are approved by the graduate program director.

Students who transfer directly from a MASc program into the PhD program must complete nine courses worth a total of 27 credits and a dissertation worth 40 credits (NUCL 6001G PhD Thesis). In addition to the nine courses, the students must successfully complete NUCL 6002G Workshop and Professional Development and NUCL 6003G Doctoral Seminar.

Within 18 months of entry into the PhD program, students must prepare a written research proposal and pass an oral candidacy exam. PhD students must also successfully defend their dissertation in front of an examining committee.

10.7.5 Graduate diplomas in Nuclear Technology and Nuclear Design Engineering

To earn a graduate diploma, students are required to complete four courses approved by the graduate program director that are relevant to one of the areas of specialization. Each diploma has a set of defined courses relevant to the area of specialization and potentially, some non-specialist courses. The four courses must be completed within a three-year period with a minimum passing grade of B-minus for each course.

Transfer credit for a course that had been taken at UOIT, or for a similar course taken at another institution within the last three years, may be granted by the FESNS Graduate Program Director, as long as the mark received in the course for which transfer credit is requested was a "B" or higher, and that the course has not been used to meet the degree or diploma requirements in another program either at UOIT or at another post-secondary institution.

The student must select the specific diploma he or she wishes to obtain at the time of registration. Any changes to this choice, and to the selection of courses which are designed to achieve the intent of the specific specialty, must be approved by the graduate program director. It should be noted that any one course can only be counted towards one diploma and that transfer credits between other graduate diploma programs are not permitted.

As part of the degree requirements for the graduate diplomas in Nuclear Technology, students must:

• Complete a minimum of two courses from the specialty, including at least one NUCL course;

• Complete no more than one course from another specialty and/or up to two courses from the non-specialist common courses;

• Complete a minimum of two NUCL courses at the 5000 level; and

• Subject to the approval of the graduate program director, one graduate course may be taken that is not listed for the graduate diplomas in Nuclear Technology (i.e., from a graduate program offered by other UOIT faculties).

Of the four required courses for each graduate diploma, no more than one may be selected from the specified undergraduate course options.

Students who complete any of the graduate diplomas in Nuclear Technology, and wish to be considered for admission to the MASc or the MEng in Nuclear Engineering, may have up to six of the 12 credits counted toward their master's degree. Students who are enrolled in the graduate diploma program, and wish to switch to the MASc or MEng in Nuclear Engineering, may apply for admission. If an offer of admission is granted, they may be able to transfer all of their credits from the diploma program to the master's degree. In this case, they would not receive the graduate diploma. Students who have completed UOIT's MASc or MEng in Nuclear Engineering, or an equivalent program, and who wish to enrol in the graduate diploma program, may transfer up to six credits toward the diploma depending on the courses they have taken in their master's program.

Diplomas in the field of Nuclear Power

1. Fuel, Materials and Chemistry

NUCL 5080G Advanced Topics in Environmental Degradation of Materials

NUCL 5220G Fuel Management in Nuclear Reactors

NUCL 5300G Advanced Topics in Radioactive Waste Management

NUCL 5450G Advanced Material Analysis

ENGR 4510U Nuclear Plant Chemistry

ENGR 4610U Corrosion for Engineers

ENGR 4620U Radioactive Waste Management Design

ENGR 4680U Nuclear Materials

ENGR 4810U Nuclear Fuel Cycles

2. Operation and Maintenance

NUCL 5100G Nuclear Plant Systems and Operation

NUCL 5250G Power Plant Thermodynamics

NUCL 5270G Control, Instrumentation and Electrical Systems in CANDU Based Nuclear Power Plants

