UNIVERSITY OF ONTARIO

INSTITUTE OF TECHNOLOGY

(UOIT)

Brief for the Appraisal of

Doctor of Philosophy (PhD) in

Electrical and Computer Engineering (ECE)

Submitted to the

Ontario Council on Graduate Studies (OCGS)

September 2008

Table of Contents

VOLUME I: The Program

1 INTRODUCTION

1.1 Brief listing of program

The doctoral program leads to the degree of Doctor of Philosophy (PhD) in Electrical and Computer Engineering (ECE). This doctoral program is a new program to be offered at the University of Ontario Institute of Technology (UOIT) by the Faculty of Engineering and Applied Science (FEAS). The program is planned to be launched in September 2009, following all necessary approvals obtained by the UOIT.

1.2 Background

Bill 109, an Act to establish the University of Ontario Institute of Technology, was passed by the Ontario Legislature on June 27, 2002, and the UOIT took in its first undergraduate engineering students in the fall of 2003.

The underlying reason for the creation of a university in Durham Region was the significant lack of university graduates in the rapidly growing region, this was especially noteworthy in view of the fact that the rate of increase of the population of Durham Region was, and continues to be, several times that of Ontario as a whole.

1.2.1 UOIT Undergraduate Engineering Programs and Graduate Programs

The University of Ontario Institute of Technology (UOIT) consists of seven Faculties, two of which offer undergraduate and graduate degree programs in engineering: the Faculty of Engineering and Applied Science (FEAS) and the Faculty of Energy Systems and Nuclear Science (FESNS).

Table 1.1 lists the UOIT four-year undergraduate engineering honors programs. In parallel to these six four-year undergraduate engineering programs, there are also six five-year undergraduate engineering and management programs, in which students take an additional year to complete ten business and management courses.

Table 1.1 – UOIT Undergraduate Engineering Programs

Program	Launch Date	Faculty
Bachelor of Manufacturing Engineering	Sept. 2003	Engineering and Applied Science
Bachelor of Nuclear Engineering	Sept. 2003	Energy Systems and Nuclear Science
Bachelor of Mechanical Engineering	Sept. 2004	Engineering and Applied Science
Bachelor of Electrical Engineering	Sept. 2005	Engineering and Applied Science
Bachelor of Software Engineering	Sept. 2005	Engineering and Applied Science
Bachelor of Automotive Engineering	Sept. 2005	Engineering and Applied Science

With the rapid growth and success of the undergraduate programs, the UOIT proceeded to launch its first master’s program in 2005 and first PhD program in 2008, as reflected in Table 1.2.

Table 1.2 – UOIT Graduate Programs

Program	Launch Date	Faculty
Master of Information Technology Security	Sept. 2005	Business & Information Technology
Master's in Mechanical Engineering	Sept. 2006	Engineering & Applied Science
Master's in Electrical & Computer Engineering	Sept. 2007	Engineering & Applied Science
Master's in Applied Bioscience	Sept. 2007	Science
Master's in Materials Science	Sept. 2007	Science
Master's in Modeling and Computational Science	Sept. 2007	Science
Master's in Automotive Engineering	Jan. 2008	Engineering & Applied Science
Master's in Nuclear Engineering	Sept. 2008	Energy Systems & Nuclear Science
Doctor of Philosophy in Mechanical Engineering	Sept. 2008	Engineering & Applied Science

1.2.2 Graduate Engineering Programs in Ontario

As reflected in Table 1.3—which lists Ontario's universities offering graduate programs in engineering—the universities in Ontario that currently offer graduate programs specifically in Electrical and Computer Engineering are Carleton University, University of Ottawa, McMaster University, Queen's University, Royal Military College of Canada, Ryerson University, University of Toronto, University of Waterloo, and University of Windsor. The University of Western Ontario also offers graduate studies in Electrical and Computer Engineering, but its program is listed under the general title of Engineering Science. There are therefore a total of ten institutions offering graduate programs in Electrical and Computer Engineering in Ontario.

Table 1.3 – Current Graduate Engineering Programs in Ontario

University	Programs	Degrees
Brock University	Geological Engineering	MSc
Carleton University	Civil Engineering[1] Electrical Engineering[1] Environmental Engineering[1] Geological Engineering[1] Mechanical & Aerospace Engineering[1] Software Engineering ConGESE[2] Telecommunications Technology Management	MASc/MEng/PhD MASc/MEng/PhD MASc/MEng/PhD MSc/PhD MASc/MEng/PhD MEng MEng
University of Guelph	Engineering	MEng/MSc/PhD
Lakehead University	Environmental Engineering Engineering (Control) Geological Engineering	MSc MSc MSc
Laurentian University	Mineral Resources Engineering Geological Engineering	MASc/MEng MSc/PhD
McMaster University	Chemical Engineering Civil Engineering Design & Manufacturing[3] Electrical & Computer Engineering Engineering Physics Geological Engineering Materials Science & Engineering Mechanical Engineering Software Engineering	MASc/MEng/PhD MASc/MEng/PhD MEng MASc/MEng/PhD MEng/PhD MSc/PhD MASc/MSc/PhD MASc/MEng/PhD MASc/MEng/PhD

University of Ontario Institute of Technology	Mechanical Engineering	MASc/MEng/PhD
	Electrical and Computer Engineering	MASc/MEng
	Automotive Engineering	MASc/MEng
	Nuclear Engineering	MASc/MEng
University of Ottawa	Chemical Engineering	MASc/MEng/PhD
	Civil Engineering[1]	MASc/MEng/PhD
	Electrical Engineering[1]	MASc/MEng/PhD
	Engineering Management	MEng
	Environmental Engineering[1]	MASc/MEng/PhD
	Geological Engineering[1]	MSc/PhD
	Mechanical & Aerospace Engineering[1]	MASc/MEng/PhD
	Software Engineering ConGESE[2]	MEng
Queen's University	Chemical Engineering	MEng/MSc/PhD
	Civil Engineering	MEng/MSc/MSc(Eng)/PhD
	Design & Manufacturing[3]	MEng
	Electrical & Computer Engineering	MEng/MSc/MSc(Eng)/PhD
	Geo-engineering[4]	MSc/MScE/PhD
	Materials & Metallurgical Engineering	MEng/MSc/MSc(Eng)/PhD
	Mechanical Engineering	MEng/MSc/MSc(Eng)/PhD
	Mining Engineering	MEng/MSc/MSc(Eng)/PhD
Royal Military College of Canada	Chemistry & Chemical Engineering	MSc/MEng/PhD
	Civil Engineering	MEng/PhD
	Defence Engineering & Management	MDEM
	Electrical & Computer Engineering	MEng/PhD
	Mechanical Engineering	MASc/MEng/PhD
Ryerson University	Chemical Engineering	MASc/MEng
	Civil Engineering	MASc/MEng/PhD
	Electrical & Computer Engineering	MASc/MEng/PhD
	Elect. & Comp. Eng. – Computer Networks	MASc/MEng
	Environmental Applied Science & Management	MASc
	Mechanical Engineering	MASc/MEng/PhD
University of Toronto	Aerospace Science & Engineering	MASc/MEng/PhD
	Biomedical Engineering	MASc/PhD
	Chemical Engineering & Applied Chemistry	MASc/MEng/PhD
	Civil Engineering	MASc/MEng/PhD
	Clinical Biomedical Engineering	MHSc
	Design & Manufacturing[3]	MEngDM
	Electrical & Computer Engineering	MASc/MEng/PhD
	Engineering & Management	BASc/MBA
	Environmental Engineering[5]	MASc/MEng/PhD
	Environmental Studies[5]	MASc/MEng/PhD
	Geological Engineering	MASc/MSc/PhD
	Integrated Manufacturing[5]	MEng
	Knowledge Media Design[5]	MASc/PhD
	Materials Science & Engineering	MASc/MEng/PhD
	Mechanical & Industrial Engineering	MASc/MEng/PhD
	Software Engineering ConGESE[2]	MEng
	Telecommunications	MEng
	Wood Engineering[5]	MASc
University of Waterloo	Chemical Engineering	MASc/PhD
	Civil Engineering	MASc/MEng/PhD
	Design & Manufacturing[3]	MEng
	Electrical & Computer Engineering	MASc/MEng/PhD
	Geological Engineering	MSc/PhD
	Management of Technology	MASc
	Management Sciences	MASc/MMSc/PhD
	Mechanical Engineering	MASc/MEng/PhD
	Software Engineering ConGESE[2]	MASc
	Systems Design Engineering	MASc/MEng/PhD

University of Western Ontario	Biomedical Engineering	MESc/PhD
	Design & Manufacturing[3]	MEng
	Geological Engineering	MSc/PhD
	Engineering Science	MESc/MEng/PhD
University of Windsor	Civil Engineering	MASc/MEng/PhD
	Electrical Engineering	MASc/MEng/PhD
	Engineering Materials	MASc/MEng/PhD
	Environmental Engineering	MASc/MEng/PhD
	Geological Engineering	MSc/PhD
	Industrial Engineering	MASc/MEng
	Manufacturing Systems	PhD
	Mechanical Engineering	MASc/MEng/PhD

Sources: Advanced Design and Manufacturing Institute, Canadian Council of Professional Engineers (CCPE), Consortium for Graduate Education in Software Engineering, and Ontario Council on Graduate Studies (OCGS).

[1] *Joint program between Carleton University & the University of Ottawa (The Ottawa-Carleton Institute for Electrical & Computer Engineering (OCIECE))*

[2] *ConGESE: Consortium for Graduate Education in Software Engineering – Joint program between Carleton University, University of Ottawa, Queen's University, University of Toronto, University of Waterloo, University of Western Ontario, and York University. Note that only schools that offer ConGESE master's degrees through engineering departments are noted in the table.*

Figure 1.1 indicates the cities in Ontario offering graduate programs in Electrical and Computer Engineering. Note that Kingston, Toronto, and Ottawa each have two universities offering graduate engineering programs. The demand for Electrical and Computer Engineering graduate studies is evident based on the increasing student enrolment in full-time Electrical and Computer Engineering graduate programs across Ontario.

Figure 1.1 – Map of cities offering graduate programs in Electrical and Computer Engineering in Ontario (Large Circles ●) as well as the location of the University of Ontario Institute of Technology in Oshawa; *Source: Yahoo! Maps (http://maps.yahoo.com/).*

Table 1.4 shows the total enrolment for ECE programs in Ontario in terms of the number of full-time and part-time doctoral and master's students. The table shows that since the academic year 2000-2001, there has been a very slight reduction in enrolments in part-time master's and doctoral programs. However, there has been a significant year-to-year increase in enrolment in both full-time master's and doctoral programs. In fact, there has been a rapid increase in the number of full-time students in both master's and doctoral programs in the five year period. Growths of 205% and 173% for doctoral and master's programs clearly indicate a significant and consistent demand for graduate studies in Electrical and Computer Engineering in Ontario.

Table 1.4 – Enrolment in Electrical & Computer Engineering Graduate Programs in Ontario

Program	00-01	01-02	02-03	03-04	04-05	Growth: 2000-2005
Doctoral Full-Time	322	353	437	572	662	205%
Doctoral Part-Time	55	44	44	42	46	-16%
Master's Full-Time	527	688	750	790	814	154%
Master's Part-Time	278	295	341	295	277	~ 0%
Doctoral & Master's Full-Time	849	1041	1187	1362	1476	173%
Doctoral & Master's Part-Time	333	339	385	337	323	-3%

Source: Ontario Council on Graduate Studies (OCGS) Macroindicator Data 2004-2005 (data includes Carleton/Ottawa, McMaster, Queens, Ryerson, Toronto, Waterloo, Windsor universities).

Due to recent events in the United States, there has been a shift in international graduate student applications from the United States to Canada. Noting Canada is the highest per capita immigrant-receiving nation in the world, many immigrants are very interested in upgrading their technical skills and pursuing higher education in order to obtain high-paying employment and to have a high standard of living. These trends are adding to the demand for increased graduate student spaces in Ontario, where about half of the new immigrants to Canada decide to reside. The Government of Canada has outlined a number of goals and targets in its Innovation Strategy, as reported by Industry Canada in 2002, including:

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 federal government'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 doctorate 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 1M.

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 Electrical and Computer Engineering (ECE) at UOIT, by focusing on select fields, 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 in 2003. 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 programs proposed by UOIT and the location of the university make it a logical choice for expanding Electrical and Computer Engineering graduate school capacity in Ontario. Within the Greater Toronto Area (GTA), there are currently only two universities offering graduate programs in ECE: Ryerson University and the University of Toronto. According to Statistics Canada, the population of the GTA as of the 2006 census was about 5.1 million and that of greater Montréal area was about 3.6 million. However, Montreal has four universities that offer graduate programs in Electrical and Computer Engineering: Concordia University, École de Technologie Supérieure, École Polytechnique, and McGill University. Comparing the GTA to greater Montréal area on the basis of population, the GTA lacks Electrical and Computer Engineering graduate school capacity. The addition of a PhD program in Electrical and Computer Engineering at UOIT will help increase the capacity in Electrical and Computer Engineering within the GTA. Also, according to Statistics Canada, Oshawa is one of the fastest growing cities in the country.

Figure 1.2 shows the location of graduate engineering programs in the GTA and neighboring cities. It shows that there are no engineering graduate schools in the eastern half of the GTA or in any neighboring cities east of the GTA. All of the graduate schools in the region are located in the centre of the GTA or in neighboring cities west of the GTA. The location of UOIT makes it an excellent choice for bringing increased engineering graduate school capacity to the eastern half of the GTA and neighboring cities, towns, and municipalities. In addition to being in a strategic location based on the population growth of the GTA, the location of UOIT is also ideal for taking advantage of a number of major industrial companies in the eastern half of the GTA whose areas are very relevant to the PhD Electrical and Computer Engineering program being proposed by UOIT. They include General Motors of Canada, Siemens, and Ontario Power Generation, including two major nuclear power plants in Darlington and Pickering. Also, there are many large companies, such as Nortel Networks, Research in Motion, in addition to numerous firms across southern Ontario, with the sole focus on Information and Communications Technology (ICT), a major thrust in ECE.

According to Industry Canada, between 1997 and October 2005, the ICT sector grew by 8.4% per year, more than twice as fast as the Canadian economy (3.6%). This faster growth of the sector also means that the ICT industries have accounted for 10.8% of the national growth since 1997. According to Industry Canada, employment in the ICT sector is characterized by a high level of education. In fact, in 2004, 38% of all workers had a university degree, compared to a national average of 21%. Noting that Ontario accounted for about 48% of all ICT sector revenues in Canada in 2003, there exists a very strong need for graduate programs in Electrical and Computer Engineering in the GTA to educate highly qualified personnel in the ICT arena.

Figure 1.2 – A map of universities offering graduate engineering programs within the GTA and neighboring cities and the location of the UOIT (note that the University of Guelph does not offer a graduate program in ECE); *Source: Yahoo! Maps (http://maps.yahoo.com/)*.

According to 2006 Government of Ontario Budget, by 2020, Ontario will need to refurbish, rebuild, replace or conserve approximately 25,000 MW of generation, representing approximately 80% of Ontario's current capacity, to meet the province's demand. The government has initiated one of the most ambitious building programs in North America for new electricity generation, including two new nuclear reactors to be built in Darlington, with close proximity to UOIT. It is based on a comprehensive energy plan focused on long-term stability and sustainability.

The government's aggressive move and comprehensive energy plan is in line with the fact that energy has been a key research area to be pursued by UOIT from its inception in 2003. At the Faculty of Engineering and Applied Science, faculty members with established research records are being hired to build a strong research nucleus in this important field, as well as to pursue the creation of Research Chairs in this area through support from Industry, CRC allocations, and NSERC Industrial Chairs. The Faculty of Engineering and Applied Science is already home to a CRC Tier 1 in the field of energy.

1.2.3 Faculty of Engineering and Applied Science Mission

The mission of the Faculty of Engineering and Applied Science is to contribute to society through excellence in education, scholarship, and service. We will provide for our graduate students a rigorous education and endeavor to instill in them the attitudes, values, and vision that will prepare them for a lifetime of continued learning and leadership in their chosen careers. We engage in scholarship of discovery, innovation, application, and integration.

1.2.4 Rationale for a PhD Program in ECE at UOIT

The reasons to launch the PhD program in ECE, following the launch of ECE Master's programs in September 2007, are many-fold:

i) To help meet the UOIT's strategic research goals focusing on technology and engineering, as reflected in Bill 109 passed by the Ontario Legislature in 2002;

ii) To help meet the growing provincial demand for graduate programs, including Ontario's double cohort students pursuing ECE PhD studies and the UOIT's students completing their ECE MASc program;

iii) To help attract highly-qualified faculty members with outstanding research potential/records to contribute to teaching excellence in our undergraduate ECE programs, as well as to help acquire much needed qualified graduate students to work as teaching assistants in our ECE undergraduate courses;

iv) To allow the PhD program in ECE to be a catalyst to help attract senior faculty members—those who are already leading vigorous research programs by supervising PhD students. It is anticipated that with the PhD program in ECE in place, prospective senior faculty members could consider the UOIT as a research-intensive university where they could well continue their research efforts, without compromising the quality and the quantity of their research publications. The future senior faculty members would also serve as mentors to the young promising faculty members in such areas as graduate student supervision, research management, and the preparation of research grant applications, and above all;

v) To enable ECE faculty members to effectively meet their indispensable obligations associated with research grants from adjudicated funding sources. It is an essential requirement, as set by some funding agencies such as NSERC, to train highly-qualified personnel. In order for the ECE faculty members to meet this crucial commitment to provide financial support to students from their research grants and to carry out significant research programs leading to refereed journal publications, the PhD program is critical. With the plan to launch the PhD program in 2009, the UOIT has been successful in hiring excellent faculty with both outstanding research records and impressive industrial experiences.

