Lakehead University

New Program Proposal Brief
for the
PhD
in
Electrical and Computer Engineering

Submitted to the
Office of the Vice-President Academic
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VOLUME I: The Program

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1.1 Overview of the Home Unit

Graduate study in Electrical Engineering has been offered since 1996 with the MSc Eng, Control program; a collaboration of the departments of Mechanical and Chemical Engineering. Since 2008, the Department of Electrical Engineering has offered the MSc Eng, Electrical/Computer. A third Masters degree, the MSc Eng, Environmental is also offered in collaboration between the Departments of Civil, Chemical, and Mechanical Engineering. The Faculty of Engineering is in the process of introducing a fourth new degree, the MSc Eng, Mechanical. The proposed PhD program will be the first doctoral program in Engineering at Lakehead University.

1.2 Objective of the Program

The objective of this PhD program is to train students to conduct independent scientific research in the discipline of Electrical and Computer Engineering and its related sub-disciplines.

The new PhD program is consistent with the priorities identified in Lakehead University's strategic plan for 2010-2013:

- The "Sustainability of the University" objective calls for increasing student enrolment at Lakehead. The creation of this program will make it possible to recruit doctoral students in Engineering and to retain current qualified master students, and open up a whole new pool of potential students for the University.
- The "Comprehensiveness of the Academy" objective requires increasing the depth and breadth of Lakehead University's academic programs. Because the University does not currently have a doctoral-level engineering program, creating such a program will meet that objective.
- The "Research Growth" objective states that Lakehead University should become one of the top research universities in Canada. Having a PhD program is a necessary step towards this objective. It will allow the training of new researchers, improve our faculty's funding success, and increase our institution's research output. To quote the Academic Plan 2012-2017, "Strong graduate programs are fundamental to advanced research and in many disciplines graduate students are essential components of the support structure for teaching and research activities."
- Finally, the "Diversity" objective aims to increase the cultural diversity of the university community. Essentially, a PhD program recruits from the best students

world-wide regardless of country of origin, and thus contributes to a large and diverse student body.

1.3 Rationale for the development of the new program

The creation of this program is closely aligned with the University's 2012-2017 Academic Plan. In particular, the program would help to achieve the following major objectives:

- Recruitment and retention of outstanding faculty
- Recruitment of outstanding undergraduate and graduate students
- Attainment of more research funds from industry and from federal and provincial agencies
- Promotion of Lakehead University's research in the region and beyond
- Synergistic effects on campus through multidisciplinary research
- Strengthening of graduate programs and training of highly qualified personnel
- Producing innovative research with contributions of enduring relevance to the region, Canada and the world.

Due to the distance between Lakehead and other universities in the Province, the existing Masters programs together with the proposed PhD would provide an opportunity for regional students in the region wishing to pursue graduate studies locally.

1.4 Program Demand

There has been a clear demand for PhD-level Highly-Qualified Personnel (HQP) in engineering for over a decade now. In 2002, the Canadian federal government launched its Innovation Strategy, with the goal to raise Canada to the top 5 countries in the world in terms of research and development (R&D) spending per capita[1]. This created a need for 100,000 new science and engineering HQP over the following decade, according to NSERC's estimates. However, according to a Statistics Canada report[2], Canadian universities only graduate 3,000 new PhDs per year. In other words, there was a demand for 70,000 more PhDs than would have graduated over the 2002-

[1] NSERC HQP Workshops final report, Kaufman Thomas and Associates, 2002. [http://www.nserc-crsng.gc.ca/nserc-crsng/Reports-Rapports/HQPWorshopAteliersPHQ_eng.asp]

[2] Where are the Scientists and Engineers, Michael McKenzie, 2007.

2012 period. The same Statistics Canada reports highlighted that there is a "high demand" for PhD HQP both in Canada and internationally. Finally, a tri-agency report[3] in 2010 noted that "the fastest-growing sectors of our economy are those relying on highly-skilled workers and innovation generators". This realization underlies their recommendation to nurture Canadian HQP talent.

There is thus a clear need for these new science and engineering PhD holders. Moreover, according to the aforementioned Statistics Canada report, this demand breaks down almost evenly between the public and private sectors: 57% of PhDs had careers in the public sector against 43% in the private sector. And within the group of science and engineering, the engineering PhD enjoyed the highest employment rates.

The proposed program will help respond to the demand for engineering PhDs highlighted above. Moreover, creating a local pool of highly-qualified R&D engineers will help to develop the high-tech sector in Thunder Bay and North-Western Ontario, a priority for our municipal and provincial governments.

Within Lakehead University, there is evidence that the proposed program is needed. The MSc program in Electrical and Computer Engineering is currently the largest Master's program in the Faculty of Engineering in terms of student enrolment, and in fact accounts for half of the graduate students in the Faculty. Many of these students have expressed an interest in pursuing a PhD (a half-dozen are currently openly considering it); but without the option to do so in Engineering at Lakehead, they either transfer to a science program (Chemistry being a popular option, with two of our Master's students transferring there for their PhD recently) or to another university.

1.5 Degree Nomenclature

This program requires the student to perform highly specialized, independent, original research that makes a distinct contribution of knowledge to the discipline of Electrical and Computer Engineering and culminates in a dissertation. The focus of the research can include, but is not limited to, robotics, control systems, intelligent systems, communication systems, and microelectronics. Graduates will have the degree of "Doctor of Philosophy in Electrical and Computer Engineering". Hereafter, the program will be referred to as the PhD in ECE.

[3] Creating Canada's Future: Investing in Research for Impact Today and Tomorrow, co-sponsored by CIHR, NSERC and SSHRC, 2010. [http://www.nserc-crsng.gc.ca/_doc/Reports-Rapports/Tri-agencyFINA_e.pdf]

2. Program Learner Outcomes

2.1 The Program Objectives and Learner Outcomes are in accordance with the general framework of the University's plans as they reflect the following goals:

The PhD in ECE program is consistent with the core objectives of Lakehead University: to advance knowledge, to train highly-qualified researchers, and to become one of the leading research universities in Canada. Moreover, Lakehead University has adopted the OCAV Graduate Degree Level Expectations in these six broad categories:

E1. Depth and breadth of knowledge

E2. Knowledge of methodologies

E3. Application of knowledge

E4. Communication skills

E5. Awareness of limits of knowledge

E6. Autonomy and professional capacity

The PhD in ECE program has targets in all six categories:

E1. The candidate must perform a thorough and in-depth review of knowledge in the area of specialization related to their research work. This review must show a solid understanding of the foundations and seminal works of the area, as well as provide a technical overview of the latest developments. The candidate must also achieve high marks (as defined in Section 5.4 "Course Requirements") in relevant engineering graduate courses selected by their supervisor.

E2. A successful candidate will be capable of understanding, designing and preparing the methodology to undertake an engineering research project.

E3. By completing a dissertation, the candidate will demonstrate an ability to review the current state of scientific research in an area, develop an original methodology and obtain novel results that make a positive contribution to that area. A dissertation will normally include both theoretical scientific advancements and practical implementation of a prototype to demonstrate the validity of the theoretical conclusions. It is acceptable for a dissertation to have only theoretical or practical results, given the nature of research projects.

E4. Successful PhD candidates will present their work orally during their comprehensive exam, the PhD seminar, and finally during the dissertation defence. On these occasions, the candidate will be evaluated on his/her ability to provide a clear,

complete and scientifically-accurate presentation of the research work, results and conclusions to an audience within the allotted time, as well as answer questions. PhD candidates will be strongly encouraged to participate in scientific conferences by giving oral presentations or poster sessions to present their work. This will give them complementary experience: while the comprehensive, seminar, and defence can last for several hours and are done before an audience with which the candidate is likely familiar, conference presentations are considerably shorter and presented to international experts the candidate has not previously met. In parallel to these oral presentations, a candidate is expected to demonstrate written communication skills by completing a written dissertation as a requirement for the degree. Candidates are also encouraged to get involved in preparing manuscripts for publication based on their research results.

E5. In the background review and in the oral presentations, candidates will study and discuss the extent of knowledge in the area. This will sensitize the student on the limits of knowledge, the steps to follow to increase knowledge, and the potential for new solutions and contributions when performing research.

E6. Developing an original solution to a large research problem will allow the candidate to develop the skills needed to tackle complex problems step by step. The candidate will learn about and come to understand the importance of being systematic and disciplined, of keeping records and of being objective in the evaluation of results. Furthermore, the candidate will address problems and concerns appearing during the development of a research project by building upon knowledge they obtained from published work. The candidate should be able to propose a set of solutions, and to test and evaluate them to determine the best route in solving specific problems.

The learner outcomes outlined in section 2.2 clearly address these six categories.

2.2 A set of program learner outcomes for the proposed program

LO1. Critically appraise the state of knowledge in an area of ECE related to the candidate's research. Compare and contrast the latest works in terms of the hardware implementations and algorithms used and the results obtained. (objectives E1, E2, E5)

LO2. Identify the needs and opportunities for scientific development in an area of ECE based on previous developments and limits identified in the scientific literature. (objective E5)

LO3. Critically read and understand ECE scientific work done in an area not directly related to their research. (objective E1)

LO4. Formulate and execute an engineering research plan. (objectives E2, E3, E6)

LO5. Implement a prototype of an original electrical/computer/software system and evaluate its performance compared to objective benchmarks. (objectives E3, E6)

LO6. Independently resolve problems arising during the execution of the research plan and the implementation and testing of the prototype in a scientifically-rigorous manner. (objective E6)

LO7. Communicate research work, results and conclusions in clear, complete and scientifically-accurate oral and written presentations to audiences of engineering researchers not necessarily versed in that specific area of ECE. (objective E4)

LO8. Through relevant courses selected by the supervisor from a list of graduate ECE courses, gain an in-depth understanding in specific topics of study and demonstrate this understanding by achieving high marks in the courses' evaluations and technical projects. (objective E1)

3. Admission Requirements

3.1 A summary of the admission requirements.

The applicant must hold an MSc degree in ECE or a closely-related area with at least a 70% average. Admission is dependent on the past academic history of the candidate and the assessment of the referees, the availability of space in the program and the availability and willingness of a suitable faculty member to supervise the applicant. A supervisor must be identified before the student is admitted to the program.

Applicants whose native language is not English and who have not studied in an English language school system for more than three full years will be required to present proof of English proficiency in accordance with Faculty of Graduate Studies' admission requirements.

Candidates are accepted under the general University regulations governing the graduate degrees (Appendix E), provided that the requirements of the Faculty of Engineering are also satisfied.

Application Procedure

Application for admission to the proposed program must be sent to the Office of Graduate Studies. Completed applications will be forwarded to the Committee. Admission forms for the students admitted to the proposed program will be returned to the Office of Graduate Studies.

Documents Required for Admission

The following documents are required for admission:

- A completed official Lakehead University application form for admission to Graduate Studies.
- Official transcripts of the applicant's academic record for all previous post-secondary studies to be received directly from the institution concerned.
- A minimum of three confidential letters of recommendation supplied by the applicant's previous professor(s) or direct supervisor(s) who are familiar with his/her work.
- Evidence of proficiency in the English language, as per FGS regulations.

Evaluation of Applications

The Committee will evaluate all completed applications. An admission recommendation will be made by the Committee for each successful applicant and will then be sent to the Office of Graduate Studies for approval. Upon approval of the recommendation, the Office of Graduate Studies will notify all successful applicants of their acceptance. Unsuccessful applicants will also be notified through the Office of Graduate Studies.

3.2 A discussion on the appropriateness of the Program's admission requirements for the learning outcomes established for completion of the program

As a PhD in ECE, it is appropriate to require that applicants hold an MSc in ECE. Applicants holding an MSc in a related area will also be considered for admission, based on the acquisition of a similar skill-set and technical background knowledge. The qualifying average of a minimum 70%, the review of the past academic history of the candidate, and the assessment of the referees are required for the selection of high-quality students. This will guarantee the recruitment of students who have the technical background and experience needed to understand scientific work in ECE and to carry out a thorough, in-depth review of the knowledge in the area of specialization related to their research work, as required by learning objectives LO1, LO2, LO3, and LO8. Indeed, during the conduct of their Master's thesis, students will normally have undertaken an in-depth review of the state-of-the-art of their area of study. The skills they developed in this experience and the technical knowledge they acquired from it will be needed to realize this objective of their PhD.

In order to ensure proper supervision of the candidates and provision of an enriching learning experience, the admission of students will also be dependent on the availability of space in the program and the availability and willingness of a suitable faculty member to directly mentor and supervise the applicant. While the applicant is expected to

conduct autonomous research, the faculty member will review the applicant's work, methodology and results to ensure that they are valid. This will ensure correct realization of LO4, LO5, and LO6.

The requirement of fluency in English is important because much of the program relies on communicating results to the scientific community in the form of oral (the comprehensive exam, seminar, and defence) and written presentations (the dissertation proposal, the dissertation). Additionally, the candidate is encouraged to present his/her work at scientific conferences and to publish it in peer-reviewed journals. This ensures the realization of LO7.

3.3 A sufficient explanation of alternative requirements, if any, for admission into a graduate program, such as minimum grade point average, additional languages or portfolios, along with how the program recognizes prior work or learning experience.

Transfer from Other Canadian Universities

Credit for one graduate level FCE or 2 half-courses may be given to PhD candidates transferring from other universities, in accordance with FGS regulations.

Conversion from MSc to PhD

Students enrolled in an MSc program may apply for transfer into the PhD program provided they have successfully completed their course work and have had their research proposal approved by their Master's thesis committee. The Department will allow the transfer only for students who have obtained exemplary marks in the graduate courses and who have demonstrated a capability for advanced research. The student's MSc supervisor(s) will write a letter to the Graduate Program Coordinator, requesting a transfer. If the request is approved, the Graduate Coordinator will prepare a transfer form and with this, submits the student's file to FGS for final review and approval.

Direct Entry into PhD

In certain exceptional situations and with the agreement of the supervisor(s), the Graduate Coordinator and the Dean of FGS, applicants can gain direct admission to a five-year PhD program on the basis of having a four-year degree from an accredited university. Such "direct entry" PhD applicants will demonstrate evidence of superior academic credentials and outstanding research potential.

4. Structure

4.1 Program Regulations and Requirements

The Calendar entry for the proposed program can be found in Appendix E and an extract of the current Calendar with general University Graduate Studies Regulations is provided in Appendix F. To summarize, graduate students in the program are required to:

R1. Complete the required course work;

R2. Pass a comprehensive examination (ENGI 6701);

R3. Present and attend PhD seminars (ENGI 6710);

R4. Accomplish independent and original research work;

R5. Document their research work in a dissertation followed by an oral defence;

4.2 Explanation for how the program's structure will result in students meeting the specified program learning outcomes and degree level expectations. A discussion of the teaching component (Graduate Assistantship) and what it provides the student.

Requirement R1 is for the student to complete the course work, and the time-to-completion section below shows that this expectation should be achieved in the first year of the program. The course work consists of three courses which are chosen in consultation with the supervisor, in accordance with LO8. Spending one year of the program focusing on these courses will ensure the realization of LO8. These courses will help the student become familiar with advanced topics in ECE and in their particular area of study. They will thus help the student in achieving learning objective LO3. During these courses, students will develop applied skills and learn methodologies that may become useful over the execution of their research work, and thus contribute to achieving LO6. The details of how each course allows the student to achieve these three learner outcomes are presented in Appendix A.

The comprehensive exam (ENGI 6701) (requirement R2), taken at the beginning of the second year of the program, serves a dual purpose of evaluating the student's foundational knowledge related to his/her general area of research, and of being the first major evaluation of the student's research work. It will allow the student to share what they have learned during their background review, and to explain their proposed research methodology to their committee. The Committee will indicate to the applicant whether there exist other papers or areas that would be beneficial to consider and add to their background review, and indicate any concerns or improvements they can make to the methodology. This serves to guarantee the correct realization of LO1, LO2, and LO4, and is a first test of LO7. The comments and feedback from the Committee at this point are crucial to shape and direct the initial steps of the scientific investigation that the candidate is undertaking.

The PhD seminar (ENGI 6710) of requirement R3 serves a double function. The first function is when the student gives a seminar; the student achieves the goal of demonstrating their research progress, in a manner similar to the comprehensive exam but at a later stage in the research. This is a realization of LO7. Moreover, this allows the student to present an update on the research work done since the comprehensive exam. The second function is when the student attends other seminars, in areas of ECE that may be more or less related to their area of research. The student gains a perspective on research done in other areas, the challenges faced, and the similarities and differences with their own area. This serves to achieve LO3.

The majority of the time spent in the program is dedicated to the research work of Requirement R4. This is the period during which the candidate, in consultation with the supervisor, is expected to conduct independent scientific research, thereby achieving LO4, LO5 and LO6. This period ends with the production of a dissertation and its presentation to the committee at an oral defence (requirement R5). This dissertation must contain original research which makes a distinct contribution of knowledge to the chosen discipline, and the candidate is encouraged to demonstrate this by publishing his/her work in a peer-reviewed scientific journal. Requirements R4 and R5 together are meant to verify the successful achievement of LO4, LO5 and LO6. Moreover, requirement R5 is the ultimate test of LO7, in addition to a final verification of LO1, LO2, and LO5.

The following matrix summarizes how the program's structure and requirements relate to the program learner outcomes:

	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8
R1: Courses			x			x		x
R2: Comprehensive exam	x	x		x			x	
R3: PhD seminar			x				x	
R4: Research work				x	x	x		
R5: Dissertation and defence	x	x			x		x	

4.3 Times-to-Completion

The typical full-time student is expected to complete the doctoral program in 4 years (twelve terms). As shown in the following timeline, the first year (three terms) would be spent doing coursework and preparing for the comprehensive exam. The next two years (six terms) would be spent doing research and satisfying the other requirements. The final year (three terms) would be used to write the dissertation and prepare the defence.