NUCL 5280G Advanced Reactor Control

ENGR 5121G Advanced Turbo Machinery

ENGR 5740G User Interface Design

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

ENGR 4670U Shielding Design

3. Reactor Systems

NUCL 5200G Reactor Physics

NUCL 5210G Advanced Reactor Physics

NUCL 5215G Advanced Reactor Engineering

NUCL 5230G Advanced Nuclear Thermalhydraulics

NUCL 5240G Heat Transfer in Nuclear Reactor Applications

NUCL 5290G Advances in Nuclear Power Plant Systems

ENGR 5122G Computational Fluid Dynamics

ENGR 4700U Nuclear Plant Design and Simulation

ENGR 4730U Reactor Control

ENGR 4780U Nuclear Reactor Design

4. Safety, Licensing and Regulatory Affairs

NUCL 5050G Applied Risk Analysis

NUCL 5070G Environmental Modelling

NUCL 5090G Occupational Health and Safety

NUCL 5260G Reactor Containment Systems

NUCL 5430G Advanced Dosimetry

NUCL 5440G Advanced Radiation Biophysics and Microdosimetry

ENGR 4520U Nuclear Plant Safety Design

ENGR 4660U Risk Analysis Methods

RADI 4220U Radiation Biophysics and Dosimetry

RADI 4550U Radiation Detection and Measurement

Diplomas in the field of Radiological and Health Physics

5. Health Physics

NUCL 5070G Environmental Modelling

NUCL 5090G Occupational Health and Safety

NUCL 5300G Advanced Topics in Radioactive Waste Management

NUCL 5430G Advanced Dosimetry

NUCL 5440G Advanced Radiation Biophysics and Microdosimetry

ENGR 4620U Radioactive Waste Management Design

ENGR 4670U Shielding Design

RADI 4220U Radiation Biophysics and Dosimetry

RADI 4550U Radiation Detection and Measurement

6. Radiological Applications

NUCL 5400G Advanced Radiation Science

NUCL 5410G Physics of Radiation Therapy (cross-listed with RADI 4320)

NUCL 5460G Industrial Radiography

NUCL 5470G Nuclear Forensic Analysis

RADI 4430U Industrial Applications of Radiation Techniques

RADI 4440U Radioisotopes and Radiation Machines

Non-specialist courses common to all diploma programs

NUCL 5010G Project Management for Nuclear Engineers

NUCL 5020G Mathematical Methods in Nuclear Applications

NUCL 5030G Transport Theory

NUCL 5040G Monte Carlo Methods (cross-listed with MCSC 6165G)

NUCL 5060G Nuclear Concepts for Engineers and Scientists

NUCL 5065G Thermalhydraulics Concepts for Engineers and Scientists

NUCL 5275G Safety Instrumented Systems (SIS)

NUCL 5285G Advanced Process Control Systems

NUCL 5420G Aerosol Mechanics

ENGR 5010G Advanced Optimization

MCSC 6120G Numerical Methods for Ordinary Differential Equations

MCSC 6210G Advanced Topics in Mathematical Modelling

MCSC 6230G Advanced Topics in High-Performance Computing

6. Nuclear Design Engineering

ENGR 4520U Nuclear Plant Safety Design
NUCL 5100G Nuclear Plant Systems and Operation
NUCL 5120G Design of Nuclear Plant Systems
NUCL 5130G Nuclear Design Processes and Techniques

10.8 Course listing

Core graduate courses offered by the Faculty of Energy Systems and Nuclear Science

NUCL 5001G MASc Thesis

NUCL 5003G Seminar

NUCL 5004G Directed Studies

NUCL 5005G Special Topics

NUCL 5006G Industrial Research Project

NUCL 5009G Graduate Research Project

NUCL 5010G Project Management for Nuclear Engineers

NUCL 5020G Mathematical Methods in Nuclear Applications

NUCL 5030G Transport Theory

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 5100G Nuclear Plant Systems and Operation

NUCL 5120G Design of Nuclear Plant Systems

NUCL 5130G Nuclear Design Processes and Techniques

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 (SIS)

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 5350G Regulatory Affairs and Licensing Concepts

NUCL 5400G Advanced Radiation Science

NUCL 5410G Physics of Radiation Therapy

NUCL 5420G Aerosol Mechanics

NUCL 5430G Advanced Dosimetry

NUCL 5440G Advanced Radiation Biophysics and Microdosimetry

NUCL 5450G Advanced Material Analysis

NUCL 5460G Industrial Radiography

NUCL 5470G Nuclear Forensic Analysis

NUCL 6000G PhD Candidacy Exam

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

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 RealTime 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