1.3 Objectives of the Program

There are four objectives common to the graduate programs:

- Depth – To provide students with a detailed understanding of the fundamental knowledge prerequisites for the practice of, or for advanced study in communications and signal processing, software systems, control systems, energy and power systems.

- 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 with diverse needs and for lifelong learning and enrichment.

- 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 objectives of the PhD program in ECE are to furnish the students with the highest possible level of knowledge and scholarship in their areas of expertise. This will be achieved through advancing independent initiatives, critical thinking, methodological analysis, creative problem solving, and practical design synthesis. This will in turn prepare graduates for a career in research in the industry or government research labs or academia. During their careers as academics, they should then be able to train Canada's next-generation of research scientists and also be actively involved in independent as well as collaborative research.

Graduates of the program are expected to develop leading-edge expertise, and to be able to conduct independent, original, high-quality research. The goals of the PhD program are achieved through a combination of advanced course work, independent research, research seminars, mandatory professional workshops, conference presentations, refereed research publications, and a novel research dissertation. The research dissertation must comprise a new, yet significant, contribution to the field of study.

1.4 Method used for the self-study

This appraisal was prepared by the members of the Graduate Committee of the Faculty of Engineering and Applied Science. The appraisal has gone through comprehensive reviews by the Graduate Committee and the Faculty Council of the Faculty of Engineering and Applied Science, the Dean of Graduate Studies, the UOIT Graduate Studies Committee, and the Academic Council of the UOIT.

1.5 Fields in the programs

This PhD program comprises the following four fields:

(1) Communications and Signal Processing;

(2) Software Systems;

(3) Control Systems;

(4) Power and Energy Systems.

These broad fields mainly:

- reflect the research expertise of the current faculty members,
- project those of future faculty hires,
- echo the government priorities,
- address general interests of the local industry, and
- highlight the university strategic research plan.

1.6 Review concerns expressed in previous appraisal and actions taken

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

1.7 Special matters and innovative features

As reflected in the faculty CVs provided in Volume-II, a group of very well-qualified faculty members—all graduates of prestigious universities in Canada, the US, and overseas, with solid records of success in securing funding grants, and many with extensive industrial experiences in their areas of expertise—have been hired to conduct significant research in areas of potential interest to doctoral candidates in the discipline.

Students enrolled in the PhD program in Mechanical Engineering (the first PhD program at the UOIT) have access to three state-of-the-art facilities that are unique to Canada: the Automotive Centre of Excellence, the Borehole Thermal Energy Storage System, and the Integrated Manufacturing Centre. It is thus expected, and in fact encouraged, that students enrolled in the PhD program in ECE may capitalize on closer collaboration with students and faculty in Mechanical Engineering, in areas such as energy, robotics and mechatronics.

The University of Ontario Institute of Technology, as the only laptop-based university in Ontario, provides students with access to its Mobile Learning Environment. Graduate students at UOIT have access to library resources, email, the Internet, and to other online services. In addition, UOIT is a member of the Shared Hierarchical Academic Research Computing Network (SHARCNET).

Should the program be approved and implemented by mid 2009 as planned, it will provide an academic option for graduates of UOIT's own MASc program in ECE, who started their master's programs in the fall 2007.

The PhD program in ECE at the UOIT will possess a rather unique set of innovative features, including:

- UOIT is a new university, and can thus grow rapidly—in terms of hiring new faculty members, offering innovative courses, and setting new directions—to meet the dynamic market demand and government priorities;
- This PhD program also focuses on professional development and entrepreneurship, through workshops; this prepares its graduates in the private sector to lead efforts in research, design and development of cutting-edge technologies;
- Most of ECE faculty members have considerable industrial experiences; this ensures that the research remains both applied and innovative, and also helps establish and maintain a strong long-term collaboration with industry;
- Canada, as reported by the Conference Board of Canada in June 2008, trails its competitors in fostering PhD graduates and in producing graduates in the fields that underpin innovation, such as engineering, and fares poorly, for research is not successfully commercialized and used as a source of advantage for companies seeking global market share. Against this backdrop, UOIT, as mandated by the Government of Ontario, is quite involved in technology transfer and commercialization.
- In response to the UOIT's constant drive to avoid research silos within the university and to retain its current interdisciplinary orientation, many of the faculty members involved in this PhD program have multidisciplinary research interests in such broad areas as health, security, energy, robotics, and e-commerce; this broader research perspective can significantly enrich the students' education and help them recognize and appreciate the value of diverse applications, methods and disciplines in identifying and solving research problems.

2 THE FACULTY

2.1 List of current faculty by field

Table 2.1 lists the faculty members involved in the PhD program and identifies their research field, gender, home unit, and supervisory privileges. Graduate faculty appointments, categories of graduate teaching and supervision privileges are described in Section 2 of the General Policies and Procedures for Graduate Studies at the UOIT (see Appendix B). Curricula Vitae for all faculty members listed in Table 2.1 are provided in Volume II of this submission.

There is only one person who may retire within the next seven years. Faculty member retirements are uncertain due to the recent removal of the obligatory retirement age.

There are seven core female faculty members involved in this program. Out of the four core female faculty members in the Faculty of Engineering and Applied Science (FEAS), one holds an NSERC University Faculty Award (UFA). There are two who have cross-appointments between FEAS and another Faculty, and there is one, with cross-appointment between the Faculty of Business and Information Technology and the Faculty of Heath Sciences, who holds a Tier-2 Canada Research Chair in Health Informatics.

Currently there are 27 core faculty members involved in the program. There are five Category 1, one Category 2, and twenty one Category 3 core faculty members. Most of the professors in Table 2.1 are classified as Category 3 because they are or were involved in the teaching and supervision of previously developed UOIT graduate programs. However, this must be emphatically noted that there is a core group of faculty members whose involvement, in terms of graduate teaching and/or research, will be primarily with the ECE programs at the master's and PhD levels. This core faculty group consists of the following 12 faculty members: Drs. Dong, Eklund, El-Khamy, Grami, Liscano, Marceau, Milman, Rahnamayan, Ren, Shahbazpanahi, Sood, and Wang.

Also, UOIT is open to offering adjunct professorships both to well-qualified external academics and to professionals with industrials ties, who would contribute to the program in terms of student supervision and teaching of the graduate courses.

In addition to the core faculty members in the Faculty of Engineering and Applied Science with ECE educational backgrounds and research expertise in ECE, there are other faculty members at the UOIT who will contribute their expertise and time to teach and co-supervise students, including:

- Faculty of Engineering and Applied Science faculty members, with Mechanical Engineering background in the fields of Control Systems and Energy Systems,

- Faculty of Energy Systems and Nuclear Engineering faculty members in the fields of Power Systems and Control Systems,

- Faculty of Business and Information Technology faculty members, with Information and Communications Technology background in the fields of Communications and Software Systems,

Table 2.2 shows the plan for new faculty hires. The faculty hired will be at all levels to ensure a healthy balance between full professors, associate professors, and assistant professors across all areas of interests.

Table 2.1 – Faculty Members by Field

Faculty Name & Rank [1]	M / F	Retirement	Home Unit [2]	Supervisory Privileges	Fields [3]			
					Communications and Signal Processing	Software Systems	Control Systems	Power & Energy Systems
Category 1								
M. Dong* – Assistant	F		FEAS	Full	X			
M. El-Khamy* – Assistant	M		FEAS	Full	X			
R. Milman* – Assistant	F		FEAS	Full			X	
S. Rahnamayan* – Assistant	M		FEAS	Full		X		
Y. Wang* -- Assistant	F		FEAS	Full	X			
Category 2								
V. Sood* – Associate	M		FEAS	Full				X
Category 3								
G. Bereznai – Full	M	11	FESNS	Full				X
I. Dincer – Full	M		FEAS	Full				X
M. Eklund* – Assistant	M		FEAS	Full			X	
K. El-Khatib – Assistant	M		FBIT	Full		X		
E. Esmailzadeh – Full	M		FEAS	Full			X	
A. Grami* – Associate	M		FBIT/FEAS	Full	X			
S. Heydari – Assistant	M		FBIT	Full	X			
P. Hung – Associate	M		FBIT	Full		X		
X. Lin - Assistant	M		FBIT	Full		X		
R. Liscano* – Associate	M		FEAS	Full		X		
L. Lu – Assistant	F		FESNS/FEAS	Full			X	
R. Marceau* – Full	M		FEAS	Full				X
C. McGregor - Associate	F		FBIT/FHS	Full		X		
G. Naterer – Full	M		FEAS	Full				X
S. Nokleby – Assistant	M		FEAS	Full			X	
B. Reddy – Associate	M		FEAS	Full				X
J. Ren* – Assistant	F		FEAS	Full			X	
S. Shahbazpanahi*–Assistant	M		FEAS	Full	X			
M. Vargas Martin – Assistant	M		FBIT/FEAS	Full		X		
D. Zhang – Associate	M		FEAS	Full			X	
Y. Zhu – Assistant	F		FBIT/FEAS	Full		X		
Category 6								
M. Bennett	M		FEAS	Full		X		

* There is a core group of professors whose involvement will be primarily with the master's and PhD programs in Electrical and Computer Engineering since their academic qualifications, experience and research interests are most closely aligned with the foci and fields of the proposed program.

[1] 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.

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 & Applied Science
FBIT: Faculty of Business & Information Technology
FESNS: Faculty of Energy Systems and Nuclear Science
FHS: Faculty of Health Sciences

[3] Field 1: Communications & Signal Processing
Field 2: Software Systems
Field 3: Control Systems
Field 4: Power & Energy Systems

It is expected that, in the steady state, the areas of expertise of the Electrical and Computer Engineering faculty members will include Communications and Signal Processing, Software Systems, Systems Control, and Power and Energy Systems.

Table 2.2 – Planned Faculty Hiring in ECE for the Years 2009 - 2013

		Number in Each Field			
Academic Year	Total Number	Communications & Signal Processing	Software Systems	Control Systems	Power & Energy Systems
2009 - 2010	4	0	2	0	2
2010 - 2011	2	1	1	0	0
2011 - 2012	2	0	1	0	1
2012 - 2013	2	1	0	1	0

2.2 External operating research funding

Table 2.3 presents the external operating research funding that faculty members have received since the formation of the Faculty in 2003. Table 2.4 presents the total external research funding by field from 2003 to 2008. Faculty members are actively applying for funding from the Natural Sciences and Engineering Research Council (NSERC) of Canada, the Canadian Foundation for Innovation (CFI), and Ontario Centres of Excellence (OCE) as well as from industry. Note that the funding listed represents only confirmed funding and shall significantly increase as more faculty members are hired and the faculty successfully secure additional funding from various sources.

Table 2.3 - Operating Research Funding by Year

	Source [6]			
Year [1]	Granting Councils [2]	Other Peer Adjudicated [3]	Contracts	Others [4]
2003	$115,000	$75,000	$15,000	$40,000
2004	$229,000	$122,000	$10,000	$60,000
2005	$289,000	$453,000	$35,000	$84,000
2006	$417,000	$117,000	$179,000	$175,000
2007	$1,046,000	$2,609,000	$563,000	$427,000
2008[5]	$1,092,000	$1,065,000	$10,000	$226,000
Totals	$3,152,000	$4,417,000	$812,000	$972,000

[1] *Calendar year.*
[2] *NSERC; CFI.*
[3] *ORF, OCE, NCE-Auto21/-MITACS, NCIT, OPIC, NSFC, and others.*
[4] *University start-up grants and other miscellaneous research funding.*
[5] *Confirmed to date.*
[6] *Rounded down to the nearest thousand.*

Table 2.4 - Operating Research Funding by Field: 2003 to 2008

Program Fields	Granting Councils	Other peer adjudicated	Contracts	Others
Communications & Signal Processing	$286,000	$290,000	$1000	$170,000
Software Systems	$834,000	$1,374,000	$286,000	$496,000
Control Systems	$426,000	$643,000	$393,000	$266,000
Power & Energy Systems	$1,660,000	$2,134,000	$132,000	$80,000

2.3 Graduate supervision

Table 2.5 lists the completed and current numbers of thesis supervisions by faculty member. The Table shows that there is a good balance of senior professors, who have successfully graduated students and new professors, who have not yet graduated students. A number of the faculty members involved in the proposed program currently hold adjunct appointments at other universities. Table 2.6 outlines these adjunct appointments.

Table 2.5 - Completed and current numbers of thesis supervisions/co-supervision by faculty member

		Completed			Current		
		Master's	PhD	PDF	Master's	PhD	PDF
Core Faculty Members							
Bereznai	Dean (FESNS)	2	0	0	0	0	0
Dincer		9	7	17	12	7	6
Dong		0	0	0	0	0	0
Eklund		0	0	0	1	0	0
El-Khamy		0	0	0	0	0	0
El-Khatib		1	0	0	6	1	0
Esmailzadeh		29	8	4	6	4	2
Grami		0	0	0	1	1	0
Heydari		0	0	0	0	0	0
Hung		7	0	0	5	3	1
Lin		0	0	0	0	0	0
Liscano		10	0	0	3	1	0
Lu		0	0	1	5	0	0
Marceau	Provost & Acting Dean (FEAS)	13	4	0	0	0	0
McGregor	Tier-2 CRC: Health Informatics	1	1	0	1	3	1
Milman		0	0	0	0	0	0
Naterer	Tier-1 CRC: Advanced Energy Systems, Director Research, Graduate Studies & Development	9	6	4	9	3	2
Nokleby		3	0	1	6	1	0
Rahnamayan		0	0	0	0	0	0
Reddy		7	1	2	3	1	2
Ren		0	0	0	0	0	0
Shahbazpanahi		4	3	0	4	3	0
Sood		38	0	1	2	1	0
Vargas Martin		2	0	0	4	1	0
Wang		0	0	0	0	0	0
Zhang		4	0	1	8	2	0
Zhu		0	0	0	1	0	0
Non-Core Faculty Members							
Bennett	Acting Associate Dean (FEAS)	27	1	0	0	0	0

Table 2.6 – Adjunct Appointments

	University
Core Faculty Members	
Dincer	University of Toronto University of Waterloo Carleton University
Esmailzadeh	University of Toronto University of Waterloo Concordia University Sharif University of Technology (Iran)
Grami	Ryerson University York University
Hung	University of Waterloo
Liscano	Dalhousie University University of Ottawa
Lu	University of Western Ontario
McGregor	Dalhousie University University of Western Sydney (Australia)
Naterer	University of Toronto University of Manitoba
Nokleby	University of Victoria
Reddy	University of New Brunswick
Ren	University of Western Ontario
Shahbazpanahi	McMaster University
Sood	Concordia University Ryerson University University of Western Ontario University of Quebec in Montreal
Vargas Martin	Universidad Autonoma de Aguascalientes (Mexico)
Zhang	University of Saskatwchen Dong Hua University (China)
Non-Core Faculty Members	
Bennett	University of Western Ontario

2.4 Current and recent teaching assignments

Table 2.7 shows the planned teaching loads for the 2007-2008, academic year. Table 2.8 shows the teaching assignments for the 2006-2007 academic year and Table 2.9 shows the teaching assignments for the 2005-2006 academic year. Note that the numbers in the brackets following the course number correspond to weekly lecture/lab/tutorial hours respectively. Moreover, many of the faculty members are involved in ENGR 4999U, the design thesis course.