Year 1 Fall: Initial registration, course work and background review

Year 1 Winter: Course work, background review, and selection of the committee
Year 1 Spring/Summer: Preliminary research work and thesis proposal redaction
Year 2 Fall: Comprehensive examination and research work
Year 2 Winter: Research work
Year 2 Spring/Summer: Research work and PhD seminar
Year 3 Fall: Research work
Year 3 Winter: Research work
Year 3 Spring/Summer: Research work
Year 4 Fall: Dissertation writing
Year 4 Winter: Dissertation writing and defence
Year 4 Spring/Summer: Corrections to dissertation and final submission

Residency Requirements

Doctoral candidates in this program are expected to be on campus at Lakehead University for the duration of their doctoral program. Exceptions are allowed if:

- The candidate needs to take a course that is offered at another university but not at Lakehead University and that cannot be taken through distance education. (Given the geographic distance between Lakehead University and other Ontario universities, it is accepted that the candidate will not reside at our campus during the semester that course is taking place.)

- The research project requires using equipment or facilities not available at Lakehead University. (The candidate thus needs to work on-site at an off-campus location to do their research.)

5. Program Content

5.1 Curriculum

The areas of specialization in the proposed program are Electrical Engineering, Computer Engineering, Software Engineering, and Mechatronics. The first three are well-established disciplines. The fourth, Mechatronics, is a new but increasingly important area that overlaps the three first disciplines and Mechanical Engineering. Having an engineering doctoral program that encompasses Mechatronics will put Lakehead University at the forefront of Canadian engineering graduate programs.

The expertise of the core faculty members covers these areas of specializations and will allow them to contribute to graduate courses and supervisory committees. Evidence for this is provided in the curriculum vitae of the individual core faculty members (Volume II).

5.2 Program Innovations

Graduate students are required to give at least one presentation at departmental seminars to gather comments on their research work from professors and other students prior to the oral dissertation defence. Graduate students are also required to attend PhD seminars and other academic activities. This increased focus on oral presentations is an innovative way for our students both to become more comfortable with presenting their work and more familiar with work being done in other areas of research.

The inclusion of the multidisciplinary area of Mechatronics Engineering in the program is an innovative aspect as well. At present, only three universities in Canada offer a Mechatronics program (the University of Waterloo, Simon Fraser University, and McMaster University). Lakehead University is well-positioned to offer such a program, as we already have well-developed expertise in all the disciplines comprising it: electrical engineering, software engineering, mechanical engineering, and control engineering. It is thus a natural extension of our program that will put us among the leading engineering schools in Canada.

5.3 Research Requirements

Each student will be assigned a supervisor, (and optionally a co-supervisor) at the point of admission by the Engineering Graduate Studies and Research Committee. Supervision of all graduate students will be provided by their supervisor. Students are required to report their progress to their supervisor on a mutually agreed upon basis.

After completion of the course work and before taking the comprehensive examination, the student, in consultation with his/her supervisor, will form a Supervisory Committee. The composition of this committee will normally remain the same until the completion of the PhD program. It will consist of at least three, and normally no more than six, faculty members as follows:

- The supervisor, along with the co-supervisor if there is one.
- Two faculty members from Lakehead University knowledgeable in the student's research area, no more than one of whom can be external to the ECE PhD program.
- In addition, at a later time but before the doctoral defence, one external member from outside Lakehead University will be added to the committee. This external member should have expertise in the area of research of the thesis and meet all other criteria from the Faculty of Graduate Studies regarding the selection of external reviewers. Selection of the external examiner will be made by the Supervisor, in consultation with the Graduate Coordinator.

The largest part of the doctoral work is the original research conducted under the direction of a supervisor. A PhD should include significant original contributions to a area of research specialization related to Electrical and Computer Engineering. The writing and defence of the dissertation and the development of original research and results are required.

Comprehensive Examination (ENGI 6701):

The comprehensive examination experience serves two main purposes:

- To examine and approve the student's dissertation proposal;
- To verify that the student has a broad knowledge of the general foundations of the chosen area of specialization.

The comprehensive examination should be taken after the completion of course work, 8 to 12 months, and no later than 16 months, after the beginning of the doctoral program. It must be taken on the same semester that the student registers for it. It takes place in front of the Supervisory Committee. The Graduate Coordinator (or designate) is normally the Chair of the Comprehensive Examination and is responsible for arranging it. If the Graduate Coordinator is also part of the committee, another member of the Graduate Faculty will be appointed as Chair. The Comprehensive Examination is open to the public, and all ECE students and faculty members are invited to attend.

To accomplish the first purpose, the student must produce a dissertation proposal submitted to each member of the committee at least one month prior to the examination. This proposal will present the proposed research project, a background review, and all research work done to date. At the beginning of the comprehensive examination, the student will make a 30-minute presentation of the proposal and this will be followed by a question period related to the proposal before the Committee.

To accomplish the second purpose, each member of the student's Supervisory Committee will ask questions related to foundational areas of knowledge relevant to the student's research area. The questions will be asked orally by the members during the examination.

Once all the committee members' questions have been asked and satisfactorily answered by the student, the student and any audience members will be asked to leave the room, so that the committee can deliberate. The deliberations must take into account the dissertation proposal, the proposal presentation and the student's answers to the oral questions in the question periods. Once the Committee makes its decision,

the student will be called back into the room and informed of the result. One of two decisions may be reached:

- The student passes the examination. This decision may be qualified by some notes, for example requesting that the student audits a specific course, conducts a review of a specific scientific area of specialization, or expands the research in a specific manner. The student passing his comprehensive examination earns the privilege to be called “Doctoral Candidate” or “Ph.D. Candidate”.

- The student must be re-examined. This counts neither as a pass nor a fail. This decision must be justified by specific reasons, such as important weaknesses in the proposed research or training of the student, and also include directions to correct these weaknesses in a manner that will be satisfactory to the committee upon re-examination.

- The student fails the examination. Specific reasons justifying this failure must be given. These may include the student showing a severe weakness in a relevant scientific area of specialization, or significant scientific flaws in the proposed research. These reasons must be deemed to severe to be surmountable in order to justify this decision.

If the committee does not unanimously agree on a decision, they may call in the student for another question period. After this new question period is completed, the student is once again asked to leave the room as the committee resumes its deliberations. This may be repeated as many times as needed. If the committee still cannot reach a unanimous decision and no more questions are requested, then a vote is taken on the decision, and if more than one committee member votes for failure the student is considered to have failed, otherwise the student must be re-examined.

A re-examination must be conducted within six months after the first comprehensive examination. A student is only allowed to receive a re-examination decision once during a first attempt at taking the comprehensive examination; upon a re-examination, the Supervisory Committee must choose between the pass or fail decision.

If the student fails the comprehensive examination, the student will be withdrawn from the Doctoral program. Students admitted to a Doctoral program without completion of a Master's program who fail the Comprehensive Examination will be permitted, at the discretion of the academic unit, to change their program to the Master's in Electrical and Computer Engineering.

PhD Seminar (ENGI 6710)

The PhD seminar experience serves two main purposes:

- To examine the candidate's research progress;
- To familiarize the candidate with research done in other areas of Electrical and Computer Engineering.

The Seminar should be taken after the successful completion of the comprehensive exam, 20 to 24 months, and no later than 28 months, after the beginning of the doctoral program. It must be taken in the same semester that the candidate registers for it. It is chaired by the Supervisor; but while it is recommended that the entire Supervisory Committee attend, it is not required. The Seminar is open to the public, and all ECE students and faculty members are invited to attend.

To accomplish the first purpose, the candidate will prepare and make a 30-minute presentation on his/her research work, which will include a comprehensive background of the research area, the objectives of the research project, the latest progress since the comprehensive exam, and the planned work leading to the defence. The presentation will be followed by questions from the audience.

To accomplish the second purpose, the candidate will attend the seminar presentations of other students in the PhD program in Electrical and Computer Engineering. Prior to registering for his/her own seminar, the candidate must have attended at least 6 seminars or acceptable alternatives:

- ECE PhD oral defence, provided it is not by a student whose seminar the candidate has already attended;
- Seminar of an MSc student in ECE;
- Research presentation by a graduate student or a faculty member in another department on a topic deemed relevant to the candidate's research by the candidate's supervisor;
- Research presentation by an ECE faculty member;
- Research presentation by a visiting scholar in ECE.

For each seminar attended, the candidate must produce a form listing the seminar's title, the presenter's name, the date and place of the seminar, and signed by the presenter's supervisor (or by the presenter if it is a faculty member). The candidate must give these signed forms to his/her supervisor at the time of his/her own seminar. It

is the candidate's responsibility to collect these forms and to give them to his/her supervisor.

Doctoral dissertation and oral defence

A Doctoral dissertation must ensure that breadth of knowledge and skills are acquired by doctoral candidates through highly specialized, independent, original research which makes a distinct contribution of knowledge to the discipline. Please refer to the Faculty of Graduate Studies PhD regulations regarding the doctoral dissertation and its examination. Doctoral candidates are also encouraged to demonstrate the originality and contribution of their research by presenting their results at academic conferences. Ideally, the candidate should have at least one paper published or accepted for publication in a peer-reviewed journal by the time of his/her defence.

The candidate's entire supervisory committee, including the external examiner, must be provided copies of the dissertation by the candidate for review and evaluation. Based on their reviews, the Committee will decide among the four possible outcomes:

- Dissertation Accepted. The candidate may now proceed to the oral defence. This decision may be qualified by minor notes, such as the correction of grammatical errors identified by the committee members in the dissertation or the clarification of specific statements in the dissertation. The Supervisor will review and approve corrections before the final dissertation copies are submitted to the Office of Graduate Studies.

- Dissertation Accepted with Minor Revisions. This decision must be justified by a non-trivial workload, such as a significant discussion to be added to the background review, a supplementary set of empirical experiments needed to study the problem, or an important analysis of the results to be conducted. This workload should normally take about a month to complete. These corrections must be reviewed by the supervisor, and optionally by any other committee member who deems it necessary. The student may schedule the oral defence while working on the minor revisions.

- Dissertation Accepted with Major Revisions. This decision means that major work still remains to be done in the research, which will require several months to do. This work should normally be of both a theoretical and applied nature, and must be clearly identified by the committee members. Subsequently, the candidate will have to update the dissertation. The candidate has at most one year to complete the work. Once completed, the candidate may proceed to the oral defence.

- Dissertation Rejected. This decision means that the thesis is insufficient for a doctoral degree. The research is fundamentally flawed and the project is unsalvageable. The candidate may not proceed to the oral defence, and may be expelled from the doctoral program.

The doctoral defence (ENGI 6901) is the final evaluation of a doctoral candidate's work. It must take place at most three years after the comprehensive examination. The candidate's entire supervisory committee, including the external examiner, must attend either in person, via teleconference, or through the proxy of another faculty member to whom that committee member has given clear questions and instructions to evaluate the candidate. The Defence will be chaired by a faculty member who is not a member of the candidate's academic unit or supervisory committee. The Chair ensures time limits are respected and that the examination proceeds smoothly. The Chair will vote only in the case of a tie.

The Oral Defence Order of Events is included with the FGS doctoral regulations.

At the end of the Defence, the candidate and any audience members will be asked to leave the room as the Supervisory Committee deliberates. The Committee will consider both the oral defence and the dissertation when deciding among the four possible outcomes:

- Oral Defence Accepted. The candidate passes the defence. This decision may be qualified by minor notes, such as the clarification of specific statements made by the student. The final dissertation copies are submitted to the Office of Graduate Studies.

- Oral Defence Accepted with Minor Revisions. This decision must be justified by a non-trivial workload, such as a significant discussion to be added to the background review, a supplementary set of empirical experiments needed to study the problem, or an important analysis of the results to be conducted. This workload should normally take about a month to complete, and will require an update of the dissertation. These corrections must be reviewed by the supervisor, and optionally by any other committee member who deems it necessary, before the final dissertation copies are submitted to the Office of Graduate Studies.

- Oral Defence Accepted with Major Revisions. This decision means that major work still remains to be done in the research, which will require several months to do. This work should normally be of both a theoretical and applied nature, and must be clearly identified by the committee members. Subsequently, the

candidate will have to update the dissertation and take the defence again. The candidate has at most one year to complete the work and retake the defence. A candidate might retake the defence multiple times for different reasons; however, a candidate asked to retake the defence twice for the same reasons is considered to have failed the defence.

- Oral Defence Rejected. This decision means that the thesis is insufficient for a doctoral degree. The research is fundamentally flawed and the project is unsalvageable. The candidate who fails the defence may be expelled from the doctoral program.

If the committee cannot reach a unanimous decision, the candidate will be called in for another question period. After this new question period is completed, the candidate and audience are once again asked to leave the room as the committee resumes its deliberations. This may be repeated as many times as needed.

5.4 Course Requirements

A minimum of three half-credit graduate courses beyond the Master's level are normally completed within the first year of registration. To satisfy the program requirements, the three half-credit courses must comply with the following regulations:

1. They must be three half-credit graduate-level ECE courses that have not been taken at the Master's level.

2. No more than one course can be a relevant graduate-level course selected from outside the list of ECE graduate courses.

3. No more than one "Advanced Topics in Electrical and Computer Engineering" (ENGI 5631) course with the student's supervisor will be accepted as a half-credit course.

In addition to the three half-credit courses, students must take the PhD Seminar course (ENGI 6710).

All students will maintain a minimum cumulative average of B in the course work and a minimal final mark of 70% in each individual course.

The list of graduate ECE courses is given below (see Appendix D for details):

ENGI 5131: Microelectronics

ENGI 5132: Digital Communication Systems

ENGI 5231: Computer Architecture

ENGI 5232: Software Construction and Evolution

ENGI 5431: Advanced Power Electronics

ENGI 5432: Semiconductor devices

ENGI 5433: Design of RF ICs

ENGI 5434: Wireless Communication Systems

ENGI 5331: Digital ASIC Design

ENGI 5332: Advanced Computer Engineering

ENGI 5333: Computer Networks

ENGI 5334: Web Engineering

ENGI 5111: Control Engineering Concepts

ENGI 5211: Robust Control

ENGI 5411: Intelligent Control

ENGI 5631: Advanced topics in Electrical and Computer Engineering

ENGI 5732: Nonlinear Control

ENGI 5733: Robotics

ENGI 5734: Natural Language Processing

ENGI 5735: Advances in Semiconductor Materials

ENGI 5736: Nanostructured Materials

ENGI 5273: Mechatronics

CS 5313: Artificial Intelligence

5.5 Reporting Requirements

Students must submit a term report for every term that they are enrolled in the PhD program. The purpose of this reporting is to ensure proper tracking and documenting of the students' progress in-between the milestones of section 5.3 (the Comprehensive Examination, the Seminar, and the Defence), and to detect potential issues as early as possible. To this end, each student must complete a report detailing their progress towards the realisation of the Learners' Outcome of the PhD program. It is the student's

responsibility to complete this report, to have it read and signed by their Supervisor, and to submit it to the Graduate Coordinator after the end of the term. A report template that students can fill in is given in Appendix G.

6. Mode of Delivery

6.1 A description of mode(s) of delivery

This program will combine several modes of delivery:

M1. Course work: students are expected to take three half-credit courses delivered in a face-to-face setting by the instructor, which include an applied component (such as labs, projects, etc.) and an objective evaluation (such as exams, project marks, etc.)

M2. Research work: the program is research-oriented, and students are expected to accomplish independent and original research work. While the details will vary and be at the discretion of the supervisor, this research will normally have both a theoretical and an experimental component.

M3. Dissertation: students are expected to produce a dissertation describing their research work.

M4. Oral presentations: students are expected to pass an oral comprehensive exam and an oral defence. A third oral presentation, the research seminar, is required but not graded.

M5. Peer-reviewed publications: students are encouraged to submit their work for publication in a peer-reviewed journal.

6.2 A discussion on the appropriateness of the proposed mode(s) of delivery to meet the intended program learner outcomes and Degree Level Expectations

The modes of delivery relate directly to the learner outcomes defined previously.

M1. Course work: this will provide students with foundations in the concepts, tools and methods in their area of study. While the details of the mode of course delivery will vary based on what the instructor feels is the best way to convey the material, a normal course is expected to include in-class lectures to present the theoretical material and lab work to gain practical understanding and experience, and occasionally students should be called upon to present some of their work in front of the class. It thus helps achieve learning objective LO1 (to gain a critical understanding of the state-of-the-art in the chosen research area), LO3 (to gain a critical perspective on other research areas in ECE), and LO8 (gain and demonstrate an in-depth understanding in specific topics of study).

M2. Research work: producing independent original research work is central to the PhD program. Students must devise original methodologies, solve the various problems they will encounter, obtain valid results and analyze them objectively. This is a direct realization of LO2 (identify opportunities for scientific development), LO4 (formulate and carry out a research plan), LO5 (implement a prototype) and LO6 (resolve problems arising during research).

M3. Dissertation: Scientific research is not simply conducting experiments, but also properly documenting the methodology and conditions used and the results obtained. The production of a dissertation is the culmination of the student's research work done in M2 and the verification of the realization of the associated learning objectives.

M4. Oral presentations: Learning objective LO7 states that students must develop the ability to communicate their research work, results and conclusions in a clear, complete and scientifically-accurate presentation to an audience of peers that is not necessarily versed in that specific area of knowledge. The three oral presentations in the program, the Comprehensive Exam, PhD Seminar, and Defence, along with the two written presentations of the dissertation proposal before the comprehensive exam and the dissertation before the defence, accomplish this objective.

M5. Peer-reviewed publications: a valid program of research is one that contributes to the advancement of knowledge in their area. After having conducted a thorough background review and rigorous research project, and having presented their results orally and in writing, a successful PhD candidate should be able to publish his/her work in peer-reviewed publications. Doing so achieves learning objective LO7.