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 Differential Equations

UNENE courses

UN 0500 Industrial Research Project, UOIT

UN 0501 Fuel Management

UN 0600 Industrial Research Project, University of Western Ontario

UN 0601 Control, Instrumentation and Electrical Systems in CANDU based Nuclear Power Plants

UN 0602 Nuclear Fuel Waste Management

UN 0603 Project Management for Nuclear Engineers

UN 0700 Industrial Research Project, University of Waterloo

UN 0701 Engineering Risk and Reliability

UN 0702 Power Plant Thermodynamics

UN 0800 Industrial Research Project, McMaster University

UN 0801 Nuclear Plant Systems and Operations

UN 0802 Nuclear Reactor Analysis

UN 0803 Nuclear Reactor Safety Design

UN 0804 Nuclear Reactor Heat Transport System Design

UN 0805 Introduction to Operational Health Physics

UN 0806 Nuclear Fuel Engineering

UN 0900 Industrial Research Project, Queen's University

UN 0901 Nuclear Materials

UN 1000 Industrial Research Project, University of Toronto

UN 1001 Reactor Chemistry and Corrosion

Undergraduate Nuclear Engineering courses available for credit towards a graduate program in the Faculty of Energy Systems and Nuclear Science

ENGR 4510U Nuclear Plant Chemistry

ENGR 4520U Nuclear Plant Safety Design

ENGR 4610U Corrosion for Engineers

ENGR 4620U Radioactive Waste Management Design

ENGR 4640U Nuclear Plant Operations

ENGR 4660U Risk Analysis Methods

ENGR 4670U Shielding Design

ENGR 4680U Nuclear Materials

ENGR 4700U Nuclear Plant Design and Simulation

ENGR 4730U Reactor Control

ENGR 4780U Nuclear Reactor Design

ENGR 4810U Nuclear Fuel Cycles

ENGR 4880U Principles of Fusion Energy

Undergraduate Health Physics and Radiation Science courses available for credit towards a graduate program in the Faculty of Energy Systems and Nuclear Science

RADI 4220 Radiation Biophysics and Dosimetry

RADI 4430 Industrial Applications of Radiation Techniques

RADI 4440 Radioisotopes and Radiation Machines

RADI 4550 Radiation Detection and Measurement

Note: Course descriptions for the undergraduate courses listed above can be found in the 2012-2013 Undergraduate Academic Calendar and Course Catalogue located on the UOIT website at www.uoit.ca.

NEW COURSE TEMPLATE

Faculty: Energy Systems and Nuclear Science		
Course title: Design of Nuclear Plant Systems		
Course number: NUCL 5120G	**Cross-listings:**	**_X___ Core ____ Elective**
Credit weight: 3	**Contact hours:** 3 Lecture	

CALENDAR DESCRIPTION

The course presents the main design and operating features of nuclear power plants, including the plant life cycle, plant layout, the key steps in the process of nuclear plant design, including the design and operation of unit control schemes, shutdown and safety systems, reactor cooling, shutdown and emergency core cooling systems, steam generator design features, level and pressure control, turbine and generator, feedheating systems, unit electrical, service water and air systems, the fuel handling and storage systems. Where appropriate nuclear power plant simulators are used to demonstrate the key design features of plant systems and unit behaviour, including those of using pressurized and boiling light water, pressurized heavy water and gas cooled reactors; small, medium and large reactors.

Prerequisites	
Co-requisites	
Credit restrictions	ENGR 4700U
Credit exemptions	

LEARNING OUTCOMES

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

- Describe and explain the significance of the NPP Life cycle (from Concept to Green-site), Typical Plant Layout
- Describe and explain the significance of the Design Process: Impact of the License on Design, Design Requirements, Assumptions, Design Description
- Describe and explain the significance of the External Requirements: Siting and Layout, Client and Environmental Requirements
- Describe and explain the design features of the following systems used in Production and Generation: Turbine and Generator, Steam Supply, Condenser, Reheaters, Moisture Separators, Steam Generator, Pressure and Inventory Control
- Describe and explain the design features of the following Heat Sources and Heat Sinks: reactor core, moderator, end shields, pumps, heaters, lighting; Shutdown cooling, RCW, RSW, Service Water; the ultimate heat sink, impact of maintenance
- Describe and explain the design features of the Fuel Handling Systems: Fuel storage and delivery, fuel transfer, damaged fuel and used fuel storage, dry storage, long term disposal and recovery
- Describe and explain the significance of the Design Review Process, the Role of Simulation in Design
- Describe and explain the significance of the Safety Concepts: Revisit of Control, Cool, Contain, and Monitor; Detection (instrumentation), control (control room and computers); Concept of auto-shutdown versus trip, basic trip coverage concept; ECC system