Table 2.7 – Proposed Teaching Assignments for 2008 – 2009

Member	Rank	Undergraduate	Graduate
Core Faculty Members			
Dincer	Full	ENGR 2320U (3/1/1), ENGR 3260U (3/0/0) ENGR 3930U (3/1/1)	ENGR 5100G (3/0/0)
Dong	Assistant	ENGR 4500U (3/0/0), ENGR 5640G (3/0/0)	
Eklund	Assistant	ENGR 2200U (3/1.5/2)	
El-Khatib	Assistant	INFR 1100U (3/1/1), INFR 2820U (3/0/0)	
Esmailzadeh	Full	ENGR 4010U (3/0/1), ENGR 3350U (3/2/1) ENGR 3210U (3/2/1)	ENGR 5242G (3/0/0)
Grami	Associate	BUSI 1900U (3/0/1.5), BUSI 1900U (3/0/1.5) INFR 3710U (3/0/0), INFR 3720U (3/0/0) ENGR 3130U (3/1.5/2), INFR 1516 (3/1.5/0)	
Heydari	Assistant	INFR 1410U (3/3/0), INFR 1420U (3/30) INFR 3830U (3/0/0)	
Hung	Associate	BUSI 1830U (3/0/0), BUSI 2510U (3/0/0)	MITS 6200G (3/0/0)
Lin	Assistant	INFR 4620U (3/1.5/0)	MITS 6100G (3/0/0)
Liscano	Associate	ENGR 2710U (3/0/2), ENGR 3720U (3/0/3) ENGR 4790U (3/3/2)	ENGR 5720G (3/0/0)
Lu	Assistant	ENGR 2790U (3/1/1)	
McGregor	Associate	HLSC 4201 (3/0/0)	MITS 5600G (3/0/0)
Milman	Assistant	ENGR 4100U (3/1.5/2), ENGR 2110U (3/0/2)	ENGR 5920G (3/0/0)
Naterer	Full	ENGR 2860U (3/2/1)	
Nokleby	Assistant	ENGR 4280U (3/1/1), ENGR 4320U (3/3/0) ENGR 4330U (3/3/0), ENGR 4331U (0/3/1)	
Rahnamayan	Assistant	ENGR 1200U (3/0/0). ENGR 2720U (3/0/0)	
Reddy	Associate	ENGR 4410 (3/1/2), ENGR 4430 (3/0/2) ENGR 4240 (3/1/2)	
Ren	Assistant	ENGR 3140 (3/1.5/2), ENGR 3490 (3/1.5/2)	
Shahbazpanahi	Assistant	ENGR 3110U (3/2/1.5), ENGR 4420U (3/2/1.5)	ENGR 5610G (3/0/0)
Sood	Associate	ENGR 2360U (3/0/1.5)	ENGR 5970G (3/0/0)
Vargas Martin	Assistant	ENGR 4840U (3/0/0), INFR 4630U (3/0/0) INFR 1010U (3/0/1.5)	ENGR 5670U (3/0/0)
Wang	Assistant	ENGR 4310U (3/1/1), ENGR 4750U (3/1.5/2) ENGR 2250U (3/1.5/2), ENGR 2520U (3/0/2)	ENGR 5950G (3/0/0)
Zhang	Associate	ENGR 3220U (3/1/1)	ENGR 5261G (3/0/0)
Non-Core Faculty Members			
Bennett – Acting Associate Dean		ENGR 3960U (3/1.5/2), ENGR 3360U (3/0/0) ENGR 4760U (3/0/0)	ENGR 5005G (6/0/0)

Table 2.8 – Teaching Assignments for 2007 – 2008

Member	Rank	Undergraduate	Graduate
Core Faculty Members			
Dincer	Full	ENGR 2320U (3/1/1), ENGR 3260U (3/0/0) ENGR 3930U (3/1/1)	ENGR 5100G (3/0/0)
Eklund	Assistant	ENGR 2200U (3/1.5/2), ENGR 3230U (3/1.5/2) ENGR 3330U (3/1/1)	
El-Khatib	Assistant	INFR 1100U (3/1/1), INFR 2820U (3/0/0)	MITS 6400G (3/0/0)
Esmailzadeh	Full	ENGR 3350U (3/2/1), ENGR 3210U (3/2/1)	ENGR 5283G (3/0/0) ENGR 5004G (3/0/0)
Grami	Associate	BUSI 1900U (3/0/1.5), BUSI 1900U (3/0/1.5) INFR 3710U (3/0/0), INFR 3720U (3/0/0) ENGR 3130U (3/1.5/2)	
Heydari	Assistant	INFR 1410U (3/3/0), INFR 3830U (3/0/0)	MITS 5200G (3/0/0) MITS 5610G (3/0/0)
Hung	Associate	BUSI 1650 (3/0/0), BUSI 1830U (3/0/0) BUSI 3570U (3/0/0)	MITS 5400G (3/0/0) MITS 6200G (3/0/0)
Liscano	Associate	ENGR 2710U (3/0/2), ENGR 2720U (3/3/2) ENGR 3720U (3/0/3)	ENGR 5710G (3/0/0)
Lu	Assistant	ENGR 2790U (3/1/1)	
McGregor	Associate	BUSI 1600U	
Milman	Assistant	ENGR 2110U (3/0/2), ENGR 2450U (3/1.5/2) ENGR 3070U (3/1.5/2)	
Naterer	Full	ENGR 2640U (3/2/1)	
Nokleby	Assistant	ENGR 3390U (3/2/1), ENGR 4280U (3/1/1) ENGR 4320U (3/3/0), ENGR 4330U (3/0/2)	ENGR 5010G (3/0/0)
Reddy	Associate	ENGR 2640 (3/1/2), ENGR 4410 (3/1/2) ENGR 4240 (3/1/2)	
Ren	Assistant		ENGR 5004G (3/0/0) ENGR 5940G (3/0/0)
Shahbazpanahi	Assistant	ENGR 3110U (3/2/1.5), ENGR 2790U (3/1/1) ENGR 2790U (3/1/1)	ENGR 5610U (3/0/0)
Sood	Associate	ENGR 2520U (3/0/1.5), ENGR 1400U (3/0/0) ENGR 3240U (3/1.5/3), ENGR 3250U (3/1.5/3)	ENGR 5960G (3/0/0)
Vargas Martin	Assistant	INFR 1010U (3/0/1.5), ENGR 1200U (3/0/2)	MITS 5500G (3/0/0)
Wang	Assistant	ENGR 4310U (3/1/1), ENGR 2250U (3/1.5/2)	
Zhang	Associate	ENGR 2430U (3/0/1), ENGR 2430U (3/0/1)	ENGR 5260G (3/0/0)
Zhu	Assistant	ENGR 2530U (3/0/2), INFR 3810 (3/0/0) INFR 2830 (3/3/0), BUSI 3510 (3/0/0)	
Non-Core Faculty Members			
Bennett – Acting Associate Dean		ENGR 3960U (3/1.5/2), ENGR 3360U (3/0/0) ENGR 4760U (3/0/0)	ENGR 5005G (6/0/0)

Table 2.9 – Teaching Assignments for 2006 – 2007

Member	Rank	Undergraduate	Graduate
Core Faculty Members			
Dincer	Full	ENGR 2320U (3/1/1), ENGR 3260U (3/0/0) ENGR 3450U (3/1/1), ENGR 3930U (3/1/1)	
Eklund	Assistant	ENGR 2200U (3/1.5/2), ENGR 3330U (3/1/1)	
El-Khatib	Assistant	INFR 1100U (3/1/1), INFR 1500U (3/0/0)	MITS 6400G (3/0/0)
Esmailzadeh	Full	ENGR 3350U (3/2/1), ENGR 3350U (3/2/1) ENGR 3210U (3/2/1)	ENGR 5242G (3/0/0)
Grami	Associate	BUSI 1900U (3/0/1.5), BUSI 1900U (3/0/1.5) ENGR 1400U (3/0/0)	MITS 5200G (3/0/0) (co-teaching)
Heydari	Assistant	INFR 2550U (3/0/0)	
Hung	Associate	BUSI 1650U (3/0/0), BUSI 1830U (3/0/0) BUSI 2501U (3/0/0)	MITS 6200G (3/0/0)
Liscano	Associate	ENGR 1200U (3/0/2), ENGR 2710U (3/3/2) ENGR 2720U (3/0/2)	
Lu	Assistant	ENGR 3740U (3/1/1), ENGR 4730U (3/0/1) ENGR 2360U (3/0/0), ENGR 2450U (3/1/1)	ENGR 5004G (3/0/0)
Naterer	Full	ENGR 2640U (3/2/1)	ENGR 5140G (3/0/0)
Nokleby	Assistant	ENGR 3390U (3/2/1), ENGR 3390u (3/2/1) ENGR 4280U (3/1/1)	ENGR 5010G (3/0/0)
Reddy	Associate	ENGR 4240 (3/1/2)	
Ren	Assistant	ENGR 2110U (3/0/2), ENGR 2250 (3/1.5/2)	
Shahbazpanahi	Assistant	ENGR 2790U (3/1/1), ENGR 2790U (3/1/1) ENGR 2520U (3/2/0)	
Vargas Martin	Assistant	INFR 1010U (3/0/1.5), ENGR 1200U (3/0/2)	MITS 5500G (3/0/0)
Zhang	Associate	ENGR 2260U (4/2/1), ENGR 2430U (3/0/1)	ENGR 5260G (3/0/0)
Zhu	Assistant	ENGR 2530U (3/0/2), INFR 3810 (3/0/0) INFR 2830 (3/1.5/0), BUSI 3510 (3/0/0)	
Non-Core Faculty Members			
Bennett – Acting Associate Dean		ENGR 3960U (3/1.5/2), ENGR 3360U (3/0/0) ENGR 4760U (3/0/0)	ENGR 5005G (6/0/0)

2.5 Commitment of faculty members from other graduate programs and/or other institutions

Drs. Dincer, Esmailzadeh, Naterer, Nokleby, Reddy, and Zhang are primarily involved in MASc/MEng/PhD programs in Mechanical Engineering. Drs. Lu and Bereznai are also involved in MASc/MEng programs in Nuclear Engineering. Drs. El-Khatib, Heydari, Hung, Lin, McGregor, Vargas Martin, and Zhu are primarily involved in the Master of Information Technology Security (MITS) program; Dr. McGregor will be also involved in the Master of Health Science. It is expected that the remaining 12 core faculty members would be primarily involved in the ECE graduate programs.

3 PHYSICAL AND FINANCIAL RESOURCES

3.1 Library resources

The UOIT 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 73,000-square-foot library serves students, faculty, and staff. The four-storey, $20.7-million library houses individual and collaborative learning spaces, research workstations, electronic classrooms, a reading room and periodicals collection. It offers a variety of learning spaces to suit individual learning styles and user needs. Its design also allows for future enlargement, up to double the original size. Students and faculty have access to library resources using their wireless laptops, anytime from anywhere. Within the building, patrons can work individually or collaboratively. Digital resources and complementary print collections are available and librarians provide students with the skills needed to navigate effectively through the information environment. In addition to interlibrary loans, students can search the catalogues of all Ontario university libraries and place immediate online requests for any available item. To keep faculty members and students informed of the library's continued growth and to provide easy access to resources, the UOIT Library staff have been constructing and revising its web site: www.uoit.ca/library on an ongoing basis.

It is of great importance to highlight that the library resources include *IEEEXplore*. *IEEEXplore* is an online delivery system providing full text access to the world's highest quality technical literature in electrical engineering, computer science, and electronics. *IEEEXplore* contains full text documents from IEEE journals, transactions, magazines, letters, conference proceedings, standards, and IEE (Institution of Electrical Engineers) publications. *IEEEXplore* offers more than 1.8 million documents, which can all be accessed online in an advanced search fashion. The other key databases are ACM (American Computing Machinery), Compendex, Inspec, and Computer Science Index. 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. A more detailed presentation on the library resources is listed in Appendix A: Library Resources.

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 the University of Ontario Institute of Technology, by a wide range of grants and significant donations from the Industry (both product manufacturers and service providers), and by various Government funding agencies, such as CFI, NSERC, and OCE. The facilities will be enhanced through equipment acquisitions to maintain and upgrade laboratory equipment and to reflect state-of-the-art technology and industry-focused research, as the number of faculty members is increased and the research expertise is broadened over the next few years.

Communication Networks Laboratory – This lab will focus on the research and development of leading networking technologies for the non-real and real time delivery of multimedia information, through theoretical design and simulation of innovative networking concepts. The facilities in this lab include SUN workstations and many PCs, protocol analyzers, hardware and software ATM switches, routers, and bridges to assess Voice over IP and Mobile IP performance, and to characterize the multimedia traffic in wired and wireless communications networks, with a wide range of traffic attributes and network pricing and resource management, monitoring and tomography, and protocol modeling mechanisms.

Communications and Signal Processing Laboratory – This lab provides infrastructure for research in signal processing and telecommunications including wireless systems, MIMO communications, spectral analysis and array signal processing, mobile ad hoc and sensor networks, and also satellite communications and interference analyses for a variety of system payloads and frequency bands. This lab provides an environment for the development of new information- and signal-processing algorithms from conception to implementation in software or hardware, including new coding and modulation schemes and access techniques for wire-line (twisted-pair and co-axial cable) and wireless systems using communication and signal-processing tool-sets for information processing applications in dynamically changing environments. The research encompasses theoretical analyses and modeling, computer simulation and hardware prototyping. This will provide state-of-the-art test, measurement, and proof-of-concept prototyping facilities which include radio transmission and test equipment (up to EHF frequencies), co-processor boards, audio and video equipment, data acquisition hardware, DSP development boards with test and evaluation boards. There will also be several, standalone or networked, SUN workstations and several dozen of high-speed Pentium-IV PCs with large RAMs. Software includes all of the standard programming and AI languages, symbolic algebra systems, word-processors, and various packages specific to telecommunications and signal processing.

Hacker Research Laboratory – This lab is not only used to train students through a hands-on research-based approach, but more importantly enable the faculty members and graduate students to lead research programs in their respective fields of IT security. The lab provides a physical and logical infrastructure to allow for a secured and isolated environment in which security related research can be safely performed. As the lab’s configuration is designed to be flexible, it can also be linked to external networks if required. Housed in a room of 100 square meters, the lab consists of four main Unix/Linux/Windows 2003 servers, including two SUN V20Z and two V240 servers plus CISCO routers, switches and tape backup units. These servers act as the gateway to the HR-Lab form the outside world. Other than controlling user access and supporting applications, these servers also serve the purpose of Firewall and virus/content scanning. Behind these servers are eight groups of equipment. Each group has two servers, one switch, one desktop workstation PC and one laptop workstation PC. The Pentium based server is configured to allow multi-boot from any of the Windows 2003, Unix or Linux OS for different combinations. The second server is a SUN SPARC V100 server with Solaris on it. The CISCO 2950 switch is configured for multiple VLANs. Each group can work isolated or linked. When all eight groups are linked together, it provides a large network with 16 servers and more than 32 VLAN. That is a very good environment for research on real time performance with proper network loadings. The HR-Lab is also equipped with four CISCO wireless access points and four PDAs for research in the wireless networking area.

Mobile and Pervasive Computing Laboratory – This lab provides infrastructure for research in mobile and pervasive computing. This includes service specification and discovery, mobile and distributed sensing, contextual modeling, and policy-based network management. This lab provides an environment for the development of new systems and algorithms for the support of pervasive and ubiquitous computing. The lab consists of RFID systems, wireless sensor networks, several development stations for the development of distributed service oriented software systems, and mobile robots to enable mobile sensing and communications. The laboratory is also equipped with networking simulation packages that are used for the validation of new distributed algorithms. The current focus of the research in the laboratory is in policy-based access control and multi-tier sensor networks. Some typical research in the laboratory consist of interoperability between the service oriented architectures and wireless sensor networks; semantic representations of contexts as extracted from sensory data; semantic-based access control in multi-tier networks; novel routing algorithms for sensor networks; self-localization in sensor networks; XML compression for wireless communications; and the support of plug and play in sensor networks.

Power Systems Laboratory (PSL) – This lab is to augment the teaching and research activities in power systems. Due to the huge costs involved with actual hardware for a PSL equipped with a Transients Network Analyzer, it is proposed to have initially a software based laboratory for the modeling and simulation of electro-magnetic power system transient phenomena. It is intended to have 8 PC based computer stations in operation in the laboratory. Two 64-bit high-end PCs are to be added to the equipment. The following software packages will also be available: i) Electro-Magnetics Transients Program for the modeling and simulation of electro-magnetic power system transient phenomena, ii) Load Flow and Transient Stability programs from CYME, and iii) Matlab based Power Systems Toolbox. In addition, a real time digital simulator from OPAL RT will be added for the hardware-in-loop testing of digital controllers and protection relays.

Health Informatics Laboratory – This lab simulates current and proposed next generation functions within Intensive Care Units (ICUs) and specifically Neonatal ICUs (NICUs) and contains 3 medical devices used within ICUs together with a range of small fanless PCs, laptop PCs, smart phones and computer servers. The environment can be configured to enable the simulation of a range of scenarios incorporating ICUs, Remote Hospitals, together with specialist remote access. No similar laboratory to support next generation health informatics solutions currently exists in Canada.

Integrated Manufacturing Centre (IMC) – The IMC is a 925 m^2, fully automated, industrial-grade, flexible manufacturing facility capable of fabricating and assembling a wide range of products. The IMC provides a facility to conduct research in advanced manufacturing and mechatronics engineering. The main components of the IMC, consisting of machines and robots, are divided into two areas: the manufacturing zone and the assembly zone.

Active Vibration Control Laboratory – This lab is primary used for research into the areas of adaptive, active and passive vibration control, and dynamic modeling and vibrations of nonlinear machines and flexible structures. The experimental work to be carried out is aimed at verifying the vibration suppression of time-varying and parametrically excited dynamic structures through adapting a two-tier approach: a) system identification to determine the deviations in the structural parameters, and b) a semi-active optimal re-tuning of the absorber elements. In order to show the vibration suppression improvement, initially the primary will be excited by a simple harmonic excitation. Then, by changing the frequency of excitation, the effectiveness of the re-tuning procedure is obtained. In addition to the above experiment, the use of servo-valve controlled pneumatic isolators will be considered. Feedback and feed-forward signals using displacement and velocity transducers will be fed to the control systems to excite the spool valve and in turn adjust the air trapped in the pneumatic below. The aim is to have zero level motion for a sprung mass subjected to a harmonically excited base support.