7. Assessment of Teaching and Learning

7.1 Student assessment

1. Students are expected to achieve a grade of at least 70% in each of the three half-credit courses they take, and to maintain an overall average of at least B. The mode of assessment of a student in a course will vary based on the nature of the course and what the instructor feels is the best way to evaluate understanding of the specific topics covered, but normally a course would use a combination of individual in-class or take-home exams, and individual or team technical projects with in-class presentations.

2. The comprehensive examination and the dissertation defence are evaluated by the student's Supervisory Committee In both cases, the committee must reach a decision from the outcomes defined in section 5.3.

8. Resources for Graduate Programs

- A description and analysis of the academic unit's planned utilization of existing human, physical and financial resources, and any institutional commitment to supplement those resources to support the program
- Include a plan for how the program will address financial sustainability

8.1 Faculty and Staff

All faculty members are involved in teaching and/or supervision in the Master's Programs in Control Engineering and Electrical and Computer Engineering. These faculty members have indicated their willingness to teach courses and supervise students in the proposed program. All core members are active researchers who have continuous records of peer-reviewed publications. More details on their teaching and research interests can be found in Volume II.

Dr. Samuel Pichardo and Dr. Laura Curiel are adjunct professors with the Department of Electrical Engineering at Lakehead University. They are presently involved in the ECE Master's program. They hold permanent research positions at Thunder Bay Regional Research Institute (TBRRI)

The current staff supporting the department's undergraduate and master's programs will be sufficient to support the PhD program.

TABLE 1. Faculty Members

Name and Rank	M/F	Year Appointed	Home Unit at University	Supervisory Privileges
Category 1 Core Faculty				
Tayebi, A. - Prof.	M	1999	Electrical Eng.	Full
Uddin, M. N. - Prof.	M	2001	Electrical Eng.	Full
Liu, X. P. - Prof.	M	2001	Electrical Eng.	Full
Alexandrov, D. - Prof.	M	1999	Electrical Eng.	Full

Christoffersen, C. - Assoc. Prof.	M	2002	Electrical Eng.	Full
Naser, H.- Assoc. Prof.	M	2004	Software Eng.	Full
Benlamri, R. –Prof.	M	2006	Software Eng.	Full
Yu, N-Y. - Assist. Prof.	M	2008	Electrical Eng.	Full
Manzak, A. -Assist. Prof.	M	2007	Electrical Eng.	Full
Khoury, R. -Assist. Prof.	M	2008	Software Eng.	Full
Category 2 Core Faculty				
Category 3 Core Faculty				
Liu, K. - Prof.	M	1998	Mech. Eng.	Full
Wang, W. – Assoc. Prof.	M	2004	Mech. Eng.	Full
Pichardo, S. –Adjunt Prof.	M	2008	TBRRI	Full
Curiel, L. – Adjunct Prof.	F	2008	TBRRI	Full
Non-Core Faculty				
Atoofian, E. -Assist. Prof.	M	2008	Electrical Eng.	Full

8.2 Research Funding

Operational research funding awarded to core faculty members over the past seven years amounted to $3,308,030, as detailed in Table 2a.

TABLE 2a. Operational Research Funding by Source and Year

Year[1]	Source				
	Federal	**Other**	**Foundations**	**Industry &**	**Others[4]**

	Granting Councils[2]	Government Grants[3]		Contracts	
2004-05	136,255	35,000			21,000
2005-06	174,755	30,000			13,468
2006-07	205,350	220,770			12,000
2007-08	247,700	61,620		36,120	22,200
2008-09	298,700	71,620		36,120	12,200
2009-10	351,700	90,120	29,000	36,000	22,215
2010-11	373,152	172,816	58,500	527,619	12,030
Totals	1,787,612	681,946	87,500	635,859	115,113

[1] Academic years.

[2] Includes: Examples: NSERC Discovery, Strategic & CRD; Canada Research Chair; NIH.

[3] Includes: Examples: CFI; PRE; OCE; OIT; NCE; FedNor; Industry Canada; AFMNet.

[4] Includes: Examples: University grants

Some of this research funding is guaranteed to be renewed. The funding that has been secured by faculty members over the next four years amounts to $908,822.65, as detailed in Table 2b.

TABLE 2b. Secured Operational Research Funding by Year

Year[1]	Value[2]
2011-12	$368,014.46
2012-13	$308,808.19

2013-14	$155,000.00
2014-15	$77,000.00
Totals	$908,822.65

[1] Academic years.
[2] Includes all sources.

Funding awarded for research instrumentation to core faculty over the past seven years amounted to $670,683, as detailed in Table 2c.

TABLE 2c. Research Instrumentation Funding by Source and Year

	Source				
Year[1]	**Federal Granting Councils[2]**	**Other Government Grants**	**Foundations**	**Industry & Contracts**	**Others**
2004-05					
2005-06					
2006-07	361,745				
2007-08	22,444				9,494
2008-09			12,000		265,000
2009-10					
2010-11					
Totals:	384,189		12,000		274,494

[1] Academic years.
[2] Includes: Examples are: NSERC-RTI.

8.3 Teaching Assignments

These tables detail the teaching assignments of faculty members in this program over the past three years. All Engineering courses are normally composed of both in-class lectures and applied labs.

TABLE 3a. Teaching Assignments for 2008/09.

Faculty Member	Rank	Teaching Assignments for 2008/09[1]		
		Undergraduate	**Graduate**	**Comments**
Category 1				
Alexandrov, D.	Prof.	Engi-0531 Engi-3430		Sabbatical leave (Fall term)
Christoffersen, C.	Assoc. Prof.	Engi-4557 Engi-4136 Engi-0150 Engi-0531	Engi-5611	Engi-5611: reading course in Control Engineering MSc
Yu, N-Y.	Assist. Prof.	Engi-2133 Engi-1637 Engi-0531 Engi-2439	Engi-5611	Engi-5611: reading course in Control Engineering MSc
Manzak, A.	Assist. Prof.	Engi-2151 Engi-2438 Engi-1232	Engi-5611	Engi-5611: reading course in Control Engineering MSc
Tayebi, A.	Prof.	Engi-3334	Engi-5111	Sabbatical leave (winter term)
Uddin, M. N.	Prof.	Engi-2258 Engi-1236 Engi-4632 Engi-0554 Engi-2430	Engi-5611	Engi-5611: reading course in Control Engineering MSc
Liu, X. P.	Prof.	Engi-4258	Engi-5211	Sabbatical leave (winter term)
Khoury, R.	Assist. Prof.	Engi-3655 Engi-3675 Engi-3558		
Naser, H.	Assoc. Prof.	Engi-3050 Engi-3670 Engi-4053 Engi-3051 Engi-2453		

Faculty Member	Rank	Teaching Assignments for 2008/09[1]		
		Undergraduate	Graduate	Comments
Benlamri, R.	Prof.	Engi-0655 Engi-2254 Engi-3255 Engi-3350	Engi-5611	Engi-5611: reading course in Control Engineering MSc
Category 2				
Category 3				
Liu, K.	Prof.	Engi-0579 Engi-4436 Engi-3451 Engi-4438	Engi-5611	Engi-5611: reading course in Control Engineering MSc
Wang, W.	Assoc. Prof.	Engi-1233 Engi-4032 Engi-0659 Engi-2333		
Pichardo, S.	Adjunt Prof.			
Curiel, L.	Adjunt Prof.			
Non-Core				
Atoofian, E.	Assist. Prof.	Engi-0531 Engi-0531	Engi-5611 Engi-5332	Engi-5611: reading course in Control Engineering MSc

TABLE 3b. Teaching Assignments for 2009/10.

Faculty Member	Rank	Teaching Assignments for 2009/10[1]		
		Undergraduate	Graduate	Comments
Category 1				

Faculty Member	Rank	Teaching Assignments for 2009/10[1]		
		Undergraduate	Graduate	Comments
Alexandrov, D.	Prof.	Engi-4053 Engi-4054 Engi-0531 Engi-3430		
Christoffersen, C.	Assoc. Prof.	Engi-3670 Engi-4136 Engi-2453 Engi-0150		
Yu, N-Y.	Assist. Prof.	Engi-2133 Engi-1637 Engi-2439	Engi-5132	
Manzak, A.	Assist. Prof.	Engi-2151 Engi-2438 Engi-1232	Engi-5331	
Tayebi, A.	Prof.	Engi-3334 Engi-0138 Engi-1552/3016	Engi-5111	
Uddin, M. N.	Prof.	Engi-2258 Engi-1236 Engi-4632 Engi-0554	Engi-5431	
Liu, X. P.	Prof.	Engi-4258 Engi-2430 Engi-0573	Engi-5211	
Khoury, R.	Assist. Prof.	Engi-3558 Engi-4559 Engi-3655 Engi-3675	Engi-5631	
Naser, H.	Assoc. Prof.	Engi-3050 Engi-3670 Engi-3051 Engi-2453		
Benlamri, R.	Prof.	Engi-0655 Engi-2254/Busi-3293 Engi-3255 Engi-3350	Engi-5232	
Category 2				

Faculty Member	Rank	Teaching Assignments for 2009/10[1]		
		Undergraduate	Graduate	Comments
Category 3				
Liu, K.	Prof.	Engi-0579 Engi-4436		Sabbatical leave (winter term)
Wang, W.	Assoc. Prof.	Engi-1233 Engi-4032 Engi-3451 Engi-2333		
Pichardo, S.	Adjunt Prof.			
Curiel, L.	Adjunt Prof.		ENGI-5631	
Non-Core				
Atoofian, E.	Assist. Prof.	Engi-1252, 2-3CR Engi-0531WC, 3-1.5CR Engi-1536, 3-1.5CR	Engi-5231, 3-1.5CR	

TABLE 3c. Teaching Assignments for 2010/11.

Faculty Member	Rank	Teaching Assignments for 2010/11[1]		
		Undergraduate	Graduate	Comments
Category 1				
Alexandrov, D.	Prof.	Engi4054 Engi4053 Engi3430 Engi0531		
Christoffersen, C.	Assoc. Prof.	Engi-4136 Engi-3670 Engi-0150 Engi-2453		

Faculty Member	Rank	Teaching Assignments for 2010/11[1]		
		Undergraduate	Graduate	Comments
Yu, N-Y.	Assist. Prof.	Engi-1637 Engi-2133 Engi-2439 Engi-0578		
Manzak, A.	Assist. Prof.	Engi-2438 Engi-2151 Engi-1232 Engi-0531	Engi-5631	
Tayebi, A.	Prof.	Engi-3334 Engi-0138	Engi-5111 Engi-5611	Engi-5611: reading course in Control Engineering MSc
Uddin, M. N.	Prof.	Engi-1236 Engi-2258 Engi-4632	Engi-5431	
Liu, X. P.	Prof.	Engi-4258 Engi-2258 Engi-2430	Engi-5211	
Khoury, R.	Assist. Prof.	Engi-3558 Engi-4559 Engi-3655 Engi-3051	Engi-5631	
Naser, H.	Assoc. Prof.	Engi-3050	Engi-5333	Sabbatical leave (winter term)
Benlamri, R.	Prof.	Engi-2254/Busi-3293 Engi-0655 Engi-0655 Engi-3255	Engi-5232 Engi-5334	
Category 2				
Category 3				
Liu, K.	Prof.	Engi-0579 Engi-4436 Engi-0574 Engi-3451	Engi-5901 Engi-5611	Engi-5611: reading course in Control Engineering MSc
Wang, W.	Assoc. Prof.	Engi-2434 Engi-2333		Sabbatical leave (fall term)

Faculty Member	Rank	Teaching Assignments for 2010/11[1]		
		Undergraduate	Graduate	Comments
Pichardo, S.	Adjunt Prof.		Engi-5631	
Curiel, L.	Adjunt Prof.		Engi-5631	
Non-Core				
Atoofian, E.	Assist. Prof.	Engi-1252 Engi-0531 Engi-1536	Engi-5611	Engi-5611: reading course in Control Engineering MSc

9. Financial Support for Graduate Students

9.1 Scholarships

Graduate students in the proposed program may compete for external scholarships such as the Ontario Graduate Scholarships (OGS), NSERC Graduate Scholarships, etc.

9.2 Assistantships

Currently Lakehead University provides Graduate Assistantships (GAs) for full-time graduate students (including a limited number of international students) at a rate of $9,751 per year for the 2011-2012 academic year. The GAs are available during the Fall and Winter terms. The normal duties of a regular teaching assistant appointment are marking and consulting with students with no more than 10 hours of work per week over the Fall and Winter terms. All graduate students who receive a GA are part of CUPE.

Additional assistantships will be offered to qualified graduate students by their graduate supervisors from their research grants. It is the intent of the program, whenever possible, to give top students a support package valued at approximately $20,000.

Lakehead University also provides Graduate Scholarships, Awards, and Bursaries to qualified graduate students. Various designated donor-funded awards are available to graduate students in the Faculty of Engineering.

10. Physical & Financial Resources

10.1 Library Resources

The library's existing resources are adequate to support the proposed program. A summary statement by the Chief Librarian of the University is provided in Appendix B.

10.2 Classroom, Laboratory and Research Equipment and Facilities

At the onset, the laboratories and research equipment already in use for the MSc program in Electrical and Computer Engineering are sufficient to also support the proposed program. A summary of the main research equipment and common facilities available to the proposed program is given in Appendix C.

10.3 Computer Facilities and Information Technology Support

Networked computer facilities will be available to the students of the proposed program. There are several general computer labs and classrooms, which are maintained by the Technology Services Centre. A summary statement by the Supervisor of Client Services of the Technology Services Centre of the University is provided in Appendix D.

All faculty members in the proposed program have Internet access in their offices. All students in the proposed program will be provided with computer access by their supervisors.

10.4 Office Space for Faculty and Graduate Students

Adequate space is made available for all graduate students. For those students who have a Graduate Assistantship, the space requirement is mandated by the Collective Agreement for CUPE 3905, the union to which all Graduate Assistantships belong.

All faculty members have private offices with telephones and Internet connections. The average office space per person is approximately 13 m^2.

Table 4 - Space Allocations of Program Faculty and Students at Lakehead University.

Faculty Member	Home Unit	Building – Room		
		Office	Lab	Student Desks (max. capacity)
Category 1 Core Faculty				
Alexandrov, D.	Elec. Eng.	AT5007	CB1040	3 students
Christoffersen, C.	Elec. Eng.	AT5017		
Yu, N-Y.	Elec. Eng.	AT5004		
Manzak, A.	Elec. Eng.	AT5010		
Tayebi, A.	Elec. Eng.	AT5005	AT4016	3 students
Uddin, M. N.	Elec. Eng.	AT5011	CB1030A	
Liu, X. P.	Elec. Eng.	AT5009	CB3034 CB3035	15 students 3 students
Khoury, R.	Soft. Eng.	AT5018		
Naser, H.	Soft. Eng.	AT5012	RL1012	6 students
Benlamri, R.	Soft. Eng.	AT5001		
Category 3 Core Faculty				
Liu, K.	Mech. Eng.	CB4114	CB1134	3 students
Wang, W.	Mech. Eng.	CB4057		4 students

Pichardo, S.	TBRRI	TBRII	TBRII	6 students
Curiel, L.	TBRRI	TBRII	TBRII	3 students
Non-Core				
Atoofian, E.	Elec. Eng.	AT5014		
Totals:		***15 offices***	***8 labs***	***48 students***

11. Quality and Other Indicators

11.1 Definition and use of indicators that provide evidence of quality of the faculty

The following table details the publications produced by the faculty members in the program, as well as the completed student supervisions.

Table 5 – Publication and Supervision by Faculty Members.

Faculty Member	Published Journal papers (refereed)	Published Conference papers (refereed)	Published Book chapters	Other	Completed ECE Masters Students	Completed ECE Ph.D. Students	Completed ECE Post-Doctoral Fellows
Category 1 Core Faculty							
Alexandrov, D.	14	26	0	0	9	0	0
Christoffersen, C.	2	13	2	0	10	0	0
Yu, N-Y.	9	19	0	0	3	0	0
Manzak, A.	5	9	0	0	5	1	1
Tayebi, A.	26	44	1	0	2	11	2
Uddin, M. N.	24	60	2	1 book	8	0	1

Liu, X. P.	109	54	0	0	17	5	3
Khoury, R.	6	14	0	0	1	0	0
Naser, H.	5	19	2	2 patents	6	0	0
Benlamri, R.	15	36	3		10	0	1
Category 3 Core Faculty							
Liu, K.	38	22	1	0	9	0	0
Wang, W.	39	24	2	3 patents 4 industrial products	10	3	3
Pichardo, S.	7	12	0	0	0	0	0
Curiel, L.	23	29	0	0	3	0	0
Non-Core							
Atoofian, E.	5	15	0	0	0	0	0

11.2 Evidence of a program structure and faculty research that will ensure the intellectual quality of the student experience

Section 5 presented the Doctoral program requirements. They fell into two broad categories, research requirements (section 5.3) and course requirements (section 5.4). Our faculty can ensure a student experience of the highest quality for both requirements.

The Table in section 11.1 demonstrates that our faculty members are active in engineering research and in ECE graduate student supervision, including doctoral-level supervision through cross-appointments in other universities. The areas in which they work cover a diverse range of ECE topics, as will be demonstrated below. This variety will ensure that students in the program are exposed to the latest developments in a large range of state-of-the-art engineering topics.

The engineering research areas in which our faculty members have expertise are mirrored in the list of graduate courses presented in Section 5.4. A mapping of topic/course to faculty member is presented in the Table below. The wide range of research topics covered and the overlap in expertise among the various faculty members demonstrates our Department's ability to offer a rich and varied learning experience to students.

Table 6 – Faculty Members in the Program with Expertise in Each Course Topic.