- Describe and explain the design features of the following Electrical Systems: Grid, Switchyard, Class IV, III, II, I power supplies, EPS, LACS
- Describe and explain the significance of the Design Review Process
- Describe and explain the use of Simulation Techniques, as illustrated using the Pickering and Darlington simulators, and the ACR-700 simulator
- Describe and explain the design features of the Fire Protection System.

DELIVERY MODE

Three hour lecture once a week, supported by demonstrations of key power plant system design and unit response to operating events using various nuclear plant simulators.

TEACHING AND ASSESSMENT METHODS

In-class discussions and quizzes, written assignments, mid-term exam, final exam.

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

Course developed in consultation with industry stakeholders. No new resources are required to deliver this course.

APPROVAL DATES

Date of submission	October 18, 2012
Graduate Committee approval	October 24, 2012
Faculty Council approval	October 25, 2012

NEW COURSE TEMPLATE

Faculty: Energy Systems and Nuclear Science		
Course title: Nuclear Design Processes and Techniques		
Course number: NUCL 5130G	**Cross-listings:**	__X__ Core ____ Elective
Credit weight: 3	**Contact hours:** 3 Lecture	

CALENDAR DESCRIPTION

The course presents the key principles and practices that are essential to the successful conduct of nuclear design processes and techniques, so as to ensure the safe and reliable operation of the designed systems and the overall power plant. Emphasis is placed on understanding and applying nuclear safety design concepts, quality management principles and codes, the application of standards and regulations to the design of equipment and systems, the practice of establishing safety and engineering requirements, overseeing and accepting engineering work by others, applying human performance management principles and practices for the management of knowledge work, interfacing between design, commissioning, testing and operation groups, and applying techniques to deal with emergent problems.

Prerequisites	
Co-requisites	
Credit restrictions	
Credit exemptions	

LEARNING OUTCOMES

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

- Describe and apply Nuclear Safety Design Concepts
- Describe and apply Quality Management Principles and Quality Codes
- Describe and explain the role and application of Regulations, Codes and Standards to the design of nuclear equipment and systems
- Describe and explain the role and application of Design Basis, System Classification and the Establishment of Safety Requirements
- Describe what is meant by and successfully perform cases of Specifying Engineering Requirements
- Describe and successfully perform cases of Overseeing Engineering Work
- Describe and successfully perform cases of Accepting Engineering Work
- Describe and explain the role and application of Human Performance Management for Knowledge Work
- Describe and successfully perform cases of Interface of Design with Commissioning, Testing and Operation
- Describe and successfully perform Techniques to deal with Emergent Problems (TOE, DIRP, …)

DELIVERY MODE

Three hour lecture once a week, including Case Study Discussions

TEACHING AND ASSESSMENT METHODS

In-class participation in case studies, written assignments, mid-term exam, final exam.

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

Course developed in consultation with industry stakeholders. No new resources are required to deliver this course.

APPROVAL DATES

Date of submission	October 18, 2012
Graduate Committee approval	October 24, 2012
Faculty Council approval	October 25, 2012

COURSE CHANGE TEMPLATE

Faculty: Energy Systems and Nuclear Science		
Course title: Nuclear Plant Systems and Operation		
Course number: NUCL 5100G	**Cross-listings:**	__X__ Core ____ Elective
Credit weight: 3	**Contact hours:** 3 Lecture	

CALENDAR DESCRIPTION

A combination of lectures and self-paced interactive CD are used to present the key design and operating features of a CANDU generating unit, including the principles of overall unit operation and control; the functions, equipment and operation of the main process systems; how each major system is controlled; and how reactor safety and the protection of the public is achieved. Students gain familiarity with the conduct of normal and abnormal operations on a simulated CANDU generating unit, including power manoeuvres, poison override operations, recoveries from reactor trips, recoveries from turbine trips, and responses to reactor, heat transport, steam and feed-water system malfunctions.