Mechatronic and Robotic Systems Laboratory – The Mechatronic and Robotic Systems Laboratory conducts research into advanced robotic and mechatronic systems. The lab conducts research into the kinematics and control of complex systems such as joint-redundant manipulators, mobile-manipulator systems, and redundantly-actuated parallel manipulators. Redundant manipulators and mobile-manipulator systems offer numerous advantages over traditional non-redundant systems. Effective utilization of the redundancy inherent in these systems is instrumental in moving the systems from the laboratory and applying them to real-world applications. The laboratory has a number of manipulator systems obtained through a CFI New Opportunities Grant. In addition, the laboratory works with a number of industry partners including Cameco and BRIC Engineered Systems on industrial automation projects.

Automotive Centre of Excellence (ACE) – In 2005, General Motors of Canada announced a $2.5 billion investment in GM's Canadian operations. This represents the largest and most comprehensive automotive investment in Canadian history. Together with the Ontario and Federal Governments, this "Beacon Project" aims to strengthen automotive engineering, R&D and manufacturing capabilities in Canada. As part of the Beacon Project, an Automotive Centre of Excellence (ACE) will be created at UOIT. Launched with support from GMCL and the Province of Ontario, ACE will link participating automotive companies, suppliers, automotive engineers, universities, colleges, researchers and students in a new building equipped with state-of-the-art automotive design, engineering and research facilities. ACE will anchor a new Canadian Automotive Innovation Network, which will be comprised of selected universities in Ontario, Quebec and British Columbia, led by GM's Canadian Engineering Centre in Oshawa. GM Canada will invest in the Innovation Network to enhance the competitiveness of the Canadian automotive industry through leading edge R&D. This will include investments in new research projects, Design and Research Chairs at Canadian universities and in-kind donations of computer-based design tools by GM and partners. The Centre will be owned and operated by UOIT. It will provide approximately 9,000 (gross) m^2, which translates to approximately 4,500 (net) m^2. It will be located in a new building at UOIT. ACE will comprise two main functional divisions: (i) Core Research Facility (CRF) containing a state-of-the-art climatic wind tunnel and (ii) other equipment designed to respond to automotive manufacturing issues, as well as enable research and involvement of graduate students in industry-based projects. The Integrated Research and Training Facilities (IRTF) will provide educational, lab, research, and project space for use by UOIT faculty, students and colleagues from other institutions. Also, it will serve collaborations with the automotive industry and suppliers, including graduate student research projects. The Centre will be connected to UOIT engineering labs, and it will share university services in the performance of its mandate. ACE will prepare the graduate students to take the automotive industry to a new level of competitiveness and future success. It will stimulate the development of new advanced technologies focused on future-based applications for the automotive industry in Canada. The $58 million grant provided by the Government of Ontario as part of its Ontario Automotive Investment Strategy program supports the ACE project costs for CRF and IRTF. ACE will be provide the following exceptional opportunities for graduate students at UOIT: a multi-faceted centre with world-class experimental facilities to conduct automotive related research; a way to share learning, best practices, pedagogical tools, and curriculum development with the goals of enhancing graduate studies and research opportunities; an opportunity for graduate students to work and learn alongside top professionals in the automotive industry; and a stimulating environment for research collaboration among university and industry-based researchers, ranging from the exploration of 'what if' research ideas and their implications, to the pursuit of new product design, development, and commercialization. It is imperative to note that many automotive areas of research in ACE will be focused in electrical and computer engineering, such as Automotive Software and Electronics, and Automotive Control, Robotics, and Powertrains. To this effect, ACE facilities are expected to be extensively used also by the ECE faculty members and graduate students whose focus of research and applications lie in automotive systems. ACE is expected to be ready in 2009.

Nuclear Engineering Laboratory – Extensive use of equipment, process and systems simulation is made in support of courses and research. The University has access to several codes used in the design of CANDU type nuclear power plants, as well as real-time simulations that demonstrate operational behaviours under both normal and accident conditions for nuclear power plants that use pressurized and boiling light water reactors, and pressurized heavy water reactors. A variety of virtual operator/machine interfaces are used to conduct plant operations by an individual or a team of operators. In addition, This lab conducts research into thermohydraulics modeling, reactor physics modeling, and radiation transport modeling. Equipment planned for the laboratory includes computer racks with a multi-node processing system.

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 at 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.

Additional Facilities — The 3,835 m^2 Ontario Power Generation Engineering Laboratory Building on the UOIT campus was completed in 2006. Graduate students have access to the following shared laboratories: Computer Aided Design (CAD) Laboratory, Mechatronic and Control Systems Laboratory, Electronics Laboratory, Microprocessors/Digital Systems Laboratory, and Power Systems Laboratory. In addition, a hydrogen and energy research laboratory of about 830 m^2 will become available in the fall of 2008, where ECE research in electrical/control systems will be conducted on a Marnoch power system.

3.3 Computer facilities

As mentioned previously, all students will have wireless and wired access to library resources, email, and the internet through UOIT's Mobile Learning Environment. Individual supervisors will provide computer facilities for their PhD students through their research grants.

In the fall of 2006, UOIT joined the PACE Program – Partners for the Advancement of Collaborative Engineering Education. PACE is a program between General Motors, Sun Microsystems, and UGS, that provides state-of-the-art hardware and software for engineering schools. The value of the PACE contribution to UOIT is $35 million. Dedicated engineering computer labs featuring state-of-the-art workstations and software have been established at UOIT through PACE. PhD students will have full access to the PACE hardware and software located in these labs for their studies.

UOIT is a member of the Shared Hierarchical Academic Research Computing Network (SHARCNET). SHARCNET is a High Performance Computing (HPC) institute involving 11 academic institutions in southern Ontario. The purpose of SHARCNET is to provide support for support leading-edge research. Where required, students enrolled in the proposed program will have access to this facility for their research.

3.4 Space

The Faculty of Engineering and Applied Science is located in the new Ontario Power Generation Engineering Laboratory Building. The Faculty of Energy Systems and Nuclear Science is located in UOIT's Engineering and Science Building. The current total research space allocated to Engineering is about 1,500 m^2. An additional 273 m^2 has been allocated for faculty and graduate student offices.

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 Building 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 research space averages ~25 m^2.

Graduate students will have access to shared office facilities and/or research labs. Office space totaling 62 m^2 is currently allocated exclusively to graduate students. There is shared office space available for graduate students who are Teaching Assistants. It is expected that the majority of graduate students will have their office space within the research laboratory of their respective supervisors.

In addition to the ACE facility (as described earlier) and the OPG Engineering building – which already includes offices and large lab spaces for teaching and research - UOIT has plans for an academic expansion on top of the ACE facility. This expansion, anticipated to open in the winter of 2010, will provide an additional 35,000 ft^2 of teaching, research and administrative space for Engineering.

3.5 Financial support of graduate students

Every PhD student offered admission to a graduate program in the Faculty of Engineering and Applied 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 at least $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.
- Teaching Assistantships – PhD students will be eligible to earn up to approximately $8,000 per year, on average, through teaching assistantships.
- Research Assistantships/Awards – Additional support from individual supervisors will be available to students. Faculty members have been successful in receiving research contracts from industry, and some of these contracts are expected to be used to support graduate students.
- Work-Study and Other Forms of Employment-Based Learning will be available.
- Provincial Loan Programs are also available.

4 PROGRAM REGULATIONS AND COURSES

4.1 The intellectual development and the educational experience of the student

As mentioned earlier, there are four objectives common to the graduate programs in engineering:

Depth: To provide students with a detailed 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, or in 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.

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 Engineering and Applied 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.

The mission of the Faculty of Engineering and Applied Science is to contribute to society through excellence in education, scholarship, and service. We will provide for our graduate students a rigorous education and endeavor to instill in them the attitudes, values, and vision that will prepare them for a lifetime of continued learning and leadership in their chosen careers. We engage in scholarship of discovery, application, and integration.

In order for our students and faculty to engage in scholarship of discovery, application, and integration, UOIT is making every effort to provide state-of-the-art learning resources, including the library, learning technologies, and laboratories.

As can be seen in Section 2, a team of highly qualified faculty is contributing to the development of the students and ongoing monitoring of program quality and student progress. In addition, academic support staff and student support services also contribute to the operation of the program and provide service, guidance and support for graduate students.

4.1.3 Curriculum and program requirements

Program learning outcomes

Graduates of the engineering PhD 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 for research.

4. Apply the principles of effective data management, information organization, and information-retrieval skills to data of various types.

5. Utilize analytical, numerical, experimental, interpretive and expository skills in conducting projects and research.

6. Expand and enhance the application of specific and well-concentrated research to engineering problems and practice.

7. Critically evaluate advanced information and knowledge and examine their application in 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. Appreciate the importance of and develop strategies for further education and lifelong learning.

11. Design and conduct experiments and analyze and interpret experimental data and computational results.

12. Demonstrate effective oral and written communication skills.

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 novel research dissertation. The research dissertation must comprise a new contribution, yet significant, to the field of study.

The combination of courses and research will be designed collaboratively between the student and an assigned faculty advisor. Each student will have the opportunity to acquire the prerequisites for specialized practice, or for advanced study, in the fields of communications and signal processing, software systems, control systems, and power and energy systems, including their scientific principles, analysis techniques, and design methodologies. 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 modeled, 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 programs 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; intellectual property; 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 entitled "Tri-Agency Statement of Principles on Key Professional Skills for New Researchers and Professional Skills Development" and "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-centered 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. The Faculty of Engineering and Applied Science invites recognized experts and leading-edge researchers to present seminars and advise on student and faculty research. UOIT's rich network of industry and academic contacts, as exemplified by the ACE project, will provide access to exceptional researchers and professionals.

Scholarly activities

As can be seen in the basic outlines provided in Section 4.3, many courses, as well as the projects and dissertation activities, require students to undertake significant independent work and to organize and provide reports and seminars. This supports students' skill development in such areas as leadership, organization, communication, and professional presentation. 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 engineering graduate programs will be encouraged to attend professional conferences and educational sessions which may take place at UOIT or outside the university. PhD students will be encouraged to attend and participate in conferences and workshops relevant for their specialized area 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 PhD program in the Faculty of Engineering and Applied 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 Engineering and Applied Science as outlined below.

Part-time studies

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

Admission requirements

The minimum admission requirement for the PhD program is completion of a MASc level degree in engineering at a Canadian university or its equivalent, 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.

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:

- The student's mother tongue or first language is English;
- 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;
- The student has achieved the required proficiency on one of the tests in English language acceptable to the University of Ontario Institute of Technology (see below);

Recommended Scores - English Language Proficiency Tests (higher scores may be required) are as follows:

- ◊ TOEFL (computer based) 220
- ◊ TOEFL (paper based) 560
- ◊ IELTS 7
- ◊ MELAB 85
- ◊ CAEL 60

Degree requirements

For the PhD program, a student must complete four courses, with a minimum grade of B-, worth a total of 12 credits and a dissertation worth 40 credits (ENGR 6001: Dissertation). In addition to the four courses and dissertation, the student must successfully complete ENGR 6002G: Workshops and ENGR 6003G: Seminar.

For a student who has transferred directly from a MASc program, after one-full year, into the PhD program, the student must complete nine courses worth a total of 27 credits and a dissertation worth 40 credits (ENGR 6001: Dissertation). In addition to the nine courses, the student must successfully complete ENGR 6002G: Workshops and ENGR 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, measured from the date the student entered the program. No financial support will be available 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.

Supervisory committee

Guidelines regarding supervisory committee are provided in Section 5 & 6 of the Graduate Studies Polices and Procedures, provided as Appendix-B at the end of the Appraisal Brief.

PhD candidacy examinations

Each student in the doctoral program is required to prepare a written research proposal and pass an oral candidacy exam. Full-time students are expected to complete the oral candidacy exam within 18 months of their initial registration in the program. The examination is to determine whether the candidate has the appropriate background knowledge and expertise to undertake a dissertation in the selected field of study.

An Examination Committee will conduct the examination. The goal of the examining committee is to determine that the candidate has sufficient understanding of the background information, rationale, and methodological issues to perform and analyze his/her research topic.

This Committee consists of at least 2 members from the student's Supervisory Committee (the student's Supervisory Committee must be established prior to the oral examination), Graduate Program Director (or delegate) as Chair, where the Chair cannot be a member of the student's Supervisory Committee, and one additional member of the Graduate Faculty who is not a member of the student's supervisory committee. All members of the Committee are voting members. In the case of co-supervision, co-supervisors collectively have one vote. The Examination Committee must be established at least three weeks prior to the exam.

It is the candidate's responsibility to contact members of the Examination Committee to ascertain the breadth of material to be examined (e.g. defined by textbooks, reading list or course work). The candidacy examination comprises a written dissertation proposal which must be distributed to the Examination Committee 3 full weeks prior to the examination date. The purpose is to focus the oral examination on the proposed research of the candidate, and associated background knowledge needed to conduct the proposed research, an oral presentation of the PhD research plan (preferably 20 minutes and not to exceed 30 minutes), open questioning of the candidate by the

Examination Committee to ascertain the capabilities of the candidate to carry out the proposed research. At the end of the oral exam, the chair will ask the candidate and audience to leave the room, after which the Examining Committee will meet in a closed session. The Examining Committee will deliberate and make an evaluation of satisfactory or unsatisfactory. A written report will be prepared by the chair, signed by all Committee members and submitted to the Office of Graduate Studies, with copies to the members of the Examination Committee. The results will be communicated to the student by the chair of the Committee.

A judgment of satisfactory will allow the student to proceed with PhD studies. If the judgment is unsatisfactory, the student will be required to re-take the exam within 4 months. For a second exam, the examination team must contain an additional second member of the Graduate Faculty. A judgment of satisfactory in a second exam will allow the student to proceed with his/her PhD studies. A second unsatisfactory judgment will result in a grade of FAIL and the student will be required to withdraw from the PhD program.

Progress reports

After completing the first year of their program and in each year thereafter, PhD students must complete a progress report that outlines their progress in the previous year and research 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.

Dissertation evaluation procedures

Dissertation 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).

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 that govern distance delivery.

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 study in residence at UOIT.

4.3 Graduate course listing and outlines

Table 4.1 lists the proposed graduate courses to be offered, followed by detailed outlines for the proposed courses. Courses related to the Communications and Signal Processing areas are numbered as ENGR 56xxG. Courses related to the Software Systems areas are numbered as ENGR 57xxG. Courses related to Electronics and Mechatronics areas are numbered as ENGR 58xxG. Courses related to Control Systems as well as Power and Energy Systems areas are numbered as ENGR 59xxG. Courses numbered ENGR 50xxG and ENGR 60xxG are common to all fields. Note that ENGR 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 Programs Director.

Courses will be offered on the basis of demand with the expectation that courses will be offered at a minimum of once every three years. Note that all 5000 level courses are shared with either the MASc program or MEng program in Electrical and Computer Engineering.

4.4 Collateral and supporting departments

As mentioned earlier, in addition to the core faculty members in the Faculty of Engineering and Applied Science (FEAS) with ECE educational backgrounds and research expertise, there are other faculty members at the UOIT who will contribute their expertise and time to teach and co-supervise students, including FEAS faculty members, with Mechanical Engineering expertise in the fields of Control Systems and Energy Systems, Faculty of Energy Systems and Nuclear Engineering faculty members in the fields of Power Systems and Control Systems, and Faculty of Business and Information Technology faculty members, with Information and Communications Technology expertise in the fields of Software Systems and Communications.