Topic	Course	Expert faculty member(s)
Microelectronics	ENGI 5131	Carlos Christoffersen, Ali Manzak
Digital Communication Systems	ENGI 5132	Nam Yu, Hassan Naser, Carlos Christoffersen
Computer Architecture	ENGI 5231	Ehsan Atoofian, Samuel Pichardo
Software Construction and Evolution	ENGI 5232	Samuel Pichardo, Rachid Benlamri
Advanced Power Electronics	ENGI 5431	Mohammad Uddin
Semiconductor devices	ENGI 5432	Carlos Christoffersen, Dimiter Alexandrov
Design of RF ICs	ENGI 5433	Carlos Christoffersen
Wireless Communication Systems	ENGI 5434	Nam Yu, Hassan Naser, Carlos Christoffersen
Digital ASIC Design	ENGI 5331	Ali Manzak
Advanced Computer Engineering	ENGI 5332	Ehsan Atoofian, Samuel Pichardo
Computer Networks	ENGI 5333	Hassan Naser, Carlos Christoffersen
Web Engineering	ENGI 5334	Rachid Benlamri
Control Engineering Concepts	ENGI 5111	Xiaoping Liu, Kefu Liu, Abdelhamid Tayebi
Robust Control	ENGI 5211	Xiaoping Liu, Abdelhamid Tayebi
Intelligent Control	ENGI 5411	Mohammad Uddin, Xiaoping Liu, Abdelhamid Tayebi
Nonlinear Control	ENGI 5732	Xiaoping Liu, Abdelhamid Tayebi
Robotics	ENGI 5733	Xiaoping Liu, Kefu Liu, Abdelhamid Tayebi
Natural Language Processing	ENGI 5734	Richard Khoury
Advances in Semiconductor Materials	ENGI 5735	Dimiter Alexandrov
Nanostructured Materials	ENGI 5736	Dimiter Alexandrov

Finally, we note the cross-disciplinary nature of our proposed program. Four faculty members in the program are external to the area of Electrical, Computer and Software Engineering. They are Dr. K. Liu (Mechanical Engineering), Dr. W. Wang (Mechanical Engineering), Dr. S. Pichardo (TBRRI) and Dr. L. Curiel (TBRRI). This makes it possible to lead cutting-edge research projects in several areas not covered by traditional ECE programs, including notably Mechatronics Engineering and Medical Technology R&D.

12. Budget

1. Tuition (2012-13 values) for domestic students is set at $2,508 per term for the first three terms of a program and $2,277 for any subsequent terms. Tuition for international students is currently $4,950 per term or $14,850 per year (2012-13). Tuition revenue estimates in the table are based on the normal time-to-completion path of 12 terms described in Section 4.3.

2. For the BIU computation, we assume that PhD students have previously completed a 2-year MSc and received BIU for that program. Consequently, they will only be eligible to receive BIU for 3 years of their PhD program.

3. Currently Lakehead University provides Graduate Assistantships (GAs) for full-time domestic graduate students at a rate of $9,751 per year for the 2011-2012 year. This support can also be offered to a limited number of international students. In calculating expenses of GAs assigned by the Faculty of Graduate Studies, it is assumed that all of the domestic students are to be assigned GAs, which is the current practice, but that none of the international students will receive GAs.

4. Graduate students may also be offered additional assistantship by their graduate supervisors from research grants, and various donor-funded awards are available. These are not included in this budget.

5. It is anticipated that approximately 30% of the tuition fees from international students will be used as international GAs in the Faculty of Engineering.

6. This budget does not account for increases in salaries, costs, tuition, funding, etc.

7. There are 15 faculty members in categories 1, 3 and non-core, as well as 2 technologists in the Department of Electrical Engineering. This is sufficient to begin the Ph.D. program. An additional faculty member may be hired once the PhD program grows sufficiently.

8. We expect to reach a steady state in the program in six years. Projected steady-state enrolment is approximately 14 PhD students, with a mix of domestic and international students. Four new students, including both domestic and international students, would

be recruited each year to replace graduating students. The budget of Table 7 uses plausible values of 6 domestic students and 8 international students as an example.

9. We assume 100% student retention rate for continuing students in this budget (i.e. no student leaves the program without completing it).

10. The budget assumes that new sessional instructors will be hired to teach undergraduate courses in Electrical Engineering and/or Software Engineering. This will free up tenured or tenure-track faculty members to teach the graduate courses required for this PhD program.

Table 7 – Example 6-Year Budget for the Program.

	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
New full-time Domestic students	1	1	2	1	2	2
Continuing full-time Domestic students	0	1	2	4	4	4
New full-time International students	1	2	2	2	2	2
Continuing full-time International students	0	1	3	5	6	6
Part-time students	0	0	0	0	0	0
TOTAL students	**2**	**5**	**9**	**12**	**14**	**14**
Tuition for Domestic students ($2,508/term or $2,277/term)	7,524	14,355	28,710	34,848	42,372	42,372
Tuition for International students ($4,950/term or $14,850/year)	14,850	44,550	74,250	103,950	118,800	118,800
Funding (BIU) for Domestic students ($26,000/year for 3 years)	26,000	52,000	104,000	104,000	130,000	130,000
TOTAL Revenues	**48,374**	**110,905**	**206,960**	**242,798**	**291,172**	**292,172**
Graduate Assistantships ($9,751/year for Domestic students)	9,751	19,502	39,004	48,755	58,506	58,506
New faculty member ($100,000/year)	0	0	0	100,000	100,000	100,000
New technologist	0	0	0	0	0	0
New Sessional Instructor ($8,000/course)	8,000	16,000	24,000	0	0	0
Consumables	10,000	10,000	10,000	10,000	10,000	10,000
Marketing	10,000	10,000	10,000	10,000	10,000	10,000
TOTAL Expenditures	**37,751**	**55,502**	**83,004**	**168,755**	**178,506**	**178,506**
NET INCOME	**10,623**	**55,403**	**123,956**	**74,043**	**112,666**	**112,666**

Appendix A: Student Learner Outcomes of the Graduate Courses

This section demonstrates how the Student Learner Outcomes of each graduate course in the PhD program relates to the Program Learner Outcomes detailed in Section 2.2. We show that any course taken will satisfy LO3, LO8, and to a more limited extent LO6.

ENGI 5131: Microelectronics

- SLO5131.1: Demonstrate the ability to design CMOS integrated circuits. (LO6, LO8)
- SLO5131.2: Demonstrate an understanding of the process and considerations involved in laying out and fabricating CMOS integrated circuits. (LO3, LO8)
- SLO5131.3: Demonstrate an understanding of digital and analog circuit blocks. (LO3, LO8)
- SLO5131.4: Demonstrate an ability to perform testing and verification of CMOS circuits. (LO3, LO8)
- SLO5131.5: Demonstrate an understanding of the process and considerations involved in laying out and fabricating CMOS integrated circuits. (LO3, LO8)
- SLO5131.6: Demonstrate the ability to use computer software to aid in the design of CMOS circuits. (LO3, LO8)

ENGI 5132: Digital Communication Systems

- SLO5132.1: Demonstrate an understanding of the analysis and design of digital communication systems. (LO3, LO8)
- SLO5132.2: Demonstrate the ability to model the characteristics of communication signals and systems. (LO6, LO8)
- SLO5132.3: Demonstrate the ability to use modulation techniques and to mathematically predict their performance in AWGN and dispersive channels. (LO3, LO8)
- SLO5132.4: Demonstrate the ability to perform channel equalization. (LO6, LO8)
- SLO5132.5: Demonstrate the ability to perform carrier and symbol synchronization. (LO6, LO8)

ENGI 5231: Computer Architecture

- SLO5231.1: Demonstrate an understanding of CISC and RISC microprocessors. (LO3, LO8)
- SLO5231.2: Demonstrate an understanding and ability to use performance metrics for microprocessors. (LO3, LO8)
- SLO5231.3: Demonstrate the ability to design the instruction set of a new microprocessor. (LO3, LO8)
- SLO5231.4: Demonstrate the ability to describe and implement algorithms on microprocessors. (LO6, LO8)

- SLO5231.5: Demonstrate an understanding of cache and virtual memory organization schemes, their advantages and limitations. (LO3, LO8)
- SLO5231.6: Demonstrate an understanding of protection and sharing schemes, their advantages and limitations. (LO3, LO8)
- SLO5231.7: Demonstrate an understanding of multithreaded architectures, their advantages and limitations. (LO3, LO8)
- SLO5231.8: Demonstrate an understanding of parallel computing, including symmetric multiprocessors and DSP processors. (LO3, LO8)

ENGI 5232: Software Construction and Evolution

- SLO5232.1: Demonstrate an understanding of methods and techniques to allow a software system to evolve, and survive. (LO3, LO8)
- SLO5232.2: Demonstrate the ability to construct software components identified and described in design documents. (LO6, LO8)
- SLO5232.3: Demonstrate an understanding of the principles of code reuse and an ability to implement code for reusability. (LO3, LO6, LO8)
- SLO5232.4: Demonstrate an understanding of and an ability to perform unit, integration, system and acceptance testing. (LO3, LO6, LO8)

ENGI 5431: Advanced Power Electronics

- SLO5431.1: Demonstrate the ability to understand and use rectifiers and inverters. (LO3, LO8)
- SLO5431.2: Demonstrate the ability to understand and use harmonic generation by solid-state power converters. (LO3, LO8)
- SLO5431.3: Demonstrate the ability to design control circuits for rectifiers and inverters. (LO3, LO6, LO8)
- SLO5431.4: Demonstrate the ability to describe and implement applications of microprocessors to machine drives. (LO6, LO8)

ENGI 5432: Semiconductor devices

- SLO5432.1: Demonstrate an understanding of the theory underlying active and passive semiconductor devices, including operation, modeling, parameter extraction, scaling issues, and higher order effects. (LO3, LO8)
- SLO5432.2: Demonstrate an ability to model physical semiconductor devices using CAD tools. (LO6, LO8)

ENGI 5433: Design of RF ICs

- SLO5433.1: Demonstrate an understanding of transistor models. (LO3, LO8)
- SLO5433.2: Demonstrate an ability to perform small-signal analysis. (LO3, LO6, LO8)
- SLO5433.3: Demonstrate an ability to design amplifiers. (LO3, LO8)
- SLO5433.4: Demonstrate an understanding of biasing. (LO3, LO8)

- SLO5433.5: Demonstrate an ability to perform noise analysis. (LO3, LO6, LO8)
- SLO5433.6: Demonstrate an understanding of real-world examples of Radio Frequency Integrated Circuits, such as amplifiers, filters, oscillators, PLL and frequency synthesizers. (LO3, LO8)
- SLO5433.7: Demonstrate an ability to design and evaluate the performance of RFICs. (LO6, LO8)

ENGI 5434: Wireless Communication Systems

- SLO5434.1: Demonstrate an understanding of the fundamentals of cellular system design. (LO3, LO8)
- SLO5434.2: Demonstrate an understanding of the principles of propagation in mobile radio channels. (LO3, LO8)
- SLO5434.3: Demonstrate an understanding of modulation techniques for mobile radio. (LO3, LO8)
- SLO5434.4: Demonstrate an understanding of diversity and diversity combining techniques. (LO3, LO8)
- SLO5434.5: Demonstrate an understanding of multiple access techniques. (LO3, LO8)
- SLO5434.5: Demonstrate an ability to design and model cellular systems. (LO6, LO8)

ENGI 5331: Digital ASIC Design

- SLO5331.1: Demonstrate an understanding of the design flow of digital ASIC. (LO3, LO8)
- SLO5331.2: Demonstrate an understanding of and ability to use the hardware description language of digital ASIC. (LO3, LO8)
- SLO5331.3: Demonstrate an ability to analyze and apply CMOS logic. (LO3, LO8)
- SLO5331.4: Demonstrate an ability to perform verification, simulation, and testing of digital ASIC. (LO6, LO8)
- SLO5331.5: Demonstrate an understanding of IC packaging. (LO3, LO8)
- SLO5331.6: Demonstrate an understanding of the design flow of digital ASIC. (LO3, LO8)
- SLO5331.7: Demonstrate an understanding of field programmable gate arrays and mask programmable gate arrays. (LO3, LO8)
- SLO5331.8: Demonstrate an ability to use Computer Aided Design algorithms to design digital ASIC. (LO3, LO8)

ENGI 5332: Advanced Computer Engineering

- SLO5332.1: Demonstrate an understanding of advanced aspects of computer architecture. (LO3, LO8)

- SLO5332.2: Demonstrate an advanced understanding of parallel systems. (LO3, LO8)
- SLO5332.3: Demonstrate an advanced understanding of memory systems. (LO3, LO8)
- SLO5332.4: Demonstrate an ability to design digital systems for testability. (LO6, LO8)

ENGI 5333: Computer Networks

- SLO5333.1: Demonstrate an understanding of various network architectures, including: layered network architectures, local area networks, wireless/optical access networks, ATM networks, Internet. (LO3, LO8)
- SLO5333.2: Demonstrate an advanced understanding of networking topics, including: multiplexing and switching, delay and loss performance, medium access control, mobility management, routing, flow control, Internet protocol; transport layer: transmission control protocol; differentiated services IP. (LO3, LO8)
- SLO5333.3: Demonstrate an ability to design computer networks. (LO6, LO8)

ENGI 5334: Web Engineering

- SLO5334.1: Demonstrate an understanding of Web Engineering technologies. (LO3, LO8)
- SLO5334.2: Demonstrate an ability to use client-side scripting and server-side programming languages. (LO3, LO8)
- SLO5334.3: Demonstrate an ability to design and implement software and components for web applications and web services. (LO6, LO8)
- SLO5334.4: Demonstrate an understanding of Web modeling languages, Web ontology languages, and the Semantic Web. (LO3, LO8)
- SLO5334.5: Demonstrate an ability to describe algorithms for context-awareness and adaptive information delivery. (LO3, LO8)

ENGI 5111: Control Engineering Concepts

- SLO5111.1: Demonstrate an understanding of digital control. (LO3, LO8)
- SLO5111.2: Demonstrate an ability to compute and use the z-transform. (LO3, LO8)
- SLO5111.3: Demonstrate an ability to handle stochastic processes with random variables. (LO3, LO8)
- SLO5111.4: Demonstrate an ability to describe, implement and use filters, including the Kalman filter. (LO6, LO8)
- SLO5111.5: Demonstrate an ability to perform a harmonic analysis of systems. (LO6, LO8)

ENGI 5211: Robust Control

- SLO5211.1: Demonstrate an ability to perform the sate space representation and analysis of a system. (LO3, LO8)
- SLO5211.2: Demonstrate an ability to perform the singular value analysis of a system. (LO3, LO8)
- SLO5211.3: Demonstrate an ability to describe and follow the H2 and Hinf methods of controller design. (LO6, LO8)

ENGI 5411: Intelligent Control

- SLO5411.1: Demonstrate an understanding of different options for knowledge representation in a system. (LO3, LO8)
- SLO5411.2: Demonstrate an ability to describe and use inference engines. (LO3, LO8)
- SLO5411.3: Demonstrate an understanding of approximate reasoning methods. (LO3, LO8)
- SLO5411.4: Demonstrate an ability to describe and use a fuzzy logic control system. (LO3, LO8)
- SLO5411.5: Demonstrate an understanding of machine learning. (LO3, LO8)
- SLO5411.6: Demonstrate an ability to design and implement an intelligent control system. (LO6, LO8)

ENGI 5631: Advanced topics in Electrical and Computer Engineering

- SLO5631.1: Demonstrate an understanding of a selected advanced topic in Electrical and Computer Engineering. (LO3, LO8)
- SLO5631.2: Demonstrate an ability to apply this knowledge in a practical system. (LO6, LO8)

ENGI 5732: Nonlinear Control

- SLO5732.1: Demonstrate an understanding of nonlinear models and nonlinear phenomena. (LO3, LO8)
- SLO5732.2 Demonstrate the ability to analyse systems in terms of their Lyapunov stability. (LO3, LO8)
- SLO5732.3 Demonstrate the ability to analyse systems in terms of their input-output stability. (LO3, LO8)
- SLO5732.4 Demonstrate the ability to analyse systems in terms of their passivity. (LO3, LO8)
- SLO5732.5 Demonstrate the ability to independently perform an advanced stability analysis of ECE systems. (LO6, LO8)
- SLO5732.6 Demonstrate the ability to analyse the stability of perturbed systems. (LO3, LO8)
- SLO5732.7 Demonstrate the ability to perform feedback linearization. (LO6, LO8)
- SLO5732.8 Develop the ability to use nonlinear design tools. (LO3, LO8)

ENGI 5733: Robotics

- SLO5733.1: Demonstrate the ability to understand and prepare the D-H representation of systems. (LO3, LO8)
- SLO5733.2: Demonstrate the ability to model and compute the forward kinematics of robot manipulators. (LO3, LO8)
- SLO5733.3: Demonstrate the ability to model and compute the inverse kinematics of robot manipulators. (LO3, LO8)
- SLO5733.4: Demonstrate the ability to model and solve systems using the Euler-Lagrange method. (LO3, LO8)
- SLO5733.5: Demonstrate the ability to model and solve systems using the Newton Euler method. (LO3, LO8)
- SLO5733.6: Demonstrate the ability to design the controls of a robot manipulator. (LO6, LO8)

ENGI 5734: Natural Language Processing

- SLO5734.1: Develop an understanding of the fundamentals of linguistics and of statistical inference in language. (LO3, LO8)
- SLO5734.2: Demonstrate the ability to apply statistical methods for the task of word sense disambiguation. (LO3, LO8)
- SLO5734.3: Demonstrate the ability to apply statistical methods for the task of part-of-speech tagging. (LO3, LO8)
- SLO5734.4: Demonstrate the ability to apply statistical methods for the task of sentence and text parsing. (LO3, LO8)
- SLO5734.5: Demonstrate the ability to describe and implement algorithms for complex NLP functions such as machine translation, information retrieval from text, and text categorization. (LO6, LO8)

ENGI 5735: Advances in Semiconductor Materials

- SLO5735.1: Develop an understanding of semiconductor materials based on compound alloys such as arsenides, phosphides, and nitrides. (LO3, LO8)
- SLO5735.2: Demonstrate the ability to determine the electrical and optical properties of semiconductor materials on the basis of their electron band structures. (LO3, LO8)
- SLO5735.3: Demonstrate the ability to compute the electron band structures on the ternary and quaternary semiconductor compound alloys. (LO6, LO8)
- SLO5735.4: Develop an understanding of phenomena in the disordered alloys such as tunnel optical absorption and excitons. (LO3, LO8)