Prerequisites	
Co-requisites	
Credit restrictions	ENGR 4640U, UN 0801
Credit exemptions	

LEARNING OUTCOMES

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

- Identify and describe the key criteria for the safe operation of a nuclear power plant
- Describe and explain the overall control schemes used in nuclear power plants
- Describe and explain the design and main functions of Reactor Structures and the Moderator System
- Describe and explain the design and main functions of the Special Safety Systems
- Describe and explain the design and operation of Power Measurement and Reactor Control
- Describe and explain the design and operation of the Reactor Regulating System and Unit Control
- Describe and explain the design and operation of the Primary Heat Transport System
- Describe and explain the design and operation of the Primary Heat Transport Control Systems
- Describe and explain the design and operation of the Steam Systems, the Turbine and Feed-Water System
- Describe and explain the design and operation of the Secondary Side Control Systems
- With the aid of a nuclear plant simulator, perform Major Transient Operations
- With the aid of a nuclear plant simulator correctly diagnose malfunctions, identify and describe corrective operator actions

DELIVERY MODE

Three hour lecture once a week, supported by an interactive CD suitable for self-study, and which includes a CANDU 9 simulator.

TEACHING AND ASSESSMENT METHODS

Assignments, mid-term exam, final exam that includes both a written part and a practical one using the CANDU 9 simulator.

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

Course modified in consultation with industry stakeholders. No new resources are required to deliver this course.

APPROVAL DATES

Date of submission	October 19, 2012
Graduate Committee approval	October 24, 2012
Faculty Council approval	October 25, 2012

COURSE CHANGE TEMPLATE

Faculty: Energy Systems and Nuclear Science		
Course title: Nuclear Plant Safety Design		
Course number: ENGR 4520U	**Cross-listings:**	__X__ **Core** ____ **Elective**
Credit weight: 3	**Contact hours:** 3 Lecture, 1 Tutorial	

CALENDAR DESCRIPTION

This course describes the regulatory requirements and the principles guiding the protection of workers and the general public from being harmed as a result of nuclear plant operations. Topics include: worker and public safety requirements; codes and standards; sources of radioactive release; defence in depth; principle of control, cool, contain; accident prevention, mitigation and accommodation; separation and independence; redundancy; common mode events; inherent safety features; plant safety systems; safety culture, management of plant safety; design basis accident; accident analysis; quantitative and probabilistic risk assessment; examples of nuclear accidents; online and off-line computer codes for the design and safety analysis of nuclear plants.

Prerequisites	ENGR 4640U, ENGR 4660U, ENGR 4700U
Co-requisites	
Credit restrictions	NUCL 4520U, UN 0803
Credit exemptions	

LEARNING OUTCOMES

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

- Describe and explain Reactor Safety Concepts, Fuel, Fuel Cooling
- Describe and explain Fuel Cooling and Heat transfer Phenomenon
- Describe and explain what is meant by Design Basis, applicable Laws, Codes and Standards
- Describe and explain RD-337, Void Reactivity
- Describe and explain Design Margin, Causes of Accidents, INES
- Describe and explain RD 310, RD 346, Role of Safety Analysis
- Describe and explain the importance of Human Factors in Nuclear Design
- Describe and explain the causes, symptoms and importance of Loss of Coolant Events and Analysis
- Describe and explain the causes, symptoms and importance of Loss of Regulation Events and Analysis
- Describe and explain the causes, symptoms and importance of Loss of Flow and Loss of Class 4 Events and Analysis
- Describe and explain the applications and importance of Risk / PRA / Beyond Design Events

DELIVERY MODE

Three hour lecture and a one hour tutorial once a week, supported by demonstrations of key safety system design and unit response to operating events that involve the operation of one or more plant safety systems using a classroom Darlington simulator.

TEACHING AND ASSESSMENT METHODS

In-class discussions and quizzes, written assignments, mid-term exam, final exam.

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

Course modified in consultation with industry stakeholders. No new resources are required to deliver this course.

APPROVAL DATES

Date of submission	October 19, 2012
Graduate Committee approval	October 24, 2012
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