Table 4.2 – List of the Proposed Graduate Courses

Course Number	**Course Title**
ENGR 6001G	Dissertation
ENGR 6002G	Workshops
ENGR 6003G	Seminar
ENGR 5004G	Directed Studies
ENGR 5005G	Special Topics
ENGR 5010G	Advanced Optimization
ENGR 5600G	Advanced Matrix Algebra
ENGR 5605G	Convex Optimization
ENGR 5610G	Stochastic Processes
ENGR 5620G	Digital Communications
ENGR 5630G	Statistical Signal Processing
ENGR 5640G	Advanced Wireless Communications
ENGR 5650G	Adaptive Systems and Applications
ENGR 5660G	Communication Networks
ENGR 5670G	Cryptography and Secure Communications
ENGR 5680G	Information Theory
ENGR 5690G	RF and Microwave Engineering for Wireless Systems
ENGR 5710G	Network Computing
ENGR 5720G	Pervasive and Mobile Computing
ENGR 5730G	Algorithms and Data Structures
ENGR 5750G	Software Quality Management
ENGR 5760G	Software Metrics
ENGR 5770G	Service Computing
ENGR 5775G	Knowledge Discovery and Data Mining
ENGR 5780G	Advanced Computer Architecture
ENGR 5850G	Analog Integrated Circuit Design
ENGR 5860G	Digital Integrated Circuit Design
ENGR 5360G	Automotive Software and Electronics
ENGR 5263G	Advanced Control
ENGR 5910G	Embedded Real-Time Control Systems
ENGR 5915G	Discrete-Time Control
ENGR 5920G	Analysis and Control of Nonlinear Systems
ENGR 5930G	Adaptive Control
ENGR 5940G	Intelligent Control Systems
ENGR 5945G	Mobile Robotic Systems
ENGR 5261G	Advanced Mechatronics: MEMS and Nanotechnology
ENGR 5950G	Computational Electromagnetics
ENGR 5960G	Power System Operations, Analysis and Planning
ENGR 5970G	Power Electronics
ENGR 5980G	Advances in Nuclear Power Plant Systems
ENGR 5985G	Advanced Power Plant Technologies
ENGR 5990G	Utility Applications of Static Converters
ENGR 5995G	Grid Integration of Renewable Energy Systems

Course Title: ENGR 6001G – Dissertation

- **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(s):** N/A
- **Student evaluation:** Within 18 months of entry into the PhD program, PhD students must prepare a written research proposal and pass an oral 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).
- **Resources to be purchased by students:** None
- **Textbook requirements:** None
- **Learning outcomes:** Students who successfully complete the PhD dissertation have reliably demonstrated the ability to:

Outcome 1: understand and explain the essential facts, concepts, principles, and theories relating to their research topic

Outcome 2: effectively use advanced tools for research

Outcome 3: apply the principles of effective data management, information organization, and information-retrieval skills to data of various types

Outcome 4: critically evaluate advanced information and knowledge and their implementation

Outcome 5: understand, explain, and solve problems using quantitative and qualitative methods

Outcome 6: design and conduct experiments, analyze and interpret experimental data, and/or computational results

Outcome 7: 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 S. Nokleby, PhD, Faculty of Engineering and Applied Science

- **Identify faculty to teach the course:**

All faculty members

- **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 6002G – Workshops

- **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(s):** A series of workshops of varying lengths on a variety of topics to develop additional competencies in PhD candidates.
- **Student evaluation:** Pass/Fail
- **Resources to be purchased by students:** None
- **Textbook requirements:** None
- **Learning outcomes:** Students who successfully complete the workshops course have reliably demonstrated the ability to:

  Outcome 1: understand project management

  Outcome 2: understand the basics of Intellectual Property (IP) and its management

  Outcome 3: create effective grant proposals

  Outcome 4: 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

  Outcome 5: understand the needs for career management and continued professional development
- **Information about course designer/developer:**

  Course designed by S. Nokleby, PhD, Faculty of Engineering and Applied Science
- **Identify faculty to teach the course:**

  The workshops will be taught by a variety of persons who are experts in the various topic areas
- **Faculty qualifications required to teach/supervise the course:**

  Expertise in the topic area

Course Title: ENGR 6003G – 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 two seminars on their dissertation research, typically within the second and final years of their program.
- **Delivery mode and teaching method(s):** Mandatory attendance in a series of seminars by internal and external speakers.
- **Student evaluation:** Pass/Fail
- **Resources to be purchased by students:** None
- **Textbook requirements:** None
- **Learning outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: comply with the social, professional, and ethical requirements involved in advanced education and research.

Outcome 2: examine and reflect on contemporary issues and professional and ethical responsibilities which impact both engineering and society as whole, and their specific area of interest.

Outcome 3: appreciate the need, and have the knowledge and skills required to further their education through lifelong learning.

Outcome 4: prepare and present a research seminar on a significant topic, to an audience of peers and experts.

Outcome 5: receive and respond to questions, critique and other feedback from peers and experts.

- **Information about course designer/developer:**

Course designed by S. Nokleby, PhD, Faculty of Engineering and Applied Science

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

N/A

- **Faculty qualifications required to teach/supervise the course:**

N/A

Course Title: ENGR 5004G – Directed Studies

- **Course Description and Content Outline:** Faculty permission may be given for supervised research 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 accurately describing the course content, the learning goals, the intended method and extent of supervision, and the method by which work will be evaluated. This course may only be taken once.
- **Delivery mode and teaching method(s):** 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
- **Learning outcomes:** Dependent on the topic

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

- **Identify faculty to teach the course:**
  All faculty members

- **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 5005G – Special Topics
• **Course Description and Content Outline:** Presents material in an emerging field or one not covered in regular offerings. May be taken more than once, provided the subject matter is substantially different. • **Delivery mode and teaching method(s):** 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 • **Learning outcomes:** Dependent on the topic
• **Information about course designer/developer:** Course designed by S. Nokleby, PhD, Faculty of Engineering and Applied Science
• **Identify faculty to teach the course:** All faculty members
• **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 5010G – Advanced Optimization

- **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; semi-definite programming algorithms; sequential quadratic programming and interior-point methods for non-convex 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):** 3 hours of lectures per week.
- **Student evaluation:** assignments: 20%, two major research projects: 80%
- **Resources to be purchased by students:** N/A
- **Suggested Textbook:**

  A. Antoniou and W-S Lu, *Practical Optimization: Algorithms and Engineering Applications*, Springer, 2007, ISBN-13: 978-0387711065
- **Learning outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: formulate and solve unconstrained and constrained optimization problems

  Outcome 2: understand how the major unconstrained, constrained, and global optimization techniques work

  Outcome 3: use optimization as a tool for solving engineering design problems
- **Information about course designer/developer:**

  Course designed by S. Nokleby, PhD, Faculty of Engineering and Applied Science
- **Identify faculty to teach the course:**

  S. Nokleby, 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

Course Title: ENGR 5600G – Advanced Matrix Algebra

Course Description and Content Outline: Review of fundamentals of linear algebra; eigenvalue decomposition and its properties and its applications; singular value decomposition and its properties and applications; the relationship between eigenvalue decomposition and singular value decomposition; Cholesky decompsotion and its application; least squares; QR decomposition; Topelitz matrices and their properties and applications.

- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 10%, mid-term test: 30%, and final exam: 60%.
- **Suggested Textbook:** R. A. Horn and C. R. Johnson*, Matrix Analysis,* Cambridge University Press, 1990, ISBN: 0521386322.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome-1: understand the engineering implications of the fundamentals of linear algebra

Outcome-2: apply different matrix decomposition techniques to solve engineering problems

Outcome-3: analyze the eigen-decomposition, singular value decomposition, and Cholesky decomposition of positive semi-definite matrices

Outcome-4: learn the applications of Matrix Algebra to signal processing, communications, and control

- **Information about Course Designer/Developer:**

Course designed by S. Shahbazpanahi, PhD, Faculty of Engineering and Applied Science

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

S. Shahbazpanahi, M. Dong

- **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

Course Title: ENGR 5605G – Convex Optimization

- **Course Description and Content Outline:** This course concentrates on recognizing and solving convex optimization problems that arise in engineering. The topics covered in this course include basics of convex analysis such as convex sets, convex functions, and convex optimization problems, log-concave and log-convex functions, quasi-convex and quasi-concave functions; convexity with respect to generalized inequality; least-squares, linear and quadratic programs, semi-definite programming; geometric programming; minimax; extremal volume; optimality conditions; Lagrange dual functions and problems; duality theory; theorems of alternative; and applications, algorithms for solving unconstrained and constrained optimization problems; interior-point methods; applications to signal processing, control, digital and analog circuit design, computational geometry, statistics.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 10%, mid-term test: 20%, project: 20%, and final exam: 50%.
- **Suggested Textbook:** S. Boyd and L. Vandenberghe, *Convex Optimization,* Cambridge University Press, 2004, ISBN: 0521833787.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome-1: obtain tools and training to recognize convex optimization problems that arise in engineering

Outcome-2: learn the basic theory of convex optimization

Outcome-3: concentrate on results from the convex optimization theory that are useful in engineering.

Outcome-4: understand thoroughly how convex optimization problems are solved

Outcome-5: distinguish between different optimization problems such as least-squares, linear and quadratic programs, semi-definite programming, minimax optimization

Outcome-6: grasp the meaning of duality theory

Outcome-7: know the theorems of alternatives

Outcome-8: appreciate applications of convex optimization to signal processing, control, digital and analog circuit design, computational geometry, statistics, and mechanical engineering

- **Information about Course Designer/Developer:**

  Course designed by M. El-Khamy, PhD, Faculty of Engineering and Applied Science

- **Identify faculty to teach the course and/or statement “faculty to be hired”:**

  M. El-Khamy, S. Shahbazpanahi, M. Dong

- **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

Course Title: ENGR 5610G – Stochastic Processes

- **Course Description and Content Outline:** Review of probability theory including, random variables, probability distribution and density functions, characteristic functions, convergence of random sequences, and laws of large numbers. Random processes, stationarity and ergodicity, correlation and power spectral density, cross-spectral densities, response of linear systems to stochastic input, innovation and factorization, Fourier and K-L expansion, mean square estimation, Applications in communications and signal processing, emphasis on problem solving using probabilistic approaches.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 10%, mid-term test: 20%, project: 20%, and final exam: 50%.
- **Suggested Textbook:** A. Papoulis and S.U. Pillai, *Probability, Random Variables and Stochastic Processes*, McGraw-Hill, 2003, ISBN: 0-07-366011-6.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:
  Outcome-1: apply the fundamentals of probability theory and random variables
  Outcome-2: understand the meaning and importance of the laws of large numbers
  Outcome-3: distinguish between strict-sense and wide-sense stationary random processes
  Outcome-4: analyze systems with stochastic inputs
  Outcome-5: obtain the correlation functions of practically important stochastic processes and analyze it
  Outcome-6: derive power spectral density for stationary signals
  Outcome-7: expand the stochastic process
  Outcome-8: factorize stochastic processes and whiten them
  Outcome-9: appreciate and benefit from applying their knowledge on stochastic processes to the applications in Communications and Signal Processing

- **Information about Course Designer/Developer:**
  Course designed by S. Shahbazpanahi, PhD, Faculty of Engineering and Applied Science

- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  S. Shahbazpanahi, A. Grami, M. El-Khamy

- **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

Course Title: ENGR 5620G – Digital Communications

- **Course Description and Content Outline:** Optimum receiver principles: AWGN, geometric representation of signals, maximum likelihood criterion and optimum decision regions, correlation receivers and matched filters, probability of error and union bound; digital bandpass modulation (FSK, PSK, QAM), baseband systems; performance comparisons: bit error rate, bandwidth, power, complexity; adaptive equalization techniques and algorithms; carrier and symbol synchronization; fundamental limits in information theory: entropy and the source coding theorem; channel capacity and the channel coding theorem; information capacity theorem and design trade-offs.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, mid-term test: 30%, and final exam: 50%.
- **Suggested Textbook:** J.G. Proakis, *Digital Communications*, McGraw-Hill, 2001, ISBN: 0-07-232111-3.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome-1: understand Gram-Schmidt orthogonalization procedure

Outcome-2: categorize classes of noise and characterize Additive White Noise Gaussian Noise and its impact on performance

Outcome-3: analyze coherent detection of signals in noise

Outcome-4: grasp the fundamentals of optimum receivers

Outcome-5: derive probability of error and assess bit error rate and symbol error rate

Outcome-6: find spectra for various modulation schemes and line codes

Outcome-7: identify trade-offs for coherent and non-coherent detection schemes

Outcome-8: know theoretical aspects design trade-offs for all M-PSK and M-QAM systems in use

Outcome-9: appreciate Shannon's theorems, their limits, roles, benefits, and design trade-offs

Outcome-10: understand complexity and performance of adaptive equalization

- **Information about Course Designer/Developer:**

Course designed by A. Grami, PhD, Faculty of Engineering and Applied Science and Faculty of Business and Information Technology

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

A. Grami, S. Shahbazpanahi, M. Dong

- **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

Course Title: ENGR 5630G – Statistical Signal Processing

- **Course Description and Content Outline:** This course covers two fundamental areas of statistical signal processing: i) detection theory: fundamentals of detection theory, Neyman-Pearson theorem, receiver operating characteristics, minimum probability of error, Bayes risk, binary multiple hypothesis testing, minimum Bayes risk detector, Maximum Likelihood detector, Chernoff bound, detection of deterministic and random signals, and ii) estimation theory: mathematics of estimation theory, Bayesian philosophy and MMSE estimator, minimum variance unbiased estimation, Cramer-Rao lower bund, linear models, general minimum variance unbiased estimation, best linear unbiased estimators, Maximum Likelihood estimation.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** mid-term test: 20%, project: 40%, and final exam: 40%.
- **Suggested Textbooks:** S. Kay, *Fundamentals of Statistical Signal Processing-Vol. I: Estimation Theory,* Prentice Hall, 1993, ISBN: 0133457117; S. Kay, *Fundamentals of Statistical Signal Processing-Vol.II: Detection Theory,* Prentice Hall, 1998, ISBN: 013504135X**;** H.L. Van Trees, *Detection, Estimation, and Modulation Theory, Part I*, John Wiley, 2004, ISBN: 0-471-09517-6.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:
  Outcome-1: apply the fundamentals of detection and estimation
  Outcome-2: characterize the operation of a detector
  Outcome-3: understand the concepts of consistency and bias in estimation
  Outcome-4: decide which criteria to use to estimate or to detect a parameter
  Outcome-5: derive performance bounds for estimation or a detection problem
  Outcome-6: analyze the performance of different estimation or detection techniques by comparing the performance of the estimator or detector with the corresponding bounds
  Outcome-7: appreciate the Maximum Likelihood approach in detection and estimation
  Outcome-8: apply the theory of estimation and detection to communication systems
  Outcome-9: grasp the basic idea of linear estimators
  Outcome-10: apply the theory of estimation to spectral analysis and array processing
- **Information about Course Designer/Developer:**
  Course designed by S. Shahbazpanahi, PhD, Faculty of Engineering and Applied Science
- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  S. Shahbazpanahi, M. Dong, M. El-Khamy
- **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

Course Title: ENGR 5640G – Advanced Wireless Communications

- **Course Description and Content Outline:** This course covers wireless communications systems, technologies, and standards; statistical modeling of wireless channels; capacity of wireless channels; channel equalization; diversity techniques including time, frequency, code, and space diversity; cooperative communications and user cooperation diversity; adaptive modulation; multiple antennas and space-time communications; multicarrier communications; multiuser communication and multiple access schemes; cognitive radio and game theory; ad hoc and wireless sensor networks.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** mid-term test: 20%, project: 40%, and final exam: 40%.
- **Suggested Textbook:** S.G. Glisic, *Advanced Wireless Communications; 4G Cognitive and Cooperative Broadband Technology*, Wiley, 2007, ISBN: 978-0130224729.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:
  Outcome-1: understand and apply the fundamentals of wireless standards communication systems.
  Outcome-2: describe the principles of wireless channel modeling
  Outcome-3: assess diversity techniques (time, space, polarization, frequency, angle, multipath)
  Outcome-4: characterize various fading channels and appreciate various fading models and parameters
  Outcome-5: explain how equalization and synchronization methods are employed in wireless environments
  Outcome-6: analyze Orthogonal Frequency Division Multiplexing and Multi-Carrier CDMA.
  Outcome-7: appreciate the benefits of user cooperation diversity
  Outcome-8: research major issues in mobile ad hoc and sensor networks and provide potential solutions
  Outcome-9: grasp the basics of space-time coding and their benefits and applications
  Outcome-10: learn the basic concept and approaches in cognitive radio

- **Information about Course Designer/Developer:**
  Course designed by S. Shahbazpanahi, PhD, Faculty of Engineering and Applied Science and Faculty of Business and Information Technology

- **Identify faculty to teach the course and/or statement “faculty to be hired”:**
  M. Dong, S. Shahbazpanahi, M. El-Khamy

- **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

Course Title: ENGR 5650G – Adaptive Systems and Applications

- **Course Description and Content Outline:** This course covers algorithms, filter structures, and applications in adaptive systems. Basic information-processing operations and recursive algorithms are discussed. Also, distinct methods for deriving recursive algorithms for the operation of adaptive filters are identified. Lastly, applications of adaptive filters, mainly to digital communication systems, are explored in details.
- **Content Outline by Topic:**
  - Linear filtering problem and their types
  - Recursive algorithms and their parameters
  - Methods for deriving algorithms
  - Applications of adaptive filters to communications
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** mid-term exam: 20%, project: 40%, assignments: 20%, and final exam: 20%.
- **Suggested Textbook:** S. Haykin, *Adaptive Filter Theory*, 2001, ISBN: 0130901261.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: model filtering, smoothing, and prediction problems

Outcome 2: analyze algorithms based on various performance measures, such as rate of convergence, mis-adjustment, robustness, computational requirements, structure, and numerical properties

Outcome 3: understand methods for deriving recursive algorithms, namely Wiener filter theory, Kalman filter theory, and least squares

Outcome 4: assess performance of transversal and lattice structures in adaptive systems

Outcome 5: apply adaptive filters to communications, namely to system identification, adaptive equalization, spectrum estimation, noise and echo cancellation, adaptive beam forming, and carrier and symbol synchronization

Outcome 6: carry out numerical analysis and computer simulations for various adaptive systems and a variety of scenarios

- **Information about Course Designer/Developer:**
  Course designed by A. Grami, PhD, Faculty of Engineering and Applied Science and Faculty of Business and Information Technology
- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  S. Shahbazpanahi, A. Grami
- **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

Course Title: ENGR 5660G – Communication Networks

- **Course Description and Content Outline:** This course provides a detailed technical presentation of important networking concepts and protocols used in modern communication network architecture. Descriptions of the principles associated with each OSI network layer is provided with many examples drawn from the Internet and wireless networks. The TCP/IP protocol stack will be discussed in detail with a variety of examples on its various layers. Particular attention is given to performance analysis of ARQ techniques, access methods (ALOHA and CSMA), and network delay and throughput analysis in WAN and LANs. Network addressing design (including VLSM and CIDR) is discussed in detail, and various routing methods (Distance vector and Link-state) are compared. Advanced networking protocols such as ATM and MPLS are briefly introduced.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 25%, project: 35%, final exam: 40%.
- **Suggested Textbook:** A. Leon-Garcia and I. Widjaja, *Communication Networks*, McGraw-Hill, 2004, ISBN: 0-07-246352-X
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome-1: provide a systematic view of the layered design of modern communication network architecture

Outcome-2: understand how various network services and applications communicate data

Outcome-3: assess circuit switching and packet switching (virtual-circuit and datagram)

Outcome-4: explain essential elements of stack protocols, including full appreciation of MAC, TCP/IP layers

Outcome-5: illustrate how the routing and traffic management in packet networks are done

Outcome-6: compare ARQ techniques in terms of complexity and performance

Outcome-7: analyze various types of wired/wireless LAN access methods, topologies and standards.