ENGI 5736: Nanostructured Materials

- SLO5736.1: Develop an understanding of the properties of the nanostructures determined on the basis of their electron band structures. (LO3, LO8)
- SLO5736.2: Demonstrate the ability to compute the properties of nanostructures using the Linear Combination of Atomic Orbitals (LCAO) method. (LO3, LO8)
- SLO5735.3: Demonstrate the ability to compute the electron band structures of two-dimensional nanostructures, and to handle new phenomena connected with relativistic particles. (LO6, LO8)

ENGI 5273: Mechatronics

- SLO5273.1: Demonstrate the ability to analyze the properties of the related linear and nonlinear systems. (LO3, LO8)
- SLO5273.2: Demonstrate the ability to apply system identification methods to model the plant to be controlled. (LO3, LO8)
- SLO5273.3: Develop the ability to analyze the characteristics of the generally used pneumatic, hydraulic, mechanical and electrical systems. (LO3, LO8)
- SLO5273.4: Demonstrate the ability to analyze the properties of the commonly used sensors for measurement of vibration, temperature, flow rate, etc. (LO3, LO8)
- SLO5273.5: Develop the ability to analyze the properties of actuation systems in the forms of mechanical, electrical, pneumatic and hydraulic. (LO3, LO8)
- SLO5273.6: Develop the ability to construct transfer functions of the first-order and second-order systems. (LO6)
- SLO5273.7: Develop the ability to analyze frequency response of a control system and define its Bode diagrams. (LO3, LO8)
- SLO5273.8: Develop the ability to design a closed-loop controller (e.g., PI, PD, PID) and analyze its stability. (LO6)
- SLO5273.9: Demonstrate the ability to choose an appropriate microprocessor for a control application and to program the microprocessor. (LO6, LO8)
- SLO5273.10: Demonstrate the ability to apply the input/output interface addressing, requirements, and adapters. (LO3, LO8)
- SLO5273.11: Demonstrate the ability to apply MATLAB/SIMILINK to design and simulate a digital control system. (LO6, LO8)

CS 5313: Artificial Intelligence

- SLO5313.1: Develop an understanding of logic and knowledge representation (LO3, LO8)
- SLO5313.2: Demonstrate the ability to use search algorithms and heuristic search algorithms (LO3, LO8)
- SLO5313.3: Develop an understanding of machine learning algorithms and an ability to train such algorithms (LO6, LO8)
- SLO5313.4: Develop an understanding of expert systems (LO3, LO8)

- SLO5313.5: Develop an understanding of uncertain reasoning (LO3, LO8)
- SLO5313.6: Develop an understanding of neural networks and genetic algorithms and an ability to use such algorithms (LO6, LO8)

Appendix B: Library Resources

Collections

The Chancellor Paterson Library maintains a solid collection of monographs and serial publications relating to Electrical and Computer Engineering. Supplemented with resources in control and software engineering and computer science, the library collection supports related graduate level programs in control engineering and mathematical sciences.

The Library's journal collection, in particular the electronic journals, is strong. In addition to subscriptions paid from the Faculty of Engineering and the Department of Computer Science library budgets, the library provides access to numerous relevant electronic journals through participation in the Canadian Research Knowledge Network (CRKN) and consortial subscriptions through the Ontario Council of University Libraries (OCUL). This includes suites of electronic journals such as *Elsevier's Science Direct, SpringerLink*, the *ACM Digital Library* and *Wiley Blackwell*. In addition, the *IEEE/IET Electronic Library (IEL*) which provides full-text access to IEEE journals, transactions, conference proceedings, and IET (formerly IEE) publications would also be of particular interest for the proposed PHD program. Through resources like these, there are approximately 900 electronic journals of relevance to computer and electrical engineering.

Knowledge Ontario resources such as *Academic One-File* and *Expanded Academic ASAP* are also available. These multidisciplinary, full-text databases have full-text academic and scholarly journal content.

The Library has approximately 3758 monograph titles in the Library of Congress Classification for Electrical Engineering, TK 1–9971. Additionally there are 1,002 monograph titles in the Library of Congress Classification for Technology and approximately 1,590 for Electronic computers/computer science/computer software, QA 75.5–76.95. In addition to the print monograph collection, the library provides access to a number of e-book collections. Within these collections titles from Springer would likely be of particular interest.

Selection

The Faculty of Engineering is responsible for selecting appropriate library resources. A library representative from the Faculty of Engineering liaises with a designated Collections Development Librarian with respect to the Faculty's library budget, the acquisition process, and consortia and serials management. It is the responsibility of the Collections Development Librarian to ensure relevant information regarding new publications is forwarded to the Faculty's representative for consideration.

Budget

The portion of the Library's books and periodicals budget expended by the Faculty of Engineering for 2008/09 was $65,781. This figure does not include the cost of indexes, abstracts and other reference materials that are paid for from other library funds. It also does not include the cost for electronic journals that are a part of CRKN and OCUL. The Faculty of Engineering also benefits, without cost to the Faculty, from a suite of electronic resources made available by Knowledge Ontario.

Access to Campus Resources

A special room in The Chancellor Paterson Library has been designated for the exclusive use of graduate students. Two computers are available for graduate student use in this area and study carrels are equipped to allow access to the Internet via lap top computers. Laptop computers are available from the Circulation Desk for students to borrow. In addition, access to the Internet is available at workstations throughout the Library and in two computer labs in the Library. The labs are equipped with 41 computers for student use. Students also have access to a scanner in each of the labs.

The Library's catalogue, *Voyager*, provides a single access point for the Library's holdings and a variety of resources including indexes, abstracts, e-books and full text electronic journals and government publications.

Availability of Resources to Identify Relevant Information

The Library's collection includes a number of electronic databases which would support the proposed PHD program in electrical and computer engineering.

The IEEE/IET Electronic Library (IEL) provides access to almost a third of the world's current electrical engineering and computer science literature, featuring high-quality content from the Institute of Electrical and Electronics Engineers (IEEE) and the Institution of Engineering and Technology (IET).

Compendex provides access to over five million summaries of journal articles, technical reports, and conference papers and proceedings in all areas of engineering.

Inspec is a bibliographic database to access 3500 scientific journals and 1500 conference proceedings in the fields of electrical and electronic engineering, physics, information technology, and computer and control systems.

Web of Science provides access to the Institute of Scientific Information's Science Citation Index Expanded.

MathSciNet includes Mathematical Reviews and Current Mathematical Publications. Mathematical Reviews is a monthly publication providing reviews of the world's current

mathematical literature. Current Mathematical Publications is a subject index of bibliographic data for recent and forthcoming publications.

The Synthesis Digital Library of Engineering and Computer Science is an information service for the research, development and educational communities in engineering and computer science. The basic component of the library is a self-contained electronic book that synthesizes an important research or development topic, authored by an expert contributor to the field.

ASTM Standards from IHS Engineering Resource Center, provides access to the full-text of current active standards.

Academic One-File is a searchable full-text database of academic and scholarly journals in a variety of subjects. Subjects include physical sciences, technology, medicine and social sciences.

Expanded Academic ASAP is a multidisciplinary database covering arts and the humanities, social sciences, and science and technology.

IngentaConnect is an index to over 22,000,000 current articles taken from over 30,000 multidisciplinary journals.

The Library also provides access to periodical literature and other materials through Scholars Portal Search (CSA Illumina). The interface provides a simple approach to searching across a number of multidisciplinary bibliographic databases across a wide field of subjects.

Proquest Dissertations and Theses (PQDT) is a comprehensive collection of over 2.3 million dissertations and theses from around the world. Bibliographic citations are available for dissertations dating from 1861 and more than 60,000 new citations are added to the database every year. From 1997 dissertations are available in full-text and may be downloaded in pdf format.

The Library provides access to Theses Canada Portal, an initiative of Library and Archives Canada, which provides access to full-text versions of Canadian theses and dissertations published from the beginning of 1998 to August 31, 2002. It also includes bibliographic records of all theses in the National Library of Canada theses collection, which was established in 1965.

Provision of Documents and Information Not Held Locally

The library provides document delivery/interlibrary loan services to enable access to articles from a variety of journals and research materials that are not held in the Lakehead University collection. Users may request an unlimited number of books from

Canadian suppliers for free. Faculty and graduate students are eligible to receive 20 articles per term at no cost.

Along with all other Ontario University Libraries, Lakehead uses the RACER system for the management of Interlibrary Loan service. This system is made available through the internet and includes a union catalogue of holdings for Ontario academic libraries as well as search profiles to discover and request materials from most Canadian and select American research institutions and library collections. Lakehead has free reciprocal borrowing agreements with select American institutions and is also a member of the Center for Research Libraries which provides free access to books, newspapers, serials, archival material and microfilm through Interlibrary Loan.

Lakehead is also a participant in the Inter University Borrowing Project (Canada) to facilitate the borrowing of books from other libraries.

User Assistance

Professional Reference Librarians are available to assist graduate students in making full use of the Library's resources. These include but are not limited to the online catalogue, electronic databases, internet resources, e-books, statistical data, and access to other library catalogues. Professional Reference Librarians provide assistance approximately 66.5 hours per week during the fall and winter terms.

In addition, Lakehead University Library is a participant in the *askON* chat reference service which was launched as a pilot project in January 2008. The *askON* service is a project of *Knowledge Ontario* involving the participation of university, college, and public libraries. Approximately 62 hours of live chat reference service is provided by the participating institutions each week during the fall and winter terms.

The Library's web page includes subject guides which present selected print and electronic information sources for each area of study at Lakehead University. These guides were prepared and are updated regularly by the Library's professional librarians.

ER Update, the Library's electronic resources blog, provides information on new electronic Library resources as well as interface changes, additional features, and maintenance windows.

The Library offers a series of workshops intended to teach research skills and develop a knowledge base for optimizing use of the Library's resources. Advanced level and discipline-specific sessions can be arranged upon request either for individuals or classes. Workshops are also provided on the use of *Refworks,* a web-based bibliography and database manager that allows one to create one's own personal database by importing references from text files or online databases.

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Anne Deighton Date

University Librarian

Appendix C: Laboratory Facilities

Modern, well-equipped laboratories are available for both research and teaching. Lakehead University is also a member of CMC Microsystems and has access to tools and fabrication services for the design of integrated circuits/microsystems. Currently the Cadence tools are installed in a university server. Several laboratory instruments are also available for short-term loan from CMC. A list of the major research equipment is given below.

1. Facilities in the Faculty of Engineering

1.1 Electronics Lab

10 Oscilloscopes, Fluke (PM3370B/023)

8 Decade Resistors, Gen.Radio (1433K)

8 Decade Resistors, Lionmount (RD1)

12 DMMs, Fluke (Mod. 45)

10 Function Generators, Agilent (33120A)

10 Power Supply, Agilent (E3611A)

1.2 Communications Lab

10 Oscilloscopes, Agilent (5445D)

12 DMMs, Fluke (Mod.45)

12 Function Generators, Agilent (33120A)

12 Power Supply, Agilent (E3611A)

8 Spectrum Analyzer, Agilent (E4411B)

1 Logic Analyzer, Agilent (1660E)

1 Network Analyzer, Agilent (8712ES), with calibration kits

1 Microwave Power Meter, Agilent (E4418B)

1 Scalar Analyzer, Marconi (6500), w. probes

1 Antenna/Microwave experiment set, Marconi

1 Microwave bench set, Marconi

12 Satellite communications equipment (LNAs, noise source, power meter,

RF-meter, feeds, attenuators, etc.)

4 Microwave oscillators, covering 2 through 18 GHz

1 Slotted line experiment set, Gen.Radio

1.3 Computer Labs

20 Computers f. Teaching

20 Computers f. Networking

54 Sun Computers

1.4 Controls Lab

4 Oscilloscopes, Fluke (PM3370B/23)

4 Power Supplies, Agilent (E3611A)

4 Function Generators, Agilent (33120A)

6 DMMs, Fluke (Mod. 45)

12 Home-built experiment sets

1.5 Electric Machines Lab

10 Differential Voltage Probes, Fluke (DP120)

20 Current Probes, Fluke (80i-110s)

46 Variable Resistors (rheostats), var.values, Cenco (82910-xx)

16 Volt-, Amp-, Wattmeters (analog)

10 Power Meters (dig.), Fluke (Mod. 39) with current clamps

8 AC motor – DC motors, mounted sets <1 HP

8 AC drives, Relcon (PWM-1000)

8 DC drives, KB Penta (KBMD-240D)

3 DC motors, Hampden

3 Wound rotor motor, Hampden

16 Variable transformers (variacs), diff models 3…10A

10 Motors, Generators, Hampden

16 Isolation transformers, Hammond

1.6 Automatic Control Lab

1 5DOF-robot manipulator (CATALYST5)

1 6DOF-robot manipulator (A465)

1 ATI Force/Torque Sensor (9105-GAMMA-R-10-2N0)

1 B21r Mobile Robot (Applied AI System)

1 Vision system for B21r Mobile Robot (Applied AI System)

1 Laser Printer (Lexmark T520N)

3 Computers and Monitors

1 Laptop (DELL I8200)

1 Scanner (HP ScanJet 3570C)

2 Signal Generators

2 Digital Multimeters

3 Power Supplies

1 dSpace (1104 DSP board + Software)

1.7 Power Electronics and Drives Research Lab

1 IGBT Training system

1 DS1104 DSP board with software

1 Labvolt Power supply

1 Interior permanent magnet synchronous induction motor

1 BEI Digital encoder

1 Easy Power software for power system analysis

39 Variacs

1.8 Broadband Communications Networks Laboratory

1 1-Gigabit Ethernet Passive Optical Network (GPON) Optical Line Termination (OLT) system, with 4 ports, high density CPU, element management system, power supply, chassis, and shelf.

1 GPON Optical Interface Module

1 1-Gigabit Ethernet, 2 Ports

1 1-Gigabit Ethernet Transceiver Module

4 Customer Premises Optical Network Terminations (ONT) Units

1 Calix Management System Release 10.0

1 7 Ft, 19 Inch rack with circuit breaker

1 Passive Optical Splitter Module

10 IBM Personal Computers and Monitors

2 Laptops (Toshiba and DELL)

2 Printers (HP and LEXMARK)

4 Gigabit Ethernet Switches

1 Wireless Router

4 Desktop IP Phones

2 32” Television Sets (Sony)

3 Motorola Set-top boxes for Video Broadcasting and VoD

1 Motorola KreaTV software for VoD

1 A Spool of Optical Fiber Cable (487 Meters of 48-Strand Single-Mode Fiber)

2 48-fiber Patch Panels

Many software Packages and Tools

1.9 Semiconductor Research Laboratory

1 Meaglow reactor for epitaxial growth of semiconductor layers on micro-, nano- and atomic (2-D structures) levels.

1 Atomic Force Microscope.

1 Electron lithography of high resolution.

1 System for Hall effect measurements.

1 Optical spectrometer from the near ultraviolet to the near infrared ranges of the optical spectrum.

1 System for photo-luminescence measurements (PL spectrum).

2. General

1 Oscilloscope, Tektronic 2445A

8 Oscilloscopes, Hitachi (V-222)

10 Oscilloscopes, Agilent (5445D)

6 Oscilloscopes, Fluke (PM3370B/23)

5 Oscilloscopes, Instek (GOS 553G)

12 Oscilloscopes, older types

3 Frequency Counters, Agilent (53181A)

8 Frequency Counters, older types

10 Voltmeters, H&P (427A)

8 Multimeters, analog, AVO (Model 8)

15 DMMs, Wavetek/Fluke (BDM40-U)

4 Function Generators, Agilent (33120A)

12 Function Generators, B&K Prec. (3010)

3 Function Generators, Global (105-2003)

8 Function Generators, older models

30 Power Supplies, diff., mostly older models, incl. home-made

8 Power Supplies, Goodwill (GPR-3020)

4 Power Supplies, Agilent (E3611A)

8 Power Supplies, Agilent (E3620A)

6 Power Supplies, GW (GPS-1850)

6 Power Supplies, GW (GPS-3303)

6 Power Supplies, GW (GPR-3510HD)

10 Power Supplies, Instek (GPS3303)

4 FPGA boards in AT4020.

Appendix D: Computer Facilities

TSC Technology Facilities

The Technology Services Centre (TSC) brings together the skills, knowledge and technology to provide Academic and Administrative Computing, Information Services, Voice and Data Communications and Computing Services in the areas of learning and research. Our goal is to assist the University in fulfilling its Academic mission, and to provide the support and guidance necessary to enhance the effectiveness of the institution in all its' service offerings. With a team of over 30 highly trained and skilled individuals, the TSC remains committed to supporting and strengthening our students' academic careers by providing University-wide access to information and technology resources.

The Advanced Technology Academic Centre (ATAC) opened its doors in September 2003 at Lakehead University, Thunder Bay Campus equipping the University with a modern, high-tech instruction, research and learning facility. In addition to providing more classroom space for students from many faculties, the Centre houses research and teaching laboratories for technology-intensive courses in software engineering, electrical engineering, geographic information systems, and computer science. ATAC's state-of-the-art Technology Enhanced classroom environments have expanded distance education through greater access to video-conferencing and other distributed learning tools. The TSC client base, including students, faculty and staff, have access to the Computer Helpdesk located on the second floor of the ATAC and there are a number of kiosks distributed on the first floor of the building that provide Internet access for our users.

