A proposal to update and reinstitute the Computer Engineering program at Dalhousie University

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1 Introduction

The Department of Electrical and Computer Engineering at Dalhousie University offers a number of Computer Engineering courses (*Systems Analysis*, *Computer Architecture*, *Operating Systems*,[1] *Real Time Systems*, and *Computer Networks*) originally developed by the Department in the early 1990s as part of a Computer Engineering option. At its peak in the late 1990s, the number of Computer Engineering students often equalled or exceeded the number of Electrical Engineering students.

In the early 2000s, the option was turned into a distinct degree (i.e., a Computer Engineering degree as opposed to an Electrical Engineering degree with a Computer Engineering option). However, by 2009, falling enrollment in Computer Engineering and a push to consolidate programs within the Faculty of Engineering resulted in the Computer Engineering degree being returned to its original designation as an Electrical Engineering degree with a Computer Engineering option.

At this time, a long-standing difference between the Associate Universities and the Department over the teaching of Systems Analysis in second year (which many of the Associate Universities were unable or unwilling to offer) was resolved by moving the course into third year.[2] Other changes to the program were made without consideration of their impact on it.

Consequently, students in the Computer Engineering option take an introduction to programming course in Term 1 of their first year and no other computer-related courses until Term 5 of third year. In third year, students take three computer-related courses in Term 5 (Systems Analysis, Data Structures, and Microprocessors) and three in Term 6 (Computer Architecture, Operating Systems, and Design II).[3,4] Not only is this proving to be an overly demanding workload for many students who have an inadequate software background (especially in Term 6), some of them learn halfway through their penultimate year that they have no interest whatsoever in Computer Engineering.

In the summer of 2017, it was revealed that in 2012, during the accreditation of the Electrical Engineering program, the Computer Engineering option was dropped entirely. As a result, students coming to Dalhousie for the Computer Engineering option are now awarded a degree

[1] *Operating Systems* is taught by the Faculty of Computer Science.
[2] For historical reasons, the first two years of all engineering programs are taught at the Associate Universities (of which Dalhousie is one) and the remaining two are taught at Dalhousie. The first two years are referred to as the *Core* and the final two as the *Upper-Division*.
[3] Data Structures and Microprocessors are taught to both Computer Engineering and Electrical Engineering students.
[4] Design II is taken by both Computer Engineering and Electrical Engineering students.

in Electrical Engineering, neither the degree nor the transcript makes mention of Computer Engineering.

Despite these problems (i.e., the limited exposure to software and Computer Engineering concepts prior to third year, the workload in Term 6, and the lack of a Computer Engineering degree), there is an increasing number of students taking Computer Engineering courses in the Department, all of whom are mistakenly expecting some form of recognition on their transcripts or parchment, or both.

The following proposal addresses these three problems with a series of recommendations for changing and reinstituting the Computer Engineering program at Dalhousie University. The changes to the program are based on the sample Computer Engineering program developed by ACM-IEEE for Electrical and Computer Engineering departments (ACM-IEEE, 2016). It is recommended that the Computer Engineering option be reinstituted before these changes are made and, once made, the full Computer Engineering degree be reinstituted.

The remainder of this document describes:

1. The existing Computer Engineering program in light of the sample Computer Engineering program developed by ACM-IEEE for Electrical and Computer Engineering departments (ACM-IEEE, 2016), identifying the courses missing from the Dalhousie program and suggests ways of including them.
2. Two new courses (one Core and the other Upper-Division), the partial redesign of an existing course, and the complete redesign of an existing course to bring the Dalhousie program more in line with the ACM-IEEE program.
3. Ways in which the Upper-Division course offerings can be restructured, the result of the addition of a new Upper-Division course and the need to address the existing Term 6 workload.
4. Why the Department of Electrical and Computer Engineering at Dalhousie University is able to support a Computer Engineering degree at this time.