Outcome-8: explain basic operations of application layer protocols, such as HTTP, DNS, FTP etc.

Outcome-9: explain basic features of advanced networking protocols, such as ATM and MPLS

Outcome-10: perform basic delay analysis, including Little's formula, M/M/1 queue, Erlang-B and Erlang-C formulas, and identify performance measures

- **Information about Course Designer/Developer:**

Course designed by A. Grami , PhD, and S. Heydari, PhD, Faculty of Engineering and Applied Science and Faculty of Business and Information Technology

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

S. Heydari, X. Lin

- **Faculty qualifications required to teach/supervise the course:**

PhD degree in Electrical Engineering & relevant experience in teaching & research

Faculty members will normally be registered Professional Engineers

Course Title: ENGR 5670G – Cryptography and Secure Communications

- **Course Description and Content Outline:** This course covers diverse topics on cryptography and security including classical encryption, symmetric and public-key cryptography, key management, message authentication, digital signatures, denial-of-service (DoS), distributed DoS, malicious software, and intrusion detection systems.
- **Content Outline by Topic:**
  - Introduction to security and cryptography
  - Classical cryptography and block ciphers and Data Encryption Standard
  - Advanced Encryption Standard
  - Confidentiality using symmetric encryption
  - Public-key cryptography and RSA, and key management
  - Message authentication and hash functions and authentication applications
  - Web security, malicious software & denial-of-service attacks
  - Firewalls & intrusion detection systems
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** mid-term test: 20%, project: 30%, assignments: 25%, and final exam: 25%.
- **Suggested Textbook:** W. Stallings. *Cryptography and Network Security: Principles and Practices, 4th Ed.,* Prentice Hall, 2006. ISBN: 0131873164.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: apply fundamentals of security, and symmetric and public-key cryptography, including block ciphers, RSA, key management, hash functions, detection of and reaction to mal-code attacks, mitigation of denial-of-service attacks, and network disruptions

  Outcome 2: articulate the basic fundamentals of number theory applied to cryptography in order to provide confidentiality, integrity and availability in information systems

  Outcome 3: assess the security of information systems based on the quality of cryptographic algorithms and protocols, authentication systems, firewalls, and intrusion detection systems

  Outcome 4: design secure information systems using symmetric and public-key cryptography applied to Web services and transactions

  Outcome 5: determine the suitability of a security system based on its cryptographic strengths and vulnerabilities, and the value and significance of the protected information

  Outcome 6: evaluate the security of commercial applications by understanding the fundamentals of their underlying cryptographic algorithms

- **Information about Course Designer/Developer:**
  Course designed by M. Vargas Martin, PhD, Faculty of Business and Information Technology
- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  M. Vargas Martin, X. Lin, R. Liscano
- **Faculty qualifications required to teach/supervise the course:**
  PhD degree in engineering/computer science, & relevant experience in teaching & research
  Faculty members will normally be registered Professional Engineers

Course Title: ENGR 5680G – Information Theory

- **Course Description and Content Outline:** This course covers in detail Shannon's mathematical theory of communication, 1948–present; entropy, relative entropy, and mutual information for discrete and continuous random variables; Shannon's source and channel coding theorems; mathematical models for information sources and communication channels, including memoryless, first- order Markov, ergodic, and Gaussian; calculation of capacity-cost and rate-distortion functions; Kolmogorov complexity and universal source codes; side information in source coding and communications; network information theory, including multiuser data compression, multiple access channels, broadcast channels, and multiterminal networks; discussion of philosophical and practical implications of the theory.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 10%, mid-term test: 30%, and final exam: 60%.
- **Suggested Textbook:** T. M. Cover and J. A. Thomas, *Elements of Information Theory*, Wiley, 2006, ISBN: 0471241954.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome-1: apply the fundamentals of Information Theory

Outcome-2: understand the meaning and importance of Entropy

Outcome-3: distinguish between different models for communication channels

Outcome-4: analyze the capacity of different channels

Outcome-5: obtain the rate-distortion functions

Outcome-6: grasp the meaning of Kolmogorov complexity

Outcome-7: Learn the basic principles in network coding

Outcome-8: know about multiuser data compression, multiple access channels, broadcast channels, and multiterminal networks

- **Information about Course Designer/Developer:**

Course designed by M. El-Khamy, PhD, Faculty of Engineering and Applied Science

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

M. El-Khamy

- **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

Course Title: ENGR 5690G – RF & Microwave Engineering for Wireless Systems

- **Course Description and Content Outline:** The course focuses on the analysis and design of RF and microwave circuits for applications in wireless communication systems. Overview of wireless systems, transmitter and receiver system parameters, RF network analysis, modern microwave planar technologies, passive and active RF and microwave circuits used in wireless systems, and major aspects of hardware implementations will be covered. The essentials of computer aided design of RF and microwave circuits are also addressed.
- **Content outline by topic:**
  - Overview of wireless systems
  - Transmitter and receiver system parameters
  - Impedance matching networks
  - Analysis of multiport RF networks
  - Introduction to modern microwave planar technologies
  - Microwave resonators and filters
  - Design of RF low noise amplifiers (LNA's)
  - Design of RF oscillators and mixers
  - Design of RF power amplifiers
  - Computer aided analysis, optimization, and diagnosis of circuits
  - Use of commercial CAD tools for RF circuits
  - Hybrid and monolithic RF circuits
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, projects: 30%, and final exam: 50%.
- **Suggested Textbook:** K. Chang, I. Bahl and V. Nair, *RF and Microwave Circuit and Component Design for Wireless Systems*, John Wiley & Sons, 2002, ISBN: 0471197734; D. Pozar, *Microwave Engineering*, 3rd Edition, John Wiley & Sons, 2004, ISBN-13: 978-0471644514.
- **Learning Outcomes:** Students who successfully complete the course reliably demonstrate the ability to:

  Outcome 1: obtain a thorough understanding of basic concepts and principles of RF and microwave engineering and know how to apply the fundamental concepts towards practical design objectives

  Outcome 2: design passive structures such as transmission lines, dividers, couplers, matching networks and filters

  Outcome 3: design active devices

  Outcome 4: design various RF/microwave building blocks for communication systems

  Outcome 5: know how to effectively use major commercial CAD design tools for RF circuits design and analysis

  Outcome 6: gain a thorough understanding of circuit theory and field theory

- **Information about Course Designer/Developer:**
  Course designed by Y. Wang, PhD, Faculty of Engineering & Applied Science
- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  Y. Wang
- **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 5710G – Network Computing

- **Course Description and Content Outline:** This course teaches how to design and implement loosely coupled distributed systems. It presents hands-on experience as well as theoretical background in network computing models and design principles. Topics in scalability, performance, security, resource specification and discovery, naming and indexing, and resource management for distributed systems will be discussed in the context of network computing paradigms like publish / subscribe, GRID computing, Peer-to-peer (P2P), Message Oriented Middleware (MOM), Reflective middleware, Service Oriented Applications (SOA), and Mobile Agents.
- **Content Outline by Topic:**
  - taxonomies for characterizing network computing systems
  - network computing design principles
  - performance metrics and analysis of Network Computing Systems
  - scalability of network computing systems
  - resource specification and discovery
  - naming and indexing
  - resource management
  - security
  - System architectures: publish / subscribe, GRID computing, Peer-to-peer (P2P), Message Oriented Middleware (MOM), Reflective middleware, Service Oriented Applications (SOA), and Mobile Agents
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 10%, mid-term exam: 15%, final exam: 25%, research project: 30%, class presentation: 10%.
- **Suggested Textbook:** There is no single textbook that adequately covers the topics that are taught in this course. Material will come from the instructor through lecture notes and array of papers.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: Understand network computing models and design principles

  Outcome 2: Understand how to evaluate Network Computing Systems

  Outcome 3: Familiar with the latest network computing architectures
- **Information about Course Designer/Developer:**

  Course designed by R. Liscano, Faculty of Engineering and Applied Science
- **Identify faculty to teach the course and/or statement “faculty to be hired”:**

  R. Liscano, Y. Zhu, X. Lin
- **Faculty qualifications required to teach/supervise the course:**

  PhD degree in software engineering or computer science, and relevant experience in teaching & research

Course Title: ENGR 5720 – Pervasive and Mobile Computing

- **Course Description and Content Outline:** An introduction and comprehensive view into technologies relevant to pervasive and mobile computing. An overview of cellular and personal wireless area networks, service discovery protocols, context-aware computing, and middleware platforms and software to support pervasive and mobile computing.
- **Content outline by topic:**
  - Mobility Management in Wireless Networks
  - Wireless Personal Area Networks (802.11, Bluetooth, 802.15)
  - Service Discovery Models and Protocols (JINI, Bluetooth SDP, SLP, UPnP)
  - Content Adaptation models
  - Context aware computing and contextual modeling
  - Middleware Software for Pervasive Computing: Agent Models, HAVi, OSGI.
  - Middleware Communication Protocols, SIP, and Tuple Spaces
  - Mobile Security and Privacy
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** mid-term test: 20%, project: 30%, assignments: 15%, final exam: 25%, paper review: 10%.
- **Suggested Textbook:** F. Adelstein, S.K.S. Gupta, G.G. Richard III, and L. Schwiebert, *Fundamentals of Mobile and Pervasive Computing*, McGraw-Hill, 2005, ISBN: 0-07-141237-9.
- **Learning Outcomes.** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: understand mobility management in cellular networks

Outcome 2: articulate the basic protocols required for personal wireless area networks

Outcome 3: describe, explain, and model the mechanisms required for service discovery

Outcome 4: model contextual information and understand its use on mobile applications

Outcome 5: understand the basic components required for the design of mobile middleware platforms

Outcome 6: understand how the most recent communication models are used in pervasive and mobile computing

Outcome 7: describe how media content can be adapted based on mobile constraints and contextual information

Outcome 8: understand the fundamental components required to support mobile security and privacy

- **Information about Course Designer/Developer:**

Course designed by R. Liscano, PhD, Faculty of Engineering and Applied Science

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

R. Liscano, K. El-Khatib, X. Lin

- **Faculty qualifications required to teach/supervise the course:**

PhD degree in engineering or computer science. Relevant experience in teaching and research

Faculty members will normally be registered Professional Engineers

Course Title: ENGR 5730G – Algorithms and Data Structures

- **Course Description and Content Outline:** This course presents detailed knowledge of many advanced data structures and algorithm design techniques for the construction of data structures and practical experience with implementation, evaluation, and comparison of complex data structures. It continues where a core undergraduate course on Data Structures and Algorithms left off. The students at the end of the course are able to implement and evaluate advanced data structures, describe and analyze advanced data structures, and compare advanced data structures in different computational models.
- **Content Outline by Topic:**
  Due to the fact that advanced algorithms and data structures can cover a vast set of selected topics the instructor will have some flexibility on the particular topics that will be covered. Possible topics are:
  - Advanced Design and Analysis Techniques like: Dynamic Programming; Greedy Algorithms; Amortized Analysis
  - Advance Data Structures like: B-Trees; Binomial Heaps; Fibonacci Heaps; Data Structures for Disjoint Sets
  - Advanced Graph Algorithms
  - Advanced algorithms in selected topics like: sorting networks; matrix operations; linear programming; number theoretic algorithms; string matching; NP-completeness and approximation algorithms;
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** mid-term exam: 20%, project: 35%, assignments: 15%, and final exam: 30%.
- **Suggested Textbook:** by T. Cormen, C. Leiserson, R. Rivest, and C. Stein, *Introduction to Algorithms, 2nd ed.*, MIT Press, 2006, ISBN: 0-262-03293-7.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: implement and evaluate advanced data structures

  Outcome 2: describe and analyze advanced data structures

  Outcome 3: compare advanced data structures in different computational models

  Outcome 4: knowledge of the application of advanced algorithms as applied to particular special topic areas

- **Information about Course Designer/Developer:**
  Course designed by M. Vargas Martin and R. Liscano, Faculty of Business and Information Technology and Faculty of Engineering and Applied Science
- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  M. Vargas Martin, K. El-Khatib
- **Faculty qualifications required to teach/supervise the course:**
  PhD degree in electrical/software engineering or computer science, and relevant experience in teaching & research

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 focus.
- **Content outline by topic:**
  - 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%, project: 20%, assignments: 30%, and final exam: 40%.
- **Suggested Textbook:** J. Tian, *Software Quality Engineering: Testing, Quality assurance, and Quantifiable,* Wiley-IEEE, 2005, ISBN: 978-0-471-71345-6.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: apply in-depth understanding of the importance of good quality in software
  Outcome 2: explain and use the basic Quality Life Cycle
  Outcome 3: use the 7 basic tools of quality control
  Outcome 4: write a software quality management plan
  Outcome 5: use software quality metrics
  Outcome 6: implement defect reduction programs
  Outcome 7: manage safety-software issues
  Outcome 8: plan for the evolution of software
  Outcome 9: manage software maintenance
  Outcome 10: analysis 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":**
  S. Rahnamayan, J.M. Bennett
- **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 5760G – Software Metrics

- **Course Description and Content Outline:** Analysis of software metrics. Introduction to the techniques of measurement. Syntax and semantics of software metrics. Planning a metrics program. Using metrics for prediction (quality, project time estimations). Case studies.
- **Content outline by topic:**
  - Fundamentals of Measurement and Experimentation.
  - Visualizing Metrics
  - Software Metrics
  - Estimation Metrics
  - Process Control with Software Metrics
  - Project Control with Software Metrics
  - Implementing and Managing a Metrics Program
  - Case Studies
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** mid-term exam: 10%, project: 20%, assignments: 30%, and final exam: 40%.
- Textbook requirements: Software Metrics: A Rigorous and Practical Approach*, 2nd ed.* N.E. Fenton and S.L. Pfleeger, Course Technology; 2nd edition, 1998, ISBN-13: 978-0534954253.
- **Learning Outcomes.** Students who successfully complete the course have reliably demonstrated the ability to

Outcome 1: measure in an engineering way
Outcome 2: use the Goal-Question-Metric paradigm
Outcome 3: capture meaningful metrics
Outcome 4: display the reduced data in a meaningful way
Outcome 5: apply control theory to software metrics
Outcome 6: handle metrics related to product and process, internally and externally
Outcome 7: plan and execute a measurement program
Outcome 8: predict the outcome of software activities using appropriate metrics
Outcome 9: control and predict software project management
Outcome 10: analyze case studies

- **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":**
  S. Rahnamayan, J.M. Bennett
- **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 5770G – Service Computing

- **Course Description and Content Outline:** This course introduces the fundamental concepts and applications of service computing. Service computing, as a new cross discipline, addresses how to enable IT technology to help people perform business processes more efficiently and effectively. One of the fundamental components in service computing is Web service. Web services are Internet-based application components published using standard interface description languages and universally available via uniform communication protocols. Web services let individuals and organizations do business over the Internet using standardized protocols to facilitate application-to-application interaction.
- **Content outline by topic:**
  - eXtensible Markup Language (XML)
  - Document Type Definitions (DTD)
  - XML Style Sheets (XSLT)
  - XML Path Language (XPath)
  - XML Schemas
  - Service Oriented Architecture (SOA)
  - Web Services Modelling
  - Web Services Description Language (WSDL)
  - Simple Access Object Protocol (SOAP)
  - Universal Description, Discovery and Integration (UDDI)
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, mid-term test: 20%, project: 30%, and final exam (30%).
- **Textbook requirements:** T. Erl, *Service-Oriented Architecture: A Field Guide to Integrating XML and Web Services*, Prentice Hall, 2004 ISBN: 0131428985.
- **Learning Outcomes.** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: provide a conceptual overview on contemporary XML and Web Services technologies

Outcome 2: provide hands-on and programming opportunities on selected features of the technologies

Outcome 3: provide basic skills of writing research reports

Outcome 4: provide a basis for undertaking further courses or self-learning in related and/or more specific areas

- **Information about Course Designer/Developer:**
  Course designed by P. Hung, Faculty of Business and IT
- **Identify faculty to teach the course and/or statement “faculty to be hired”:**
  P. Hung, C. McGregor
- **Faculty qualifications required to teach/supervise the course:**
  PhD degree in software engineering or computer science, and relevant experience in teaching & research