ATAC is home to the following Lakehead University departments, programs and facilities:

- Northern Ontario Medical School (NOSM)
- Technology Services Centre (TSC)
- Computer Science
- Electrical & Software Engineering
- Geographic Information Systems (GIS) Laboratories
- Multi-media Production Studio
- Part-Time Studies & Distance Education

- Robotics Engineering Laboratories
- Virtual Reality Lab

High Performance Research Computing

The High Performance Computing Centre makes its home in the ATAC. This centre offers large scale computing resources to facilitate research, discovery and innovation in all academic fields of study. The TSC staff provides support and expertise for researchers with the use of this leading edge technology and its' tools.

High-performance computing gives researchers in mathematics, engineering, computer science, finance, chemistry and health sciences, as well as any other discipline that engages in computer modeling, the advantage of having large computing power to crunch the numbers.

Lakehead is a member of SHARCNET (http://www.sharcnet.ca/), a consortium of colleges and universities with high-performance computers across south-central Ontario who have pooled their resources to create The Shared Hierarchical Academic Research Computing Network (SHARCNET).

As a member of SHARCNET, Lakehead's high-performance computing capability increases from its current level of 132 CPUs to over 3,000 CPUs, and gives researchers unlimited access to resources and support in the form of peer mentors, research collaborations, and software developers.

Lakehead has also acquired a Sun SPARC Enterprise T6340 server in 2011.

Virtual Reality

The Lakehead University Virtual Reality Environment (LUVRE) managed by the TSC, boasts the latest in state-of-the-art imaging and processing technology, truly establishing Lakehead as a leader in Virtual Reality instruction and research. High performance computers (HPC) drive the video display, rendering and complex computations. Coupled with high refresh rate projectors and a curved laser calibrated screen, these robust technologies result in a highly realistic and sophisticated interactive simulation environment that is useful for understanding spatial dynamics as well as relationships among objects, people and places.

The benefits of this system to industry, education and health care include the ability to visualize and interact with models and processes without a safety risk or financial impracticality in addition to relinquishing the need to develop/acquire actual physical models.

Virtual Reality - A Unique Learning Tool

LUVRE offers faculty and students unique experiences that are consistent with successful instructional strategies: hands-on learning, group projects and discussions, simulations and concept visualization. The virtual reality learning environment is experiential and intuitive; it is a shared information context that offers unique interactivity and can be configured for individual learning and performance styles.

LUVRE's Practical Applications

With the ability to perform highly realistic simulations of engineering, industrial planning, GIS/mapping, medical and molecular modeling, LUVRE is only limited by one's imagination. It is a valuable tool that empowers Lakehead University to engage local, national and international companies interested in the use of cost-saving VR techniques in businesses ranging from pulp paper production to health care research to mining operations.

The VR Technology

The LUVRE System utilizes:

- BARCO DLP projectors that operate at the highest possible refresh rate
- Infrared, stereoscopic LCD, CrystalEyes - shutter glasses used for Stereo 3D imaging
- A curved laser calibrated screen
- Surround sound audio system to support professional software applications used in product visualization and simulation

Telephony and the Network

Lakehead University utilizes fully converged network for data, voice and video communications. The backbone of the network is built on a redundant multi gigabit fiber optic network comprising of multiple Layer 3 routable switches, over 40 wiring closets and 8000 plus Ethernet ports. TSC supports 2600 voice over IP phones, Video Conference Units, security cameras, environmental controls, computers, printers and Servers which are all running on the same IP infrastructure.

The Teaching Environment

The Multimedia Service Unit is committed to providing a wide range of technological communication services across campus including the Orillia campus. All classrooms in the ATAC are equipped with multi-media podiums, complete with a touch panel. Furthermore each classroom boasts an in-room PC with a flat panel monitor, two USB ports, CDRom and floppy drives, Internet connects, IP telephone with speaker, laptop dock (video, audio, Internet and power), VCR player, DVD player, and document

camera. Individual network ports have been installed in the classrooms for student connectivity. The teaching labs in the ATAC are outfitted with instructor PC's and multimedia equipment as well.

Video Conferencing and teleconferencing technology is available in the three (3) large theatres as well as in multiple designated V/C rooms. A total of twelve rooms (12) in the ATAC are available for video streaming with three (3) other rooms on campus residing in the Nursing building and Regional Centre. Video and Audio digital production is available along with media conversion and linear and non linear editing. Additionally, mobile conferencing units can be deployed anywhere on campus.

General Classroom Details

All computer classrooms on both Campuses are networked. The computers in these rooms have a full range of Internet services including E-mail, web browsers, terminal emulation, FTP etc. They are also equipped with the appropriate applications such as word processors, spreadsheets, database programs, statistical analysis software, compilers and special purpose software. General student computer labs on both campuses are also available. These general student labs are never used as instruction facilities, as they are dedicated for student use at all times.

Students must have an account on the appropriate server before any computer can be used. Accounts are created automatically from student registration information. A Lakehead Web-mail account is also set up for every student at this time. Lakehead's e-mail service is provided by Google as part of a new partnership developed in November of 2006. The e-mail accounts are perpetual, never deleted and may be used by students as a personal account after graduation.

Printing Services

Printing facilities are provided via central and satellite laser printers in both monochrome and colour. The printers are located throughout the ATAC building and other locations on Campus including large scale colour plotting are provided student use.

A networked database controls Lakehead's printing services. Students are given an initial credit upon registration, then they deposit to their account as required in order to continue using these printing services. In addition to the printing services, scanners can be found at various locations on campus for student use.

Computer Classroom Bookings

The Technology Enabled Classrooms are booked for course use through the Registrar's Scheduling Office. This is necessary to ensure that timetable requirements are met. Consultation with the TSC staff is also necessary to ensure that all of the software and operating systems in the classroom match the course requirements. There are multiple

software applications installed in each classroom and there is a certain degree of coordination required in order to service all the needs of each Technology Enabled Classroom. Data projectors are provided in all ATAC TSC computer classrooms and by request from the Audio-Visual unit of the TSC for other computer labs.

Computer Classroom Usage

Computer classrooms under the supervision of TSC are available 24 hours a day for student use during the Fall and Winter Terms. This is subject to prior class bookings.

Students not only use these labs to complete course assignments but also use the labs for electronic mail, resumes, projects and personal recreation on the Internet.

Computer classrooms are used for public and high school tours, university-sponsored conferences and staff training.

Classroom Hardware Details

The majority of computer classrooms contain IBM-compatible computers. The following table shows room location, number of computers, operating system and type of computer.

Room Location	**Number of Computers**	**Operating System**	**Type of Computer**
BB1066	20	Windows	Thin Clients
CB1003	24	Windows	Desktops
CB1004 *	18	Windows	Desktops
SB1027	30	Windows	Thin Clients
Agora	12	Windows	Thin Clients (Kiosks)
BL2001	38	Windows	Mac
ATAC 1st Floor	30	Windows	Thin Clients (Kiosks)

AT3001	60	Windows	Desktops
AT3002	60	Windows	Desktops
AT3003	20	Windows	Desktops
AT3010-GIS	20	Windows	Desktops
AT3009-GIS	20	Windows	Desktops

Classroom Software Details

The software available to these systems is dependent upon the operating system. In the main teaching labs, the current standard software available includes:

- SPSS
- Microsoft Office Suite including Word, Excel, Access, FrontPage, PowerPoint, Project, Visio
- Microsoft Visual Studio.Net
- Secure SFTP / Telnet (SSH) / Putty / WinZip
- Adobe Photoshop
- ESRI campus site license for ArcGIS suite of products
- In AT4019, engineering software served from a Solaris Server, includes:
- Hysis
- AutoCAD with Mechanical Desktop
- Ram Scheduler
- Lindo
- Tutsim

Sun Workstation Classrooms

Room Location	Number of Computers	Operating System	Type of Computer
AT4019	54	Solaris 9	Sun Blade 150

The workstations connect to a Sun Solaris server, the Engineering Sun Solaris Server *Sunshine* and the SGI Origin Super Computer, *Giant*. Applications available on *Sleet* include Matlab, Ansys and SPSS along with programming languages such as Lisp, C and Fortran. *Giant* supports SAS, parallel programming, Virtual Reality and other custom applications.

Other Resources
Graphics Lab

A graphics lab with eight SGI 330 workstations, an HP DesignJet 3800 printer and a SGI 1400 server is available for GIS research. The main software packages in use are ArcView and ArcInfo.

Residence

Lakehead University Residences are fully wired with network ports available in every room and VoIP telephony.

Tech Fund

The Lakehead University Student Union (LUSU) has a Tech Fund which also provides additional computer resources for students. General use computer labs have been added through this fund including two labs in the University Library, a smaller lab in the Education Library and another in Visual Arts and Music.

Scanning Stations

Colour scanners are available to students in the main printer room in the Braun Building and in two Library computer labs. Digital still cameras, a digital video camera, laptops and data projectors can be booked by students through the Audio-Visual unit of TSC.

Internet Carousels

The ATAC building has an IBM thin client solution for the Internet Carousel system on the first floor and in the Agora. A SunRay system is used for Internet Carousels in the Centennial Building and outside the main cafeteria.

J. Terry Young

Manager, Technology Services

Lakehead University

Appendix E: Draft Calendar Entry (as of June 18, 2012)

Doctor of Philosophy (PhD) in Electrical and Computer Engineering

Graduate Co-ordinator: R. Khoury

Core: Doctoral Supervisory:
A. Tayebi (Electrical Engineering)
M. N. Uddin (Electrical Engineering)
X. P. Liu (Electrical Engineering)
D. Alexandrov (Electrical Engineering)
C. Christoffersen (Electrical Engineering)
H. Naser (Software Engineering)
R. Benlamri (Software Engineering)
N.-Y. Yu (Electrical Engineering)
A. Manzak (Electrical Engineering)
E. Atoofian (Electrical Engineering)
R. Khoury (Software Engineering)
K. Liu (Mechanical Engineering)
W. Wang (Mechanical Engineering)
S. Pichardo (Adjunct, Electrical Engineering)
L. Curiel (Adjunct, Electrical Engineering)

DOCTOR OF PHILOSOPHY (PHD) IN ELECTRICAL AND COMPUTER ENGINEERING

The PhD in Electrical and Computer Engineering satisfies the demand in academia and industry for highly qualified personnel in the field of Electrical and Computer Engineering. The program is directed to graduates from the existing Master's in Engineering programs at Lakehead University and outstanding graduates at the post graduate level from other universities.

The objective of the program is to foster students' scholarly skills and independent research abilities through a combination of formal course work and dissertation (research) work.

The areas of specialization in the proposed program are Electrical Engineering, Computer Engineering, Software Engineering, and Mechatronics. The first three are well-established disciplines. The fourth, Mechatronics, is a new but increasingly important area that overlaps the three first disciplines and Mechanical Engineering.

ADMISSION REQUIREMENTS

Candidates are accepted under the general University regulations governing the graduate degrees, provided that the requirements of the Faculty of Engineering are also

satisfied.

The applicant must hold an MSc degree in Electrical and Computer Engineering or a closely-related area with at least a 70% average. Admission is dependent on the past academic history of the candidate and the assessment of the referees, the availability of space in the program and the availability and willingness of a suitable faculty member to supervise the applicant. A supervisor must be identified before the student is admitted to the program.

ACADEMIC REGULATIONS

In addition to the Faculty of Graduate Studies PhD regulations, the following regulations apply to the PhD in Electrical and Computer Engineering program.

(a) Course Requirements

It is expected that the student will maintain a minimum cumulative average of B in the course work and a minimal final mark of 70% in each individual course.

The student choice of courses must be approved by the graduate supervisor and the Engineering Graduate Studies Committee.

A minimum of three half-credit graduate courses beyond the Master's level are normally completed within the first year of registration. To satisfy the program requirements, the three half-credit courses must comply with the following regulations:

1. They must be three half-credit graduate-level Electrical and Computer Engineering courses that have not been taken previously at the Master's level.
2. No more than one course can be a relevant graduate-level course selected from outside the List of Electrical and Computer Engineering Graduate Courses.
3. No more than one "Advanced Topics in Electrical and Computer Engineering" (ENGI 5631) course with the student's supervisor will be accepted as a half-credit course.

In addition to the three half-credit courses, students must take the "PhD Seminar" (ENGI 6710) course. This seminar is normally taken in the second year of the PhD program.

List of Electrical and Computer Engineering Graduate Courses:

ENGI 5131: Microelectronics
ENGI 5132: Digital Communication Systems
ENGI 5231: Computer Architecture
ENGI 5232: Software Construction and Evolution
ENGI 5431: Advanced Power Electronics

ENGI 5432: Semiconductor devices
ENGI 5433: Design of RF ICs
ENGI 5434: Wireless Communication Systems
ENGI 5331: Digital ASIC Design
ENGI 5332: Advanced Computer Engineering
ENGI 5333: Computer Networks
ENGI 5334: Web Engineering
ENGI 5111: Control Engineering Concepts
ENGI 5211: Robust Control
ENGI 5411: Intelligent Control
ENGI 5631: Advanced Topics in Electrical and Computer Engineering
ENGI 5732: Nonlinear Control
ENGI 5733: Robotics
ENGI 5734: Natural Language Processing
ENGI 5735: Advances in Semiconductor Materials
ENGI 5736: Nanostructured Materials
ENGI 5273: Mechatronics
CS 5313: Artificial Intelligence

(b) Research Supervision

Each student will be assigned a supervisor, (and optionally a co-supervisor) at the point of admission by the Engineering Graduate Studies and Research Committee. Supervision of all graduate students will be provided by their supervisor. Students are required to report their progress to their supervisor on a mutually agreed upon basis.

After completion of the course work and before taking the comprehensive examination, the student, in consultation with his/her supervisor, will form a Supervisory Committee consisting of at least three, and normally no more than six, faculty members as follows:

- The supervisor, along with the co-supervisor if there is one.
- Two faculty members from Lakehead University knowledgeable in the student's research area, no more than one of whom can be external to the Electrical and Computer Engineering Doctoral Supervisory list.
- In addition, at a later time but before the doctoral defence, one external member from outside Lakehead University will be added to the committee. This external member should have expertise in the area of research of the thesis and not be acquainted with the student. Selection of the external examiner will be made by the Supervisor, in consultation with the Graduate Coordinator.

(c) ENGI 6701 Comprehensive Examination

The comprehensive examination experience serves two main purposes. First, it allows the Supervisory Committee to examine and approve the student's dissertation proposal. Second, it allows the Supervisory Committee to verify that the student has a broad knowledge of the general foundations of the chosen field.

The comprehensive examination should be taken after the completion of course work, 8 to 12 months, and no later than 16 months, after the beginning of the doctoral program. It takes place in front of the Supervisory Committee.

To accomplish the first purpose, the student must produce a dissertation proposal submitted to each member of the Supervisory Committee at least one month prior to the examination. This proposal will present the proposed research project, a background review, and all research work done to date. At the beginning of the comprehensive examination, the student will make a 30-minute presentation of the proposal and this will be followed by a question period related to the proposal before the Supervisory Committee.

To accomplish the second purpose, each Supervisory Committee member will ask questions related to the student's research area. The questions will be asked orally during the examination.

At the end of the Comprehensive Examination, the Supervisory Committee must decide whether the student passes the examination, fails the examination, or must be re-examined.

If the student fails the comprehensive examination, the student will be withdrawn from the Doctoral program. Students admitted to a Doctoral program without completion of a Master's program who fail the Comprehensive Examination will be permitted, at the discretion of the academic unit, to change their program to the Master's in Electrical and Computer Engineering.

(d) ENGI 6710 PhD Seminar

The PhD seminar experience serves two main purposes. First, it allows the candidate to describe his/her research progress. Second, it allows the candidate to become familiar with research done in other areas of Electrical and Computer Engineering.

The Seminar should be taken after the successful completion of the comprehensive exam, 20 to 24 months, and no later than 28 months, after the beginning of the doctoral program. It is chaired by the Supervisor.

To accomplish the first purpose, the candidate will prepare and make a 30-minute presentation on his/her research work, which will include a comprehensive background of the research area, the objectives of the research project, the latest progress since the comprehensive exam, and the planned work leading to the defence.

To accomplish the second purpose, the candidate will attend the seminar presentations of other students in the PhD program in Electrical and Computer Engineering. Prior to registering for his/her own seminar, the candidate must have attended at least 6 seminars or acceptable alternatives.

(e) Dissertation and Oral Defence

The doctoral defence is the final evaluation of a doctoral candidate's work. It must take place at most three years after the comprehensive examination. Please see the Faculty of Graduate Studies PhD regulations regarding the preparation of the dissertation and oral defence for general information.

The dissertation must be received and reviewed by the Supervisory Committee before the oral defence can take place. Based on their review of the dissertation, the Supervisory Committee will decide among the four possible outcomes:

- Dissertation Accepted.
- Dissertation Accepted with Minor Revisions.
- Dissertation Accepted with Major Revisions.
- Dissertation Rejected.

The dissertation must be either "accepted", "accepted with minor revisions" or "accepted with major revisions" before the student is allowed to proceed to the oral defence.

After the oral defence, the Supervisory Committee will decide among the four possible outcomes:

- Oral Defence Accepted.
- Oral Defence Accepted with Minor Revisions.
- Oral Defence Accepted with Major Revisions.
- Oral Defence Rejected.

(f) Period of Studies

The typical full-time student is expected to complete the doctoral program in 4 years (twelve terms). As shown in the following timeline, the first year (three terms) would be

spent doing coursework and preparing for the comprehensive exam. The next two years (six terms) would be spent doing research and satisfying the other requirements. The final year (three terms) would be used to write the dissertation and prepare the defence.

Year 1 Fall: Initial registration, course work and background review
Year 1 Winter: Course work, background review, and selection of the committee
Year 1 Spring/Summer: Preliminary research work and thesis proposal redaction
Year 2 Fall: Comprehensive examination and research work
Year 2 Winter: Research work
Year 2 Spring/Summer: Research work and research seminar
Year 3 Fall: Research work
Year 3 Winter: Research work
Year 3 Spring/Summer: Research work
Year 4 Fall: Dissertation writing
Year 4 Winter: Dissertation writing and defence
Year 4 Spring/Summer: Corrections to dissertation and final submission

(g) Residency Requirements

Doctoral candidates in this program are expected to be on campus at Lakehead University for the duration of their doctoral program. Exceptions are allowed if:

- The candidate needs to take a course that is offered at another university but not at Lakehead University and that cannot be taken through distance education. (Given the geographic distance between Lakehead University and other Ontario universities, it is accepted that the candidate will not reside at our campus during the semester that course is taking place.)

- The research project requires using equipment or facilities not available at Lakehead University. (The candidate thus needs to work on-site at an off-campus location to do their research.)

PROGRAM

To fulfill the degree requirements, students must complete a total of eight (8) full course equivalents (FCE) at the graduate level consisting of the following components:
(a) Three half-credit graduate-level courses (worth 0.5 FCE each) (see: Academic Regulations (a) Course Requirements)
(b) PhD Seminar (ENGI 6710) (worth 0.5 FCE)
(c) Comprehensive Examination (ENGI 6701) (worth 1.0 FCE)
(d) Thesis Proposal and Seminar (ENGI 6901) (ENGI 9900) (worth 5.0 FCE)

DESCRIPTION OF NEW COURSES

ENGI 5732

Nonlinear Control

Credit weight: 0.5

Description: Students will learn about nonlinear models and nonlinear phenomena, Lyapunov stability, input-output stability, passivity, advanced stability analysis, stability of perturbed systems, feedback linearization, and nonlinear design tools.

Offering: 3-1.5 or 3-1.5

ENGI 5733

Robotics

Credit weight: 0.5

Description: Students will learn about D-H representation, forward kinematics, inverse kinematics, jacobian, Euler-Lagrange method, and Newton Euler method. This knowledge will be applied to the design of controls for robot manipulators.

Offering: 3-1.5 or 3-1.5

ENGI 5734

Natural Language Processing

Credit weight: 0.5

Description: Students will learn about the fundamentals of linguistics and of statistical inference in language, and how to apply statistical methods to basic tasks such as word sense disambiguation, part-of-speech tagging, and parsing. Students will explore recent work in advanced topics such as machine translation, information retrieval from text, and text categorization.

Offering: 3-1.5 or 3-1.5

ENGI 5735

Advances in Semiconductor Materials

Credit weight: 0.5

Description: Students will study advanced semiconductor materials based on compound alloys such as arsenides, phosphides, and nitrides. The properties of semiconductor materials - electrical and optical - will be determined on the basis of their electron band structures. Special attention will be given to calculation of the electron band structures on the ternary and quaternary semiconductor compound alloys and determination of the properties. New phenomena in the disordered alloys such as tunnel optical absorption and excitons of the structure will be studied.

Notes: Students who have successfully taken CHMS 5111 cannot register for this course.

Offering: 3-1.5 or 3-1.5

ENGI 5736
Nanostructured Materials
Credit weight: 0.5
Description: Students will study the properties of the nanostructures determined on the basis of their electron band structures, which will be calculated on the basis of Linear Combination of Atomic Orbitals (LCAO) method. Special attention will be given to calculation of the electron band structures of two-dimensional nanostructures and the related new phenomena connected with obtaining of relativistic particles in these structures.
Offering: 3-1.5 or 3-1.5

ENGI 6710
PhD Seminar
Credit weight: 0.5
Description: Students will gain experience in organizing and presenting the results of their scientific research to an audience of fellow scholars, and will become familiar with other scientific research in Electrical and Computer Engineering by attending the seminars of other students.
Notes: May only be taken by PhD students in Electrical and Computer Engineering. Must be taken no later than the seventh semester of their PhD program.
Grade Scheme: Pass/Fail
Offering: 1-0 or 1-0

ENGI 6701
PhD Comprehensive Examination
Credit weight: 1.0
Description: The comprehensive examination will assess the student's general preparedness for the PhD degree and specific areas in his or her chosen area of study and research. The exam will also assess the student's ability to integrate material from divergent areas, to reconcile theoretical, methodological and empirical issues, and to think critically and creatively.
Notes: May only be taken by PhD students in Electrical and Computer Engineering. Must be taken no later than the fourth semester of their PhD program.
Grade Scheme: Pass/Fail
Offering: 1-0 or 1-0

ENGI 6901 (9900)
PhD Dissertation
Credit weight: 5.0
Grade Scheme: Pass/Fail

Appendix F: General Graduate Studies Regulations

(As of June 18, 2012, revisions to these regulations are currently in progress)

FACULTY OF GRADUATE STUDIES

Dean of Graduate Studies

Dr. T. Philip Hicks

The University offers programs leading to the following degrees:

Master of Arts
Master of Business Administration
Master of Education
Master of Environmental Studies
Master of Forestry

Master of Science
Master of Science in Engineering
Master of Science in Forestry
Master of Science in Management
Master of Public Health
Master of Social Work

Doctor of Philosophy in Biotechnology
Doctor of Philosophy in Clinical Psychology
Joint Doctor of Philosophy in Educational Studies
Doctor of Philosophy in Forest Sciences

The University also offers collaborative programs with the following specializations:

Specialization in Gerontology
Specialization in Women's Studies

The University also offers programs which include the following graduate diploma:

Not all courses listed in the Calendar are offered every year. Supplementary information regarding course offerings and course instructors is available from the Office of the Registrar and posted in the online Course Timetable.

Courses not offered this academic year (fall/winter terms) are indicated by the words "NOT OFFERED THIS YEAR" below the course description. Nevertheless, students should refer to the Timetable as a final check.

Introduction to the Faculty of Graduate Studies

Responsibility for graduate studies resides with the Senate of the University. The Senate is advised on graduate matters by the Faculty of Graduate Studies Council. This Council is administered through the Office of Graduate Studies. It is the responsibility of this Council, through its Chair, to provide leadership in all matters pertaining to graduate studies.

Graduate Programs

The University offers courses of study leading to the following graduate degrees:
- Master of Arts (MA) in Clinical Psychology, Economics, English, History, Mathematical Sciences, Sociology;

- Master of Science (MSc) in Biology, Chemistry, Computer Science, Experimental Psychology, Geology, Kinesiology, Mathematical Sciences, Physics;

- Master of Education (MEd) in Educational Studies;

- Master of Science in Engineering (MScEng) in Control Engineering, Electrical and Computer Engineering, Environmental Engineering;
- Master of Environmental Studies (MES) in Nature-Based Recreation and Tourism, Northern Environments and Cultures;

- Master of Forestry (MF)

- Master of Science in Forestry (MScF);

- Master of Social Work (MSW)

- Master of Public Health (MPH)

- Master of Business Administration (MBA)

- Master of Science in Management (MSc(Mgt))

- Doctor of Philosphy (Ph.D.) in Biotechnology, Clinical Psychology, Educational Studies, Forest Sciences.

Collaborative Programs

- Specialization in Gerontology (Education, Kinesiology, Psychology, Social Work, Sociology)
- Specialization in Women's Studies (Education, English, History, Psychology, Public Health, Social Work, Sociology)

To be accepted into a Collaborative Program, students must first be admitted to the master's program of a collaborating academic unit.

Graduate Diploma

-Health Services and Policy Research

The Graduate Diploma in Health Services and Policy Research is offered in conjunction with a master's or doctoral degree (Economics, Public Health, Social Work, Sociology).

DOCTORAL REGULATIONS

The requirements of each doctoral program are described in sections of the Calendar under the heading for the academic unit. A doctoral student is governed by the general University regulations (pages 39-43 of the Calendar) as well as the following regulations, which are specific to doctoral students.

GENERAL ADMISSION REQUIREMENTS

Application for admission to a doctoral program must be made to the Office of Graduate Studies, Lakehead University by the deadline date of **January 15**. Late applications may be considered for admission, but may not be considered for funding.

Applicants for admission must be graduates of a recognized university and show evidence of scholarly achievement. Except where otherwise stated in the Admission Requirements of a particular program, students must have a Masters degree or its equivalent with an academic average as specified by the academic unit. An applicant holding a degree other than one in the discipline area to which admission is sought will be considered on the basis of Master's courses taken and academic standing. A Qualifying Year may be required at the Masters level to meet the admission standards. Courses taken as part of a Qualifying Year cannot be used as credit towards a doctoral degree.

Applicants applying from a university other than Lakehead University must forward official transcripts of their university record and may be required to take an examination, such as the Graduate Record Examination (GRE).

Meeting the minimum requirements does not necessarily guarantee admission. No candidate will be admitted unless the academic unit recommends admission. All applicants will be advised in writing by the Office of Graduate Studies of their admission status.

ADVANCED STANDING

With the consent of the academic unit, applicants may be granted Advanced Standing for up to one graduate level full course equivalent. No advanced credit from previous study will be given for undergraduate courses. Courses credited towards a previous degree or Qualifying Year cannot be considered for Advanced Standing. No credit will be given for a course with a grade lower than 'B'.

Requests for Advanced Standing must be submitted and approved at the time of admission to the program. To be considered for Advanced Standing, students must submit a formal request to the Office of Graduate Studies, along with the official transcript and institutionally prepared course description(s).

PROFICIENCY IN THE ENGLISH LANGUAGE

The language of instruction at Lakehead University is English. Students whose first language is not English must demonstrate that they can cope with the langugage demands of an English language university. Applicants whose native language is not English, and who cannot verify having studied in an English language school system for more than three full years, will be required to present proof of English facility by:

1. Achieving appropriate standing on one of the following tests:

TEST	Minimum Score
TOEFL - Test of English as a Foreign Language	
TOEFL paper based	550 (with no component score less than 50)
TOEFL computer based	213 (with no component score less than 17)

TOEFL internet based	80 (with no component score less than 19)
IELTS - International English Language Testing System	6.5 (no individual band score less than 6.0)
MELAB - Michigan English Language Assessment Battery	85
CAEL - Canadian Academic English Language Assessment	60

Or

2. Successfully completing the English for Academic Purposes (EAP) program offered jointly by Confederation College and Lakehead University. For more information, see Admission Requirements and Registration, Requirements for Admission to Graduate Degree Programs, page 42.

Certain academic units may require higher scores. Meeting the minimum requirements does not guarantee admission to Lakehead University.

Where the language of instruction and examination in undergraduate studies has been uniformly in English, official documentation from the institution indicating that the primary medium of instruction is English must be submitted upon request. This official documentation must come directly from the institution in the form of an official letter that states that the student's medium of instruction was English for 3 years or more. This letter must be signed by the institution's Registrar or Chief Officer. This letter must also bear the original stamp or seal of the institution or a Notary Public.

Lakehead University's Institution Code for TOEFL scores is 0888.

READMISSION TO A GRADUATE PROGRAM

Students applying to enter a graduate program, who have previously withdrawn from a graduate program, must apply for re-admission to the program and pay the application fee. Students will be credited with previous courses completed and work undertaken towards completion of program requirements at the discretion of the academic unit. The academic unit may decline to allow previously completed courses to be credited towards the graduate program applied for and/or may require a previous dissertation topic to be changed in whole or in part. The academic regulations and program requirements in effect at the time of re-admission shall apply. The allowable time-to-

completion will include all previous terms in the program. Students who have reached their time limit in the program at the point of re-admission must complete the program within three consecutive terms.

REGISTRATION STATUS

Full-Time Graduate Student

A full-time graduate student must:

1. be designated by the University as a full-time graduate student;
2. be pursuing his or her studies full-time; and
3. normally, be geographically available and visit the campus regularly.

Without forfeiting full-time status, a graduate student, while still under supervision, may be absent from the university (e.g. visiting libraries, doing field work, attending a graduate course at another institution) provided that, if any such period of absence exceeds four weeks in any one term, written evidence shall be available in the Office of Graduate Studies to the effect that the absence has the approval of the supervisor and the Graduate Coordinator of the academic unit.

Graduate Student Employment

In accordance with the Ontario Council on Graduate Studies policy, the University recommends that a full-time graduate student will normally not be employed for more than an average of ten hours per week for any term. When the student is employed as a Graduate Assistant, the ten hours per week should represent the total time spent by the student in connection with this appointment. Requests for exceptions to this rule must be approved by the Dean of Graduate Studies.

REGISTRATION AND SELECTION OF COURSES

A student is not permitted to register as a doctoral student until the application for admission has been approved. A graduate student proceeding to a degree is governed by the academic regulations and program requirements in effect in the term of admission.

Before registering, students proceeding to a doctoral degree must arrange their program with the assistance of the Graduate Coordinator of the program. Graduate students must complete all registration and withdrawal from courses by the published deadlines in the Academic Schedule of Dates. Late registration fees will apply after these dates. Any change in registration after the published deadlines must be formally requested on a "Graduate Request for Program Change/Withdrawal" form.

The calendar year is divided into three terms: **Fall Term** (September-December); **Winter Term** (January-April) and **Spring/Summer Term** (May-August). Graduate students registering for the first time normally commence their program in the Fall Term. However, in some academic units students are permitted to commence their studies in January or May.

Registration is not complete until tuition and activity fees have been paid (or arrangements have been made to pay all fees) by the deadlines published in the "University Fees" section of the Calendar. Default in fee payment may result in a student being de-registered. A student with amounts owing to the University will not be permitted to register in future sessions nor to receive a transcript or record of academic progress.

CONTINUANCE OF REGISTRATION

All graduate students must maintain continuous registration from initial registration until they have completed the requirements of their program, including submission of the final dissertation copies to the Office of Graduate Studies. It is the **student's** responsibility to ensure he/she is registered by the appropriate deadline for each term. Students who have failed to register by the deadline and have not applied for a Leave of Absence will be registered in a University placeholder course and will be assessed appropriate fees.

Students who have failed to register for two consecutive terms will be considered to have left the program and will be withdrawn. Students wanting to complete their program must apply for re-admission and pay the application fee.

WITHDRAWAL FROM PROGRAM

Students wanting to withdraw from a graduate program must complete and submit a "Graduate Request for Program Change/Withdrawal" form to the Office of the Registrar. Students who fail to do so will be registered in an University placeholder course and will be assessed appropriate fees.

PERIOD OF STUDY

Doctoral Programs

Biotechnology:

Students are expected to complete all requirements within a minimum of nine terms (3 years) to a maximum of twelve terms (4 years) of continuous full-time registration. Candidates must meet a minimum residency of three terms, two of which must be consecutive.

Clinical Psychology:

Students are expected to complete all requirements within a minimum of nine terms (3 years) to a maximum of fifteen terms (5 years) of continuous full-time registration. Candidates must meet a minimum residency of nine terms, all of which must be consecutive.

Educational Studies:

Students are expected to complete all requirements within a minimum of nine terms (3 years) up to a maximum of eighteen terms (6 years) of continuous full-time registration. Candidates must meet a minimum residency of four terms, two of which must be consecutive.

Forest Sciences:

Students are expected to complete all requirements within a minimum of nine terms (3 years) up to a maximum of twelve terms (4 years) of continuous full-time registration. Candidates must meet a minimum residency of three terms, two of which must be consecutive.

Sociology:
Students are expected to complete all requirements within a minimum of nine terms (3 years) up to a maximum of fifteen terms (5 years) of continuous full-time registration. Candidates must meet a minimum residency of six terms, all of which must be consecutive.

LEAVE OF ABSENCE
A **Leave of Absence** from a doctoral program will be granted only for exceptional circumstances, which will include: a limited term of external employment closely related to the program of study; health programs, parenting; compassionate grounds or other compelling circumstances. Leaves of Absence will be considered up to a four term limit.

A **Maternity/Parental Leave of Absence** from a graduate program will be granted to students that are either biological or adoptive parents, while they are caring for a new-born or newly adoptive child of any age. Maternity/Parental Leaves of Absence will be considered up to a three term limit per pregnancy or adoption and are in addition to any other Leave of Absence terms granted.

All Leave of Absence requests will be considered on an individual basis on the recommendation of the academic unit by the Faculty of Graduate Studies Council. A "stop-the-clock" policy will prevail with respect to payment of tuition fees and Period of

Study. A graduate student granted a Leave of Absence will not have access to University faculty, library, laboratory or other facilities.

TIME EXTENSION

A Time Extension in a Doctoral program will be granted for exceptional circumstances on a per term basis up to a four term limit.

First Term Time Extension

Recommendations for the first term beyond the allowed Period of Study originates with the Supervisor for approval by the academic unit. It is the responsibility of the academic unit to send notice, including reasons for this approval, to the Office of Graduate Studies.

Second Term up to Fourth Term Time Extensions

Recommendations for the second term up to the fourth term beyond the allowed Period of Study will be forwarded by the academic unit to the Faculty of Graduate Studies Council for consideration and final approval.

A graduate student who does not complete all requirements within one of the prescribed Periods of Study and does not receive an approved Time Extension is considered to have failed the program, unless the student applies for and is granted re-admission to the program.

A graduate student who does not successfully complete a Doctoral degree within the prescribed Period of Study and after all approved Time Extensions, must apply for re-admission to the program and pay the application fee. The academic regulations and program requirements in effect at the time of re-entry to the acadmeic program shall apply.

WAIVER OF FEES DURING AN APPROVED TIME EXTENSION

Waiver of fees during the period of an approved Time Extension will be granted for exceptional circumstances only, which will include such issues as unavailability of supervision, required courses or resources. Cases will be considered on an individual basis by the Faculty of Graduate Studies Council, normally on the recommendation of the academic unit in which the stduent is enrolled. At the time of request for a waiver, the Graduate Coordinator must present a plan to the Council outlinging how and when the issues will be resolved. (see Program Fees page 15).

PROGRAM OF STUDY

The requirements of each Doctoral program are described in sections of the Calendar under the heading for the academic unit. Each student in a Doctoral program shall

comply with any additional requirements of the academic unit in which the student is registered. Individual programs of study must be approved by the appropriate academic unit.

Any change to a student's program must be formally requested on the "Graduate Request for Program Change/Withdrawal" form and approved by the Graduate Coordinator and the Office of Graduate Studies before being submitted to the Office of the Registrar.

Doctoral Dissertation

A Doctoral dissertation must ensure that breadth of knowledge and skills are acquired by doctoral students through highly specialized, independent, original research which makes a distinct contribution of knowledge to the discipline. The dissertation will be on a subject approved by the appropriate academic unit upon the recommendation of the Supervisor following consultation with the student.

The student is required to develop a research proposal for his/her dissertation normally during the first year of the program. The proposal will be reviewed and approved by the Dissertation Committee.

Dissertation Supervisor

A dissertation Supervisor will be appointed at the time of admission by the graduate committee of the academic unit. The Supervisor will be a member of the Faculty of Graduate Studies as Core: Doctoral Supervisory Membership and approved by the Ontario Council on Graduate Studies (OCGS).

Research Ethics and Animal Care Approval

It is the responsibility of the Supervisor to ensure that a dissertation involving human subjects and non-human vertebrates are approved, respectively, by the Senate Research Ethics Board, and the University Animal Care Committee, before a student's research begins. A copy of the approval notice must be submitted by the Graduate Coordinator to the Office of Graduate Studies. A student who has not received ethical approval from one of the above groups and submitted the approval to the Office of Graduate Studies, cannot be approved for graduation.

Dissertation Committee

Each doctoral student shall have the guidance of a Dissertation Committee which will be assembled during the first semester of the initial registration of the student in the Doctoral program. The committee consists of a minimum of three faculty members, at least two of which must be Core members of the Doctoral program with the Supervisor serving as Chair of the committee. The committee will provide research advice, determine the required courses for the student, examine the Doctoral dissertation, and

may serve as members of the comprehensive examination committee. The composition of the Dissertation Committee must be approved by the graduate committee of the academic unit.

GRADING SYSTEM

Course standings in Doctoral programs will be reported as follows:
A+ 90 to 100%

A 80 to 89%

B 70 to 79%

Fail 1 to 69%

F Academic Dishonesty 0

INC Incomplete

MINIMUM SATISFACTORY ACADEMIC STANDING

To maintain registration, a doctoral student must achieve and maintain a minimum academic standing of a 'B' overall average in their courses at all times. A mark of less than 70% in a Doctoral course constitutes failure and such a course (half or full course) may not be repeated. A student whose academic performance does not meet the minimum standing will be required to withdraw from the program.

EXAMINATIONS

Transfer Qualifying Examination

Normally, an applicant to a Doctoral program would be expected to have completed a Master's degree. However, in some programs after the first term of study, students enrolled in a Master's program can request to transfer to a Doctoral program without completion of the Master's program. Students may be required to successfully complete a qualifying examination before being permitted to register in a doctoral program, otherwise the student will remain registered in the Master's program.

A qualifying examination will be arranged as soon as reasonably feasible. The purpose of the qualifying examination is to confirm the student's comprehensive level of competence in fields related to his/her intended field of specialized study. The examination thereby serves as a diagnostic of the student's readiness to undertake Doctoral studies. Upon completion of the qualifying examination, the student will be approved to transfer into the Doctoral program, or in cases of poor comprehensive performance, the student will remain in his/her Master's program.

Special Examinations

Special examinations are not permitted for students in a doctoral program.

Comprehensive Examinations

Comprehensive examinations assess the student's general preparation for the Doctoral degree and assess the knowledge of the student in the research area, the ability to integrate the materials from divergent sources and the ability and potential for carrying out advanced, original research. If the examination has more than one component, all of the components should be completed within a two-week period. It is the responsibilty of each program to develop detailed procedures for the examination.

The examination will be conducted by the graduate program in which the student is enrolled. The examination committee generally consists of three to six members of the Faculty of Graduate Studies with expertise in the area under examination. As stated above, members of the dissertation committee may serve as members of the examination committee. At least one member of the comprehensive examination committee must be external to the dissertation committee. The Graduate Coordinator (or designate) is normally the Chair of the examination committee and is responsible for arranging the comprehensive examination. If the Graduate Coordinator is also the Supervisor, another member of the Graduate Faculty will be appointed as Chair.

Upon completion of the comprehensive examination, the committee will discuss and vote on the performance of the student. If more than one member of the committee votes negatively, the student is deemed to have failed the examination. The examination committee has the authority to grant a second attempt which must be conducted within six months after the failed attempt. If the student fails the second attempt the student will be withdrawn from the Doctoral program. Students admitted to a Doctoral program without completion of a Master's program who fail the Comprehensive Examination will be permitted, at the discretion of the academic unit, to change their program to the Master's level.

Dissertation Examinations

The examination of a dissertation consists of three phases (see below for details): (1) the internal examination; (2) the external examination by a scholar external to the unversity with experience relevant to the research areas; and (3) the oral defense of the dissertation.

Doctoral students must first submit their dissertation for internal examination after which it can be submitted to an External Examiner. Once both the Internal and External

Examiner's reports have been received by the Office of Graduate Studies, with passing outcome, the student can take the oral examination of their dissertation.

If the outcome is unfavourable, the Dissertation Committee Chair shall instruct the Dean of Graduate Studies to arrange for the reconsideration of the dissertation. When the dissertation is resubmitted, the Office of Graduate Studies must: (a) resubmit copies to both examiners, instructing them to submit their evaluations by a specified date; (b) send copies of the letter to the examiners to the Graduate Coordinator and the Dissertation Supervisor.

In assessing the dissertation, the Internal and External Examiners will make one of the following reports to the Office of Graduate Studies:

1. Accepted
2. Accepted Subject to Revisions
3. Appreciable Revisions Required - A dissertation considered to require appreciable revisions is returned in revised form to the Examiner or re-evaluation through the Office of Graduate Studies.
4. Rejected - With the permission of the Dissertation Committee, the candidate whose dissertation is rejected by either of the examiners will have the option to resubmit the revised dissertation to the original examiner or to an alternative examiner using the above criteria for approval of the Examiner.

The final decision on accepting a dissertation is made by the Dissertation Committee after considering the reports of the Internal and External Examiners. A student has failed the program if the dissertation is rejected following re-examination and consideration by the Dissertation Committee.

Copy Submitted for Examination

The dissertation must be free from typographical, grammatical and other errors when submitted to the Office of Graduate Studies for examination. While this is the responsibility of the student, Supervisors should not sign off on the dissertations that are not as error free as possible.

Internal Examination

Once the Dissertation Committee has determined that the dissertation is complete, it is submitted to the Internal Examiner. The Internal Examiner is appointed following a procedure established by the academic unit. The Internal Examiner's report is submitted to the Office of Graduate Studies and to the Supervisor who will make it available to the

student as soon as possible. The dissertation may be submitted for external review only if the Internal Examiner has required no more than minor modifications or corrections to the dissertation.

External Examination

At least three (3) months before graduation the completed dissertation is sent to the External Examiner. The External Examiner is recommended by the student's Dissertation Committee and approved by the Dean of Graduate Studies. The External Examiner must have experience relevant to evaluating graduate work, and recent scholarly activity in the area of specialization. The External Examiner needs to be at 'arms length' from the program, the Supervisor and the student which means not a close friend, not a regular and current collaborator, not having been supervised recently by, not having been a visitor/teacher for some time at, and not a former colleague.

Following the approval of the External Examiner, a completed dissertation is submitted by the Supervisor, through the Graduate Coordinator, to the Office of Graduate Studies. All correspondence with the External Examiner is conducted by the Office of Graduate Studies. Failure to do so could jeopardize the student's completion of the program. The External Examiner's report is submitted to the Office of Graduate Studies who will forward final instructions along with the report to the Graduate Coordinator and to the Supervisor who will make it available to the student as soon as possible. A candidate may proceed to the oral defense only if the External Examiner's report is submitted to the Office of Graduate Studies who will forward final instructions along with the report to the Graduate Coordinator and to the Supervisor who will make it available to the student as soon as possible. A candidate may proceed to the oral defense only if the External Examiner has required no more than minor modifications or corrections to the dissertation.

Oral Examination

A candidate for a doctoral degree wil be required to take a final oral examination upon completion of the dissertation. All procedures for submission of the completed dissertation, as well as for the examiner's reports shall be satisfied before the Oral Defense is scheduled.

Oral Defense Examination Committee

The Examination Committee for the Oral Defense shall normally consist of:

1. Committee Chair - the Chair shall be appointed by the Dean of Graduate Studies and shall not be a member of the candidate's academic unit. The Committee

Chair ensures that the defense is conducted fairly, in accordance with approved guidelines and procedures and ensures that the defense adheres to the time limits indicated in the guidelines. The chair will only vote in the case of a tie.

2. Graduate Coordinator of the academic unit or designated representative. Where the Graduate Coordinator of the academic unit is also the Supervisor, the Chair of the academic unit shall appoint a designate.

3. Supervisor

4. A minimum of two members of the dissertation committee (in person, by video-conference or teleconference).

5. External Examiner in person, by video-conference, teleconference or by written submission.

Normally, all members of the Oral Defense Examination Committee shall be present. Quorum shall consist of 50% plus one in addition to the Chair. In the case where quorum is not met the defense must be postponed. Members of the University will normally be invited to attend. Prior to the date of the oral defense, the Graduate Coordinator will ensure that each member of the Examination Committee has a copy of the dissertation and copies of the Examiner's reports for their use during the oral defense.

Oral Defense Order of Events

The Oral Defense Examination Committee shall hold an in-camera meeting before the oral defense. The Committee shall review procedures for the oral defense and confirm that required Committee members are in attendance. In consultation with the Committee, the Chair shall determine the order in which Committee members shall ask questions as well as the approximate time to be allotted to questions. The Committee will also determine how any questions raised by the Examiners will be discussed by the candidate.

The following order will be followed for the Oral Defense:

1. The candidate will make a presentation in accordance with discipline guidelines.

2. The Chair will invite members of the Examination Committee and the University community to ask questions. Normally, the total time for questions will be sixty minutes and shall not exceed ninety minutes.

3. The chair will ask members of the University community and the candidate to leave the room.

4. The Chair moderates an in-camera session where the Committee members decide the outcome of the dissertation and defense. This meeting should take no more than sixty minutes. The Committee will attempt to arrive at a decision by consensus, but if consensus is not possible, a vote of a majority of members is required. In the event of a tie, the Chair shall cast the deciding vote.

Oral Defense Outcomes

The Oral Defense Examination Committee shall consider both the oral defense and the dissertation when deciding between the following possible outcomes:

1. Dissertation and Oral Defense Accepted.

   No changes required beyond the correction of typographical errors and other minor corrections of wording. The candidate's Supervisor shall review and approve the corrections before the final copies of the dissertation are submitted to the Office of Graduate Studies.

2. Dissertation and Oral Defense Accepted with Minor Revisions

   Minor revisions are required beyond typographical errors and minor corrections of wording. The candidate's Supervisor shall review and approve the corrections before the final copies of the dissertation are submitted to the Office of Graduate Studies.

3. Dissertation Accepted and Oral Defense Unacceptable

   The candidate may be required to undertake a second oral defense. The Oral Defense Examination Committee Chair shall inform the candidate in writing of the deficiencies in the oral defense and the date of the second oral defense (normally no more than six months).

After the Committee has made its decision, the candidate re-enters the examination room and the Committee Chair conveys the Committee's decision to the candidate. If the decision is favorable, the student proceeds to follow the procedures for submitting the final dissertation copies to the Office of Graduate Studies.

DISSERTATION PREPARATION
General Comments

The University requires that all dissertations conform to the specifications given below. Unless the Dean of Graduate Studies has given his/her consent in advance, departures from these norms will render a dissertation unacceptable.

Originality

Elements of the dissertation that are considered to constitute original scholarship and an advancement of knowledge in the domains in which the research was conducted must be clearly indicated.

Components

The dissertation must include:

1. A detailed table of contents
2. A brief abstract which provides a concise summary of the dissertation (350 words or less)
3. An introduction that clearly states the rationale and objectives of the research
4. A comprehensive review of the literature
5. The methods, results and discussion
6. A final conclusion and summary
7. A thorough bibliography or reference list
8. Appendices, Tables and Figures (if not included previously)
9. An appendix containing an approval of the Research Ethics Board in the case of research involving human subjects or the Animal Care Committee in the case of research involving animal subjects or biohazards.

Title Page

The title page must include:

1. The title of the dissertation
2. The name of the author and academic unit followed by Lakehead University, Thunder Bay, Ontario
   The month and year the thesis was submitted
3. The following statement: "A dissertation submitted in partial fulfillment of the requirements of the degree of..."
4. The universal copyright notice

Acknowledgements

An acknowledgements section may be included.

DISSERTATION FORMATTING

Script and Page Format

The dissertation must be typed using a word processor on standard letter size paper (8.5 x 11"). A conventional font (11-point or 12-point) must be used. Line spacing must be double or 1.5. Left-hand margins should have a width of not less than 1.5 inches to facilitate binding. The right-hand margin need not be justified but it should be well defined at approximately 1 inch. The top and bottom margins should be 1 inch.

Paper and Print Quality

The dissertation must be of laser-print quality or letter quality and be printed on standard quality paper. Candidates are encouraged to make double-sided photocopies for the initial submission of the dissertation for examination. However, at least one of the two copies submitted as the final version must be single-sided.

Pagination, Footnotes, References and Appendices

These should conform to the scholarly style appropriate to the discipline. Consistency of formatting is required throughout the dissertation and carefully checked for correct sequence and completeness. All errors must be corrected before final submission of the dissertation to the Graduate Studies Office. It is the responsibility of the student to ensure that page numbering is correct and that all pages of the dissertation are submitted.

Figures and Illustrations

Figures, tables and graphs should be positioned according to the scientific publication conventions of the discipline. Illustrations must be drawn using an ink that permits microfilming and high quality photocopying. For the same reasons, colour-coding is not recommended for graphs and charts. Charts, graphs, maps and tables that are larger than the standard page should be avoided unless absolutely necessary. Overlays must be meticulously positioned in the text.

Photographs

Photographs may be incorporated into the dissertation. The final (single-sided) copy of the dissertation must be black and white throughout. It must include either high-quality black-and-white photocopies or black-and-white reprints of colour photos. High contrast

black-and-white photos reproduce well. Photographs with a glossy finish and photographs with dark backgrounds should be avoided.

Additional Materials

Slides, tapes and diskettes are to be avoided if possible and can be included only if the candidate authorizes the reproduction of the dissertation without them.

DISSERTATION SUBMISSION PRIOR TO GRADUATION

The final dissertation must be produced in a format acceptable to the academic unit and the Library of Canada, which may include an electronic format that meets OCUL (Ontario Council of University Librarians) standards.

Three unbound copies of the final approved dissertation are to be submitted to the Office of Graduate Studies. At least one copy must contain the "Thesis Topsheet" signed by the Supervisor. The signature will signify that all comments made by Examiners have been considered by the author of the dissertation and specified corrections have been made. In addition, the academic unit must submit the "Departmental Recommendation" of the dissertation and the form indicating that the dissertation is "Ready for Binding'. The student must sign and submit the "License to the University" and the National Library of Canada form.

The graduate student will arrange payment for binding all three copies of the dissertation. One copy will be forwarded to the Library, one to the Supervisor and one to the student. Each student must complete an "Application to Graduate" form and submit it to the Office of the Registrar by the deadline dates published in the Academic Schedule.

Withholding of Dissertation

Occasionally, there are unusual circumstances under which a student may prefer that the dissertation not be published. These circumstances may involve the disclosure of patentable rights in the work before a patent can be granted or similar disclosures detrimental to the rights of the author. They may involve disclosures of facts about persons or institutions before professional ethics would permit such disclosures. With the written explanation and endorsement from the student's supervisor and the Graduate Coordinator of the academic unit, The Dean of Graduate Studies may, under substantiated circumstances of the kind indicated, permit the dissertation to be withheld from the Library for a period of up to one year. Withholding the dissertation will not affect the student's ability to graduate.

FEES FOR GRADUATE STUDENTS

For information regarding payment of fees, deadlines, methods of payment, refund schedule, miscellaneous fees, schedule of fees, co-op fees, and residence fees, see the Fees section of this calendar, pages 11-22.

Appendix G: Template of Student Activity Report

PhD in Electrical and Computer Engineering
Student Activity Report

This report must be completed by all ECE PhD Students for every term that they are enrolled. Complete with all necessary details and add additional pages if necessary. **It is the student's responsibility** to ensure that the supervisor reads and signs the form, and to return the form *fully completed* by the due date to the Graduate Coordinator. The report is due by the end of the second week of each term.

Student name:	
Supervisor name:	
Academic term covered in this report:	

Course work: List all courses taken toward your degree requirements this term, and indicate your final mark.

Research work: Comment on the progress of your research work and major research milestones (objectives, methodology, background research, implementation, experimentations, etc.) during the term.

Publications: List all publications you have submitted, accepted or appeared published over the term. Indicate authorship, title, journal/conference, dates, and pages.

Program milestones: Indicate progress done this term towards your Comprehensive Exam (ENGI 6701), your Seminar (ENGI 6710), or your Dissertation and Defence (ENGI 6109).

Seminar attendance: List all seminars you attended this term that count towards the realization of your Seminar Attendance requirement. These can include ECE PhD oral defence, ECE MSc seminars, presentations by ECE faculty members or visiting scholars, or relevant scientific presentations in other departments. Don't forget to give to your supervisor your signed attendance forms.

Presentations given: List any presentations, formal or informal, delivered over the term. Indicate title, place and date.

Overall progress: Comment on the progress of your academic and/or research work this term, referring to the objectives you set on your previous term report.

Objectives for the upcoming academic term: Outline your proposed academic and/or research objectives for the next term.

Student comments: Include anything, positive or negative, that you feel has had an effect on your academic and/or research performance this term and that should be brought to the attention of the Graduate Coordinator.

Supervisor comments: Comment on the student's academic and/or research performance this term. It is in the interest of the student and the supervisor to give detailed information.

Student signature:		Date:	
Supervisor signature:		Date:	