2 Comparing Dalhousie and ACM-IEEE Computer Engineering programs

2.1 Dalhousie

Students in Dalhousie Computer Engineering are registered as Electrical Engineering students. Rather than taking the full Electrical Engineering program, Computer Engineering students take five distinct courses: *Systems Analysis*, *Data Structures*, *Microprocessors, Computer Architecture*, *Operating Systems, Communication Networks,* and *Real Time Systems*. In addition, they take three computer-related courses as Electrical Engineers: *Computer Methods*, *Microprocessors*, and *Data Structures & Numerical Methods*. The courses common to all Electrical Engineering students and those required by students taking Dalhousie Computer Engineering are shown in Table 1.

The structure of Dalhousie Computer Engineering is such that students take a total of three computer-related courses in Term 5 and two in Term 6. This proving to be an overly demanding workload for many students, especially in Term 6.

Table 1: Dalhousie Computer Engineering courses[5]

Course	Description	Course	Description
Term 1		*Term 2*	
ENGI 1101	Engineering Design & Graphics I	ENGI 1202	Mechanics of Materials
MATH 1280	Engineering Mathematics I	MATH 1290	Engineering Mathematics II
ENGM 1081	Computer Methods	ENGM 1041	Applied Linear Algebra
CHEM 1021	Engineering Chemistry I	PHYC 1290	Physics II
PHYC 1280	Physics I	CHEM 1022	Engineering Chemistry II
Term 3		*Term 4*	
BIOL 1030	Biology for Engineers	ENGI 2203	Engineering Design II
HSTC 1800	History of Engineering I	HSTC 1801	History of Engineering II
ENGM 2101	Applied Vector Calculus	ENGM 2022	Applied Differential Equations
ENGM 2032	Probability and Statistics		Discipline-specific elective 1
ECED 2000	Electric Circuits		Discipline-specific elective 2
ENGI 2102	Thermo-Fluid Engineering I		Discipline-specific elective 3
Term 5		*Term 6*	
ECED 3003	Networks and Systems	CSCI 3120	Operating Systems
ECED 3201	Introduction to Electronics	ECED 3202	Analog Electronics
ECED 3204	Microprocessors	ECED 3403	Computer Architecture
ECED 3401	System Analysis	ECED 3511	Communication Systems
ECED 3500	Signal Analysis	ECED 3600	Modern Control Systems
ENGM 3282	Data Structures & Numerical Methods	ECED 3901	Electrical Engineering Design II
Term 7		*Term 8*	
ECED 4404	Computer Networks & Communications	CPST 3030	Engineering in Society II
ECED 4502	Digital Signal Processing	ECED 4102	Electromechanics
ECED 4513	Communication Networks	ECED 4900	Senior Year Project I
ECED 4901	Senior Year Project II	ECED 4402	Real Time Systems
	Humanities Elective		Technical Elective
	Technical Elective		

2.2 ACM-IEEE Computer Engineering Program

The ACM-IEEE Joint Task Group on Computer Engineering Curricula has developed four sample Computer Engineering program curricula, including, for example, ones for programs offered by universities in the EU and in China. The sample curricula shown here is for programs offered by Electrical and Computer Engineering departments.

The ACM-IEEE program recognizes the importance of software design, with at least one course in programming, data structures, or algorithms in the first five semesters (see Table 2 for the complete program). This is considered a sufficient foundation for higher-level courses in, for example, data communications, embedded systems, and operating systems. Moreover, the level of software education enables students to take electives in Computer Engineering, Computer

[5] Colour-coding: Blue - Computer-related courses taken by both Computer and Electrical Engineering students, Green - Courses unique to Computer Engineering students, and White - Courses common to both.

Science, or both; in fact, the ACM-IEEE Joint Task Group recommends that students not be restricted to taking courses in Electrical Engineering.

Table 2: ACM-IEEE Sample Computer Engineering Program
(Courses highlighted in green are in programming, data structures, or algorithms)

Course	Description	Credit	Course	Description	Credit
Semester 1			*Semester 2*		
MTH 101	Calculus I	3	MTH 102	Calculus II	3
CHM 101	Chemistry I & Lab	4	PHY 101	Physics I	3
CSC 101	Programming I & Lab	4	CSC 102	Programming II & Lab	4
	English Composition I	3	ECE 101	Introduction to ECE	2
	Humanities Elective	3		English Composition II	3
	Total Credit Hours	17		*Total Credit Hours*	15
Semester 3			*Semester 4*		
MTH 201	Calculus III	3	MTH 203	Differential Equations	3
PHY 201	Physics II	3	MTH 204	Discrete Structures	3
ECE 201	Digital Devices & Lab	4	ECE 202	Microprocessors & Lab	4
CSC 201	Data Structures	3	ECE 203	Circuits/Electronics I	3
MTH 202	Linear Algebra	3	MTH 205	Probability & Statistics	3
	Total Credit Hours	16		*Total Credit Hours*	16
Semester 5			*Semester 6*		
CSC 301	Introduction to Algorithms	3	CSC 302	Client/Server Programming	3
ECE 301	Circuits/Electronics II & Lab	4	ECE 303	Signals & Systems	3
ECE 302	Digital System Design & Lab	3	ECE 304	Data Communication	3
	Humanities Elective	3	ECE 305	Computer Architecture	3
				Social Science Elective	3
	Total Credit Hours	13		*Total Credit Hours*	15
Semester 7			*Semester 8*		
ECE 401	CE Design I	2	ECE 402	CE Design II	2
ECE 403	Embedded Systems & Lab	3	ECE 404	Computer Security	3
ENG 401	Writing for Engineers	3	ECE 405	Operating Systems	3
	CE Elective	3		CE Elective	3
	Fine Arts Elective	3		Social Science Elective	3
	Total Credit Hours	14		*Total Credit Hours*	14

2.3 Side-by-side comparison

Although Dalhousie Computer Engineering has undergone no significant changes over the 25 years of its existence, 74 percent of the courses in the sample ACM-IEEE program are met by Dalhousie Computer Engineering. Seven of the eight computer-related courses in Dalhousie Computer Engineering have an ACM-IEEE equivalent (see Table 3).

Table 3: ACM-IEEE courses met by existing Dalhousie courses (Dalhousie computer-related courses highlighted in green)

	ACM-IEEE		Dalhousie
Course	**Description**	**Course**	**Description**
MTH 101	Calculus I	MATH 1280	Engineering Mathematics I
CHM 101	Chemistry I & Lab	CHEM 1021	Engineering Chemistry I
CSC 101	Programming I & Lab	ENGM 1081	Computer Methods
	English Composition I	CPST 3030	Engineering in Society II
	Humanities Elective		Humanities Elective
MTH 101	Calculus II	MATH 1290	Engineering Mathematics II
PHY 101	Physics I	PHYC 1280	Physics I
CSC 102	Programming II & Lab		
ECE 101	Introduction to ECE		
	English Composition II		
MTH 201	Calculus III	ENGM 2101	Applied Vector Calculus
PHY 201	Physics II	PHYC 1290	Physics II
ECE 201	Digital Devices & Lab	ECED 3201	Introduction to Electronics
CSC 201	Data Structures	ENGM 3282	Data Structures & Numerical Methods
MTH 202	Linear Algebra	ENGM 1041	Applied Linear Algebra
MTH 203	Differential Equations	ENGM 2022	Applied Differential Equations
MTH 204	Discrete Structures		
ECE 202	Microprocessors & Lab	ECED 3204	Microprocessors
ECE 203	Circuits/Electronics I	ECED 2000	Electric Circuits
MTH 205	Probability & Statistics	ENGM 2032	Probability and Statistics
CSC 301	Introduction to Algorithms		
ECE 301	Circuits/Electronics II & Lab	ENGI 2203	Engineering Design II
ECE 302	Digital System Design & Lab	ECED 4502	Digital Signal Processing
	Humanities Elective		
	Social Science Elective		
CSC 302	Client/Server Programming	ECED 4404	Computer Networks & Communications
ECE 303	Signals & Systems	ECED 3500	Signal Analysis
ECE 304	Data Communication	ECED 4513	Communication Networks
ECE 305	Computer Architecture	ECED 3403	Computer Architecture
ECE 401	CE Design I	ECED 4900	Senior Year Project I
ECE 403	Embedded Systems & Lab	ECED 4402	Real Time Systems
ENG 401	Writing for Engineers		
	CE Elective		Technical Elective
	Fine Arts Elective		
ECE 402	CE Design II	ECED 4901	Senior Year Project II
ECE 404	Computer Security		
ECE 405	Operating Systems	CSCI 3120	Operating Systems
	CE Elective		Technical Elective
	Social Science Elective		

There are five Computer Engineering specific courses omitted from Dalhousie Computer Engineering; their ACM-IEEE number, description, and contents are:

CSC 102: Intermediate Computer Programming. Object-oriented problem solving, design, and programming; introduction to data structures, algorithm design and complexity.

ECE 101: Introduction to ECE. What it means to be an engineer, engineering ethics, engineering modeling, the design process, areas of ECE, communication skills.

MTH 204: Discrete Structures. Concepts of algorithms, induction, recursion, proofs, logic, set theory, combinatorics, graph theory fundamental to study of computer science.

CSC 301: Introduction to Algorithms. Study of complexity of algorithms and algorithm design; tools for analyzing efficiency; design of algorithms, including recurrence, divide-and-conquer, dynamic programming and greedy algorithms.

ECE 404: Information Security. Basic and advanced concepts in cryptography and network security: symmetric and asymmetric cryptography, key management, wired and wireless network security protocols, network systems security.

There are 17 courses in Dalhousie Computer Engineering that have no direct ACM-IEEE counterpart; this includes ECED 3401, System Analysis (see Table 4).

Table 4: Dalhousie Computer Engineering courses with no ACM-IEEE counterpart

Course	Description	Course	Description
ENGI 1101	Engineering Design & Graphics I		Discipline-specific elective 3
ENGI 1202	Mechanics of Materials	ECED 3003	Networks and Systems
CHEM 1022	Engineering Chemistry II	ECED 3202	Analog Electronics
BIOL 1030	Biology for Engineers	ECED 3401	System Analysis
HSTC 1800	History of Engineering I	ECED 3511	Communication Systems
ENGI 2102	Thermo-Fluid Engineering I	ECED 3600	Modern Control Systems
HSTC 1801	History of Engineering II	ECED 3901	Electrical Engineering Design II
	Discipline-specific elective 1	ECED 4102	Electromechanics
	Discipline-specific elective 2		

3 Proposed changes

The current structure of Dalhousie's four-year Electrical Engineering program precludes meeting all the courses listed in the sample ACM-IEEE program. However, by rearranging and redesigning existing courses and introducing new courses, it becomes possible to achieve more of the ACM-IEEE Computer Engineering program's recommendations.

The previous reports proposed five changes to Dalhousie Computer Engineering based on the sample ACM-IEEE program:

ENGM 3282: Data Structures and Numerical Methods: This course is to be migrated, with potential changes, to Term 4 starting in the 2018-2019 academic year. All Associate Universities participating in the existing Computer Engineering program have agreed to this change.

ECED 24xx: Introduction to Computer Engineering: An introductory course in Computer Engineering created by combining CSC 102 (Programming II & Lab) and ECE 101 (Introduction to ECE). It introduces students to Computer Engineering concepts, more complex software design methods, and computer systems. This would need to replace an existing Term 4 course. An overview of the course is given in Appendix 1.

Since this is a Term 4 course, it would need to be mounted by any Associate University participating in the Computer Engineering program. An on-line version of the course could be offered to students at Associate Universities unable to mount the course; alternatively, it could be offered by Dalhousie during the summer, between Terms 4 and 5.

ECED 34xx: Introduction to Algorithms: A course examining advanced structures and algorithms, enabling students to design better software solutions. It combines the material covered in MTH 204 (Discrete Structures) and CSC 301 (Introduction to Algorithms). This new course would replace ECED 3403 (Systems Analysis).

ECED 4402: Real Time Systems: The existing Real Time Systems course would continue to increase its focus on embedded systems, based on ECE 403 (Embedded Systems & Lab) recommendations.

ECED 44xx: Computer Security: A course in computer security, examining the physical, cyber, and human aspects of computer security. The course would be based on the contents of ECE 404 (Information Security). This would mean replacing an existing third or fourth year ECED (non-computer Electrical Engineering) course.

It has been suggested this course should be an elective in order to increase the number of electives available to Computer Engineering students. Given the importance of computer security, it should be a required, not elective, course for all students in Dalhousie Computer Engineering.

4 Incorporating the changes

Three different term structures are now considered. The structure of each ensures that there are no changes to the sequence or number of non-Computer Engineering courses.

In all cases, ENGM 3282 (Data Structures and Numerical Methods) is moved from Term 5 to Term 4, ECED 2xxx (Introduction to Computer Engineering) is taught in Term 4, and ECED 34xx (Introduction to Algorithms) replaces ECED 3401 (Systems Analysis).

4.1 Eight-term structure

The eight-term structure includes the same courses, in the same order, as in existing Dalhousie Computer Engineering described in Table 3, with the exception that the course in Computer Security is added to Term 8 (see Table 5).

As a result, Terms 6 through 8 all have six courses. Although the eight-term structure is designed for co-op, terms can be taken out-of-sequence: Term 5 (Fall), Term 7 (Winter), Term 6 (Summer), and Term 8 (Fall).

A total of 23 courses are to be taken.

Table 5: Upper-Division eight-term program
Changes are highlighted (Green – new or modified course)

Course	Description
Term 5 - Fall	
ECED 3003	Networks and Systems
ECED 3201	Introduction to Electronics
ECED 3204	Microprocessors
ECED 3401	Introduction to Algorithms
ECED 3500	Signal Analysis
Term 6 - Summer	
CSCI 3120	Operating Systems
ECED 3202	Analog Electronics
ECED 3403	Computer Architecture
ECED 3511	Communication Systems
ECED 3600	Modern Control Systems
ECED 3901	Electrical Engineering Design II
Term 7 - Winter	
ECED 4404	Computer Networks and Communications
ECED 4502	Digital Signal Processing
ECED 4513	Communication Networks
ECED 4901	Senior Year Project II
Humanities Elective	
Technical Elective	
Term 8 - Fall	
CPST 3030	Engineering in Society II
ECED 4102	Electromechanics
ECED 4900	Senior Year Project I
ECED 4402	Embedded Systems
ECED 4xxx	Computer Security
Technical Elective	

Advantages: No changes are required to the order or structure of the existing Computer Engineering program. Term 7 can be taken between Terms 5 and 6.

Disadvantages: The course-load in Term 6 remains unchanged (i.e., three software related courses) and needs to be addressed.

4.1 Nine-term structure with co-op

The eight-term structure described in the previous section has the known disadvantage of requiring the Computer Engineering students to take three demanding software-related courses in Term 6: CSCI 3120 (Operating Systems), ECED 3403 (Computer Architecture), and ECED 3901 (Electrical Engineering Design II). To address this, a nine-term structure is proposed.

The nine-term structure (Table 6) teaches the same courses as the eight-term structure, in same order, with following exceptions:

- CSCI 3120 (Operating Systems) is taught in Term 7 rather than Term 6. This reduces the course-load in Term 6 to five courses. The Operating Systems course is taught each term by the Faculty of Computer Science, so the course will be available in Term 7.
- The Technical Elective in Term 7 is moved to Term 9.
- CPST