Course Title: ENGR 5775G – Knowledge Discovery and Data Mining

- **Course Description and Content Outline:**

  The discovery of new knowledge using various data mining techniques on real world datasets & the current research directions represents the foundation context for this course. This course utilizes latest blended learning techniques to explore topics in foundations of knowledge discovery and data mining, data mining approaches and the application of data mining within such diverse domains as healthcare, business, supply chain and IT security. Current research directions, trends, issues and challenges are also explored.
- **Content Outline by Topic:**
  - Foundations of knowledge discovery and data mining
  - Data Mining Approaches including but not limited to CRISP-DM, C5, k-nearest neighbor, artificial neural networks
  - Applications of knowledge discovery and data mining within such contexts as healthcare, business, supply chain and IT security
  - Research directions in knowledge discovery and/or data mining: multi-agent mining, architectures to support temporal data mining, and service oriented approaches
  - Data collection preparation and quality: trends, issues and challenges
- **Delivery Mode and Teaching Method:** 3 hours per week consisting of 1.5 hour online self paced learning and 1.5 hours seminar/workshop representing a blended learning model
- **Student Evaluation:** Online Collaborative Work Area Contributions: 10%, Data Mining Model – Scenario Detail and Data Preparation: 15%, Data Mining Model – Collaborative Critical Review of Scenario and Data Prep: 10%, Data Mining Model – Modeling and Evaluation: 20%, Data Mining Model – Collaborative Critical Review of Modeling and Evaluation: 10%, Research Trends Review: 20%, Research Presentation: 15%
- **Textbook requirements:** There is no single textbook that adequately covers the topics that are taught in this course, material will come from the professor.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome-1: develop an awareness of latest computing and information technology competencies, methods and architectures within the context of knowledge discovery and data mining

  Outcome-2: understand the use of knowledge discovery and data mining within such diverse domains as business performance measurement, healthcare administration, clinical research, customer and supplier profiling and IT security

  Outcome-3: understand research directions within knowledge discovery and/or data mining

  Outcome-4: translate information known about data mining questions to perform the principle of the data mining process utilizing a range of latest applicable modeling techniques

  Outcome-5: develop an increased awareness of the advantages and disadvantages of the various data mining techniques available within a relevant application context

  Outcome-6: develop an increased awareness of the issues surrounding data collection, preparation and quality of data used in the data mining process

- **Information About Course Designer/Developer:**

  Course designed by C. McGregor, PhD, Faculty of Business & Information Technology and Faculty of Health Science

- **Identify faculty to teach the course and/or statement “faculty to be hired”:**

  C. McGregor

- **Faculty qualifications required to teach/supervise the course:**

  PhD degree in computer science, and relevant experience in teaching & research

Course Title: ENGR 5780G – Advanced Computer Architecture

- **Course Description and Content Outline:** This course covers evolution of computer architecture and factors influencing the design of hardware and software elements of computer systems. Topics include processor micro-architecture and pipelining, performance measures, instruction set design, cache and virtual memory organizations; protection and sharing; I/O architectures, hazards and exceptions, dependencies, branch prediction, instruction-level parallelism, memory hierarchies, cache organization, buses, rotating storage and I/O subsystem design.
- **Content Outline by Topic:**
  - Quantitative principles of computer architecture
  - Instruction set principles and examples
  - Pipelining and instruction-level parallelism
  - Vector and novel processors
  - Memory-hierarchy design
  - Storage systems
  - Interconnection networks
  - Multiprocessors
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, mid-term exam: 20%, project: 20%, and final exam: 40%.
- **Suggested Textbook:** J.L. Hennessy and D.A. Patterson, *Computer Architecture: A Quantitative Approach*, 3rd Edition, Morgan Kaufmann, 2002, ISBN: 1-55860-596-7.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: distinguish between various types of computer architectures

  Outcome 2: apply in-depth understanding of the impact of different architectures on performance

  Outcome 3: derive first-order equivalent electrical circuit for interconnection in the packaging with the help of computer aided design tools

  Outcome 4: analyze different microprocessors and their usability in various architectures

  Outcome 5: suggest ways to enhance performance of microprocessors and related architectures

  Outcome 6: explain various storage systems, interconnection networks, principles of instruction sets

- **Information about Course Designer/Developer:**
  Course designed by A. Grami, PhD, Faculty of Engineering and Applied Science and Faculty of Business and Information Technology

- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  J.M. Bennett and additional faculty to be hired

- **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 5850G – Analog Integrated Circuit Design

- **Course Description and Content Outline:** This course covers modeling of IC devices, current sources and mirrors, gain stages, level shifters, analysis and design of BJT and MOS operational amplifiers, current-feedback amplifiers, wideband amplifiers and comparators. Frequency response of amplifiers, feedback techniques, analysis and design, stability and compensation of amplifiers, high slew-rate topologies, noise in IC circuits, fully differential circuits, analog multipliers and modulators, CAD tools for circuit design and testing.
- **Content Outline by Topic:**
  - Operational amplifiers modeling, applications and topologies
  - CAD simulation tools, IC fabrication technology and device models
  - Gain stages, current sources and active loads
  - Frequency response: single-stage frequency response; multistage frequency response; frequency/time response relationship
  - Feedback: gain sensitivity; effect on distortion; feedback configurations; effect of loading
  - Frequency response and stability of feedback amplifiers
  - Noise in integrated circuits: noise sources; noise models; circuit noise calculations; equivalent input noise generators; noise bandwidth; noise figure and noise temperature.
  - Translinear and current-mode circuits
  - Analog multipliers: Gilbert multiplier; multiplier specifications; multiplier applications
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, mid-term exam: 20%, project: 20%, and final exam: 40%.
- **Suggested Textbook:** P.R. Gray, P.J. Hurst, S.H. Lewis, R.G. Meyer, J., *Analysis and Design of Analog Integrated Circuits*, 4^{th} Ed., Wiley & Sons, 2001, ISBN: 0-471-32168-0.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: analyze and design transistor-based op amp filter and oscillator topologies
Outcome 2: analyze and design multi-device gain stages in bipolar and MOS technologies
Outcome 3: analyze and design bandgap reference circuits
Outcome 4: analyze the frequency response of transistor-based amplifier topologies
Outcome 5: analyze and design feedback circuits & establish stability in feedback amplifiers
Outcome 6: analyze the noise performance of analog circuits
Outcome 7: design an analog circuit of the students choosing to meet desired specifications

- **Information about Course Designer/Developer:**
  Course designed by A. Grami, PhD, Faculty of Engineering and Applied Science and Faculty of Business and Information Technology
- **Identify faculty to teach the course and/or statement "faculty to be hired":**
  Faculty to be hired
- **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 5860G – Digital Integrated Circuit Design

- **Course Description and Content Outline:** This course covers the analysis and design of digital integrated circuits. Students are instructed in methods and the use of computer-aided design tools for the design and testing of large-scale integrated digital circuits.
- **Content Outline by Topic:**
  - o CMOS devices and manufacturing
  - o Integrated circuit inter-connect
  - o CMOS combinational and sequential logic design
  - o CMOS design implementation and timing
  - o Static and dynamic characteristics
  - o DC and transient modeling
  - o CMOS datapath and control subsystems
  - o CMOS memory subsystems
  - o CMOS testing
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, mid-term exam: 20%, project: 20%, and final exam: 40%.
- **Suggested Textbook:** J. M. Rabaey, A.P. Chandrakasan, and B. Nikolic, *Digital Integrated Circuits: Design*, Prentice Hall, 2003., ISBN: 01309009963
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: apply in depth understanding of CMOS inverter, CMOS combinational and CMOS sequential circuits

Outcome 2: study and design the arithmetic building blocks, memory and array structures

Outcome 3: explore and explain about the effect of interconnect on the performance of the circuits

Outcome 4: consider the timing issues in high speed digital circuits and implement methods to overcome the issues

Outcome 5: understand and apply the concepts of design methodologies and VLSI implementations

Outcome 6: use CAD tools to design and verify typical digital circuits

- **Information about Course Designer/Developer:**
  Course designed by A. Grami PhD, Faculty of Engineering and Applied Science and Faculty of Business and Information Technology
- **Identify faculty to teach the course and/or statement “faculty to be hired”:**
  Faculty to be hired
- **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

Course Title: ENGR 5360G – Automotive Software and Electronics

- **Course Description and Content Outline:** Automotive design software tools, including FEA, CFD, Unigraphics and other packages. Software development and integration for design and manufacturing of automobiles. Electrical systems in automobiles, including power supplies, junction transistors, sensors and rectifiers. Signal amplifiers, gain-bandwidth limitations and circuit models. Motor drive control, inverters, actuators, PWM controllers, active filters, signal conditioners, power electronics and regulators. Battery chargers and solar cells. Automotive applications and case studies.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, project: 30%, and final exam: 50%
- **Suggested Textbook:** R. Bosch, *Automotive Electrics and Automotive Electronics*, John Wiley & Sons, New York, 2004, ISBN: 1-86058-436-5.
- **Learning Outcomes.** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: have detailed understanding of electronics with applications to automotive systems, including microelectronics, sensors and control systems

Outcome 2: design automotive electrical systems, including effects of electromagnetic compatibility and interference suppression

Outcome 3: carry out analysis of alternators, batteries, starter motors and lighting systems

Outcome 4: understand sensor technologies for speed, rpm, acceleration, temperature, vibrations and force sensors

Outcome 5: design and operation of automotive software packages

Outcome 6: understand data processing, software and data transfer between automotive electronic systems

Outcome 7: gain detailed knowledge necessary to comprehend journal publications and other archival literature relevant to automotive software and electronics

- **Information about Course Designer/Developer:**

  Course designed by G. F. Naterer, PhD, Faculty of Engineering and Applied Science

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

  Faculty to be hired

- **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 5263G – Advanced Control

- **Course Description and Content Outline:** This course builds upon the knowledge students have gained in a first control course to cover more materials in an advance level. Topics include:

  A) State variables and state space models, relations between the state-space and transfer-function models (controllable and observable canonical forms, and diagonal form), solutions of linear state equations, transition matrix, state feedback and output feedback, design of servo-controlled systems, observer state-variable feedback control, multi-input multi-output (MIMO) systems.

  B) Introduction to nonlinear systems, describing functions for kinds of nonlinear systems (on/off, dry friction, dead zone, saturation, and hystersis), Kochenberger stability criterion, concept of limit cycles, inverse Nyquist loci, phase plane trajectories, isocline method, elapsed time, Lyapunov function, Lyapunov stability criterion.

  C) Sampled-data systems, pulse transfer function, zero and first order hold systems, stability and root locus in the z-plane, bilinear transformations, Routh-Hurwitz stability criterion in the z-plane, system compensation in the z-plane using root locus, and generalized PID controllers.
- **Delivery Mode and Teaching Method(s):** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 15%, mid-term exam: 25%, project: 20%, and final exam: 40%.
- **Resources to be purchased by students:** N/A
- **Suggested Textbook:** K. Ogata, *Modern Control Engineering,* 4th Ed, 2002, Prentice Hall, ISBN-13: 978-0130609076.
- **Learning Outcomes.** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: model and analyze the state space descriptions of dynamical systems

  Outcome 2: apply the concepts of controllability and observability of control systems

  Outcome 3: utilize the state variable feedback control for SISO and MIMO systems

  Outcome 4: analyze nonlinear control systems using the describing functions method

  Outcome 5: apply knowledge about nonlinear control systems, limit cycle, and instabilities

  Outcome 6: analyze and design sampled-data systems with or without a clamp
- **Information About Course Designer/Developer:**
  Course designed by E. Esmailzadeh, Ph.D., Faculty of Engineering and Applied Science
- **Identify faculty to teach the course :**
  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

Note - Students cannot get credits for ENGR 5263 (Advanced Control) course and for both ENGR 5920 (Analysis and Control of Nonlinear Systems) and ENGR 5915 (Discrete-Time Control) courses.

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 hybrid system control and 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.
- **Content outline by topic:**
  - Introduction to hybrid system control
  - Embedded system design process
  - Instruction sets for microprocessor architecture, and 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:** assignments: 15%, mid-term exam: 20%, project: 25%, and final exam: 40%.
- **Suggested Textbook:** W. Wolf, *Computers as Components,* Morgan Kaufmann Publishers, 2003, ISBN: 1-55860-541-X.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: articulate the characteristics of hybrid, embedded and real-time systems in terms of functionality, time constraints, power consumption, cost and development environment

  Outcome 2: become familiar with the design process in real-time applications; use UML modeling language to design real-time applications, and describe architecture features of major embedded processors; understand the difference between the two processors; and use instruction sets of these processors to accomplish simple operations

  Outcome 3: understand and illustrate major challenges in embedded computing system design.

  Outcome 4: 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

  Outcome 5: write simple programs with multi-tasking operating systems.

  Outcome 6: design, build and integrate hardware and software for simple real-time embedded applications

  Outcome 7: 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”:**

  M. Eklund, 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 5915G – Discrete-Time Control Systems

- **Course Description and Content Outline:** Sample-and-hold systems, discretization of analog systems, discrete-time systems analysis and design and effects of sampling on controllability and observability. Pulse transfer function, zero and first order hold systems, stability and root locus in the z-plane, transformations, Routh-Hurwitz stability criterion in the z-plane, pole-placement for discrete time systems, generalized PID controllers.
- **Content outline by topic:**
  - Introduction to Discrete-Time Control Systems.
  - The z Transform.
  - z Plane Analysis of Discrete-Time Systems.
  - Design of Discrete-Time Control Systems by Conventional Methods.
  - State Space Analysis.
  - Pole Placement and Observer Design.
  - Polynomial Equations Approach to Control Systems Design.
  - Quadratic Optimal Control.
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 15%, mid-term exam: 20%, project: 25%, and final exam: 40%.
- **Suggested Textbook:** K. Ogata, *Modern Control Engineering,* 4th Ed, 2002, Prentice Hall, ISBN-13: 978-0130609076.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: apply knowledge of the basic fundamentals of sampled time systems, and z transforms
  Outcome 2: identify discrete time systems
  Outcome 3: understand Input-output analysis and stability
  Outcome 4: understand and apply Lyapunov stability theory
  Outcome 5: linearize a system by state feedback
  Outcome 6: apply basic software tools to the analysis of discrete time systems
- **Information About Course Designer/Developer:**
  Course designed by M. Eklund, Ph.D., Faculty of Engineering and Applied Science
- **Identify faculty to teach the course and/or statement “faculty to be hired”:**
  M. Eklund, 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 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.
- **Content outline by topic:**
  - 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:** assignments: 15%, mid-term exam: 20%, project: 25%, and final exam: 40%.
- **Suggested Textbook:** H.K. Khalil, *Nonlinear Systems – 3rd Edition*. Prentice Hall, 2002, ISBN: 0130673897.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: apply knowledge of the basic fundamentals of nonlinear phenomena: multiple equilibria, limit cycles, complex dynamics, bifurcations

  Outcome 2: identify second order nonlinear systems: phase plane techniques, limit cycles- Poincare-Bendixson theory, index theory

  Outcome 3: understand Input-output analysis and stability: small gain theorem, passivity, describing functions

  Outcome 4: understand and apply Lyapunov stability theory: basic stability and instability theorems, LaSalle's theorem, indirect method of Lyapunov

  Outcome 5: linearize a system by state feedback: input-output and full state linearization, zero dynamics, inversion, tracking, stabilization

  Outcome 6: 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, R. Milman, 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.
- **Content outline by topic:**
  - 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:** assignments: 15%, mid-term exam: 20%, project: 25%, and final exam: 40%.
- **Suggested Textbook:** K. J. Astrom and B. Wittenmark, *Adaptive Control*, 2nd Ed, Addison-Wesley, 1995, ISBN: 0-201-55866-1.
- **Learning Outcomes.** Students who successfully complete the course have reliably demonstrated the ability to

  Outcome 1: utilize the fundamental concepts of adaptive control and learning

  Outcome 2: understand and apply the concepts of convergence, stability, and robustness to analyze control systems

  Outcome 3: estimate parameters and learn models from empirical data

  Outcome 4: understand and analyze the behavior of adaptive control schemes such as model reference, adaptive control and self tuning regulators

  Outcome 5: articulate perturbation and averaging theory

  Outcome 6: use advanced stability theory to analyze adaptation schemes

  Outcome 7: design of gain-scheduling controllers

  Outcome 8: 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 knowledge-based systems; knowledge representation and processing; fundamentals of fuzzy logic systems; basics of fuzzy control; fuzzy control architecture; fundamentals of artificial neural networks; multilayer perceptron; radial basis function networks; Kohonen`s self-organizing network; Hopfield network; evolutionary computing
- **Content outline by topic:**
  - General characteristics of intelligent control systems
  - Fundamentals of fuzzy set theory, and 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:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 15%, mid-term exam: 20%, project: 25%, and final exam: 40%.
- **Suggested Textbook:** C.T.Lin and C.S.G.Lee, *Neural Fuzzy systems - A Neuro-Fuzzy Synergism to Intelligent Systems*, Prentice Hall, 1996, ISBN: 9780132351690.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: understand fundamental concepts of fuzzy logic (FL), neural network (NN) and genetic algorithm (GA)

  Outcome 2: use NN/FL to model the complex static/dynamic systems

  Outcome 3: use NN/FL as a tool to construct the complex nonlinear controller to better control the complex dynamics systems

  Outcome 4: use GA to solve global optimization problem

  Outcome 5. gain hands-on experience on MATLAB toolboxes for NN and FL to solve practical control design problems

  Outcome 6: 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 5945G – Mobile Robotic Systems

- **Course Description and Content Outline:** Kinematics models and motion control for mobile robots. Navigation including path planning, obstacle avoidance and techniques for decomposition. Localization using odometry, map representation, map building, introduction to probabilistic map-based localization; Kalman filter localization and other localization systems. Computer vision including imaging and image representation, feature extraction, pattern recognition, motion from 2D image sequences, image segmentation, sensing and object pose computation, virtual reality
- **Content outline by topic:**
  - Introduction
  - Locomotion and Kinematics
  - Perception
  - Mobile Robot Localization
  - Path Planning and Navigation
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, project: 40%, and final exam: 40%.
- **Suggested Textbook:** R. Siegwart and I.R. Nourbakhsh, *Introduction to Autonomous Mobile Robots,* MIT Press, 2004, ISBN: 0-262-19502-X.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: understand the fundamentals of mobile robot locomotion including wheeled and legged systems

  Outcome 2: understand the kinematics and low-level control of mobile robotic systems

  Outcome 3: become familiar with several methods of robotic perception and sensor data interpretation, particularly with computer vision systems

  Outcome 4: become familiar with various localization schemes including Kalman filter and Markov localization

  Outcome 5: understand the principles and methods of mapping, obstacle avoidance, path planning and navigation

- **Information About Course Designer/Developer:**

  Course designed by J. Ren, M. Eklund, S Nokleby, PhD, Faculty of Engineering and Applied Science

- **Identify faculty to teach the course and/or statement “faculty to be hired”:**

  J. Ren, M. Eklund, S. Nokleby

- **Faculty qualifications required to teach/supervise the course:**

  PhD degree in electrical or mechanical engineering and relevant experience in teaching & research

  Faculty members will normally be registered Professional Engineers

Course Title: ENGR 5261G – Advanced Mechatronics: MEMS and Nanotechnology

- **Course Description and Content Outline:** This course is designed to be an introduction to MEMS (micro-electro-mechanical systems) and nanotechnology and their applications. Topics covered will include: introduction to MEMS and nanotechnology; working principles of MEMS and nanotechnology; design and fabrication of MEMS and nano-systems; microfabrication and micromachining; materials for MEMS and nanotechnology; and applications of MEMS and nanotechnology.
- **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 a final exam worth 50% of the course mark and one research project worth 30% 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.
- **Suggested Textbook: S. D.** Senturia, 2001, *Microsystem Design*, Kluwer Academic Publishers.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: understand the basic principles of how MEMS and nano-systems work.

  Outcome 2: design and analyze MEMS and nano-systems.

  Outcome 3: understand the processes for fabricating MEMS and nano-systems.

  Outcome 4: understand applications of MEMS and nanotechnology.

- **Information about course designer/developer:**

  Course designed by D. Zhang, PhD, Faculty of Engineering and Applied Science and S. Nokleby, PhD, Faculty of Engineering and Applied Science

- **Identify faculty to teach the course:** S. Nokleby, 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.

Course Title: ENGR 5950G – Computational Electromagnetics

- **Course Description and Content Outline:** The course covers the most widely used computer techniques for engineering problems dealing with the electromagnetic field and wave. Finite difference time domain method, method of moments, finite element method and asymptotic techniques will be introduced. Practical applications of these methods to RF/Microwave and millimeter wave circuits, antennas and radiowave propagation in wireless communication systems will be addressed.
- **Content outline by topic:**
  - Fundamental theorems and concepts: uniqueness theorem, principle of equivalence, electromagnetic reciprocity, theory of Green's function, Green's function for static and dynamic problems
  - Two- and three-dimensional integral equation/method-of-moments formulations
  - Variational principle and finite element method
  - Finite difference time domain method
  - Error analysis and the convergence behavior of numerical results
  - Radiation boundary conditions
  - Asymptotic techniques: ray and beam fields, geometrical and physical optics, geometrical theory of diffraction, and radiowave propagation in wireless communication systems
  - Introduction to major commercial software packages and selection of the right tools for RF and microwave circuit design
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 20%, projects: 30%, and final exam: 50%.
- **Suggested Textbook:** A. F. Peterson, S.L. Ray, and R. Mittra, *Computational Methods for Electromagnetics*, Wiley-IEEE Press, 1997, ISBN: 0-7803-1122-1.
- **Learning Outcomes:** Students who successfully complete the course reliably demonstrate the ability to:

Outcome 1: gain a thorough understanding of the most widely used computational methods: the method of moments, finite element procedures, finite difference time domain method, and asymptotic techniques

Outcome 2: make efficient and accurate formulations for electromagnetics applications and their numerical treatment

Outcome 3: implement concepts in software.

Outcome 4: know how to effectively use major commercial electromagnetic computer simulation packages

Outcome 5: understand the impact of meshing, geometrical resolution and convergence on the solution process and know the trade-offs and compromises that must be made to get an efficient solution

Outcome 6: appreciate applications in the aerospace, defense, telecommunications, wireless, electromagnetic compatibility, and electronic packaging industries

- **Information about Course Designer/Developer:**

Course designed by Y. Wang, PhD, Faculty of Engineering & Applied Science

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

Y. Wang

- **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:** Resistance, Inductance and Capacitance of 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.
- **Content Outline by Topics**
  - Resistance, Inductance and Capacitance of transmission lines
  - Representation of power system components in single phase and three phase form
  - 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
  - Transient stability simulation: deriving the swing equation, complex generator models, complex component control models, numerical simulation techniques
  - Symmetrical Components. Symmetric and Asymmetric operation of transmission systems,
  - Power system planning: operations versus planning; planning processes and criteria
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 25%, power flow design project: 25%, and final exam: 50%.
- **Suggested Textbook:** D.P. Kothari and I.J. Nagrath, *Modern Power Systems Analysis*, McGraw Hill, ISBN: 978-0-07-340455-4; S. Chapman, *Electric Machinery and Power System Fundamentals*, McGraw Hill, ISBN-13: 978-0-07-229135-4.
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome 1: 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

  Outcome 2: 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

  Outcome 3: 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

  Outcome 4: plan a transmission corridor using traditional three-phase AC transmission concepts

- **Information about Course Designer/Developer:**

  Course designed by R. Marceau, PhD, and V.K. Sood, PhD, Faculty of Engineering and Applied Science

- **Identify faculty to teach the course:**

  V.K. Sood

- **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

Course Title: ENGR 5970G – Power Electronics

- **Course Description and Content Outline:** This course covers fundamentals of power conversion techniques: single-phase and three phase rectifier and inverter circuits, switch mode converters and power supplies, resonant converters with zero-voltage switching and zero-current switching; multi-level converters, application of converters to adjustable speed motor drives and other industrial applications.
- **Content Outline by Topics**
  - Overview of power electronic switches
  - Computer simulation of converters
  - Single phase converters
  - Three phase converters
  - dc to dc switched mode converters
  - dc to ac switched mode converters
  - Resonant converters
  - Applications to motor drives
  - Industrial applications such as SVC and STATCOMs
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 25%, mid-term test: 25%, and final exam: 50%.

  Suggested Textbook: N. Mohan, T. Undeland and W. P. Robbins, *Power Electronics: Converters, Applications and Design,* 3rd Edition, Wiley, ISBN: 0-471-22693-9
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

  Outcome-1: derive averaged equivalent circuit models of converters operating in steady state

  Outcome-2: present input filter design and the resonant inverter design

  Outcome-3: understand the dynamics of discontinuous conduction mode converters and current-mode control

  Outcome-4: present the basic magnetics theory necessary for informed design of magnetic components in switching power converters

  Outcome-5: model various classes of converters and identify their technical requirements, applications and characteristics

  Outcome-6: appreciate engineering design process and the need for design-oriented analysis

  Outcome-7: develop design techniques for practical applications

- **Information about Course Designer/Developer:**

  Course designed by V.K. Sood, Ph.D., Faculty of Engineering and Applied Science

- **Identify faculty to teach the course:**

  V.K. Sood

- **Faculty qualifications required to teach/supervise the course:**

  Ph.D. degree in Electrical Engineering and relevant experience in teaching and research

  Faculty members will normally be registered Professional Engineers

Course Title: ENGR 5980G – Advances 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. Self-paced interactive CD-ROM and operation of power plant simulators will be used throughout the course.
- **Content Outline by Topics**
  - Introduction to the key design and 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 lectures per week.
- **Student Evaluation:** assignments: 30% and final exam: 70%.
- **Suggested Textbook:** G.T. Bereznai, *Nuclear Power Plant Systems and Operation*
- **Learning Outcomes:** Students who successfully complete the course have reliably demonstrated the ability to:

Outcome 1: specify the desired operating characteristics of a nuclear-electric generating unit to meet electric power system requirements

Outcome 2: 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

Outcome 3: demonstrate, using real time simulators, the normal operation of nuclear-electric power plants using various types of reactors

Outcome 4: explain the responses of various reactor types to malfunction conditions

Outcome 5: identify the conditions under which fast breeder reactors would be cost effective to construct and operate, and define the key reactor design parameters

Outcome 6: explain the improvements in the reliability of reactor safety systems, emphasizing the key characteristics of passive systems

Outcome 7: 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. T. Bereznai, Ph.D., Faculty of Energy Systems and Nuclear Science
- **Identify faculty to teach the course:**
  G.T. Bereznai
- **Faculty qualifications required to teach/supervise the course:**
  Ph.D. degree in Electrical Engineering and relevant experience in teaching and research.
  Faculty members will normally be registered Professional Engineers.

Course Title: ENGR 5985G – Advanced Power Plant Technologies

- **Course Description and Content Outline:** The course covers fundamental principles and concepts and discusses using various sources, e.g., coal, oil, gas, renewable (hydro, wind, solar, etc.) and nuclear for advanced power generation. The advances in power generation systems such as gasification systems, combined cycle power generation, cogenerations are also be considered. The solid oxide fuel cell integrated power generation systems are covered and their role in power generation systems is discussed. A special emphasis is given to nuclear-based power generation. Some energetic, environmental, economic and sustainable aspects of power plants are also covered. Efficiency analyses of the systems and their components are conducted.
- **Content Outline by Topics**
  - Coal, oil, gas, renewable-based power plants
  - Advances in coal, oil and gas based power generation systems
  - Nuclear power plant details and advances
  - Thermodynamic/efficiency analyses for systems and their components
  - Cogeneration, integrated and combined cycle power generation
  - Energetic, environmental, economic and sustainable aspects of power plants
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 10%, test: 20%, project: 30%, and final exam: 40%
- **Suggested Textbook:** N. Khartchenko, *Advanced Energy Systems*, Taylor & Francis, 1997, ISBN: 978-1560326113**;** M.M. El-Wakil, *Power Plant Technology*, McGraw Hill, 1985, ISBN: 0-07-019288-X**.**
- **Learning Outcomes:** Students who successfully complete the course will have demonstrated the ability to:

  Outcome-1: understand the principles and concepts in advanced power generation
  Outcome-2: analyze the systems and their components
  Outcome-3: understand the state-of-the art of nuclear power plants
  Outcome-4: conduct analyses on energy, environmental impact, cost and sustainability aspects of power plants
  Outcome-5: make suggestions for practical process improvements

- **Information about Course Designer/Developer:**
  Course designed by B.V. Reddy, PhD, I. Dincer, PhD, and V.K. Sood, PhD, Faculty of Engineering and Applied Science

- **Identify faculty to teach the course:**
  Team teaching: B.V. Reddy, PhD, I. Dincer, PhD, V.K. Sood, PhD.

- **Faculty qualifications required to teach/supervise the course:**
  Ph.D. degree in Electrical Engineering and relevant experience in teaching and research.
  Faculty members will normally be registered Professional Engineers.

Course Title: ENGR 5990G – Utility Applications of Static Converters

- **Course Description and Content Outline:** This course covers fundamentals of control of active and reactive power flow in the utility grid. The technology of Flexible AC Transmission Systems and High Voltage DC Transmission Systems will be explained. Modeling and simulation of these systems with the aid of digital simulators like EMTP RV will be demonstrated.
- **Content Outline by Topics**
  - Introduction to HVDC Transmission
  - Types of Converters – current source and voltage source converters
  - PLL based synchronization techniques for Power Converters
  - Forced Commutated HVDC Converters
  - Static Var Compensators – Series and Shunt
  - Active Filters
  - STATCOMs and UPFC
  - Other FACTS devices
  - Digital Simulator (EMTP RV) for analyzes will be demonstrated
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 25%, project: 25%, and final exam: 50%.
- **Suggested Textbook:** E.W. Kimbark, *HVDC Transmission,* Wiley, ISBN: 0-471-47580-7; N.G. Hingorani and L. Gyugyi, *Understanding FACTS*, IEEE PRESS, ISBN: 0-7803-3455-8, V.K. Sood, *HVDC and FACTS Controllers - Applications of Static Converters in Power Systems*, 2004, Kluwer Academic Publishers, ISBN: 1-4020-7890-0.
- **Learning Outcomes:** Students who successfully complete the course will have reliably demonstrated the ability to:

  Outcome-1: derive circuit models of converters operating in steady state

  Outcome-2: present design of filters for harmonic compensation

  Outcome-3: understand the dynamics of converters and their controllers

  Outcome-4: understand the development of gate firing and synchronisation techniques

  Outcome-5: model various classes of converters and identify their technical requirements, applications and characteristics

  Outcome-6: develop design techniques for practical applications

  Outcome-7: carry out computer simulation of grid based converter systems

- **Information about Course Designer/Developer:**

  Course designed by V.K. Sood, Ph.D., Faculty of Engineering and Applied Science.

- **Identify faculty to teach the course:**

  V.K. Sood

- **Faculty qualifications required to teach/supervise the course:**

  Ph.D. degree in Electrical Engineering and relevant experience in teaching and research.

  Faculty members will normally be registered Professional Engineers.

Course Title: ENGR 5995G – Grid Integration of Renewable Energy Systems

- **Course Description and Content Outline:** This course covers the integration of energy systems into an electrical grid, involving power generation and transmission. Particular emphasis is given on renewable energy sources such as wind, solar, hydrogen (fuel cells), small-scale hydro, tidal and bio-mass. Integration of these small and distributed energy sources into a grid presents particular problems which will be thoroughly discussed. Benefits of distributed power, competitive markets and the regulatory side of power generation systems will be examined. This course will also cover Integrated Resource Planning (IRP) and Demand-Side Management (DSM) for distributed energy resources.
- **Content Outline by Topics:**
  - Sources of energy - wind energy, solar energy, small scale hydro, hydrogen and fuel cells, tidal energy.
  - Baseload, intermediate and peaking power plants
  - Utility interface – issues and impacts
  - Conversion techniques for interfacing renewable energy sources to the grid
  - Energy conversion supply curves
  - Active/reactive power and harmonics compensation
  - Monitoring and Protection techniques
  - Grid-connected photovoltaic systems
- **Delivery Mode and Teaching Method:** 3 hours of lectures per week.
- **Student Evaluation:** assignments: 25%, mid-term test: 25% and final exam: 50%.

  Suggested Textbook: G. Masters, *Renewable and Efficient Electric Power Systems*, IEEE Press, ISBN: 0-471-28060-7; R. Wengenmayr and T. Buhrke, *Renewable Energy*, Wiley-VCH, ISBN: 978-3-527-40804-7.
- **Learning Outcomes:** Students who successfully complete the course will have reliably demonstrated the ability to:

  Outcome-1: understand the various sources of renewable energy systems

  Outcome-2: understand the utility grid and its dynamical systems

  Outcome-3: comprehend the electrical problems of interfacing the renewable energy source to the electric grid

  Outcome-4: gain understanding of distributed generation with wind, solar, hydrogen (fuel cells) and other renewable energy systems

  Outcome-5: develop planning methodologies for distributed resources, integrated resource planning and demand-side management techniques

- **Information about Course Designer/Developer:**

  Course designed by V.K. Sood, Ph.D., Faculty of Engineering and Applied Science

- **Identify faculty to teach the course:**

  Team teaching: V.K. Sood, G. Naterer, B. Reddy

- **Faculty qualifications required to teach/supervise the course:**

  Ph.D. degree in Electrical Engineering or related energy discipline

  Faculty members will normally be registered Professional Engineers

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 PhD student enrolment (both full-time and part-time students) over the next seven years. As additional faculty members are hired over the next few years, the planned enrolment in the program is expected to increase.

Table 5.1 - Projected Intake and Enrolments

Academic Year	FULL-TIME		PART-TIME		TOTAL ENROLMENT
	Intake	Enrolments	Intake	Enrolments	
2009 - 2010	2 - 4	2 - 4	0	0	2 - 4
2010 - 2011	3 - 5	5 - 9	1	1	6 - 10
2011 - 2012	4 - 6	9 - 15	1	2	11 - 17
2012 - 2013	5 - 7	14 - 21	1	3	17 - 24
2013 - 2014	6 - 8	18 - 25	1	5	23 - 30
2014 - 2015	6 - 8	21 - 28	1	6	37 - 34
2015 - 2016	6 - 8	23 - 30	1	7	30 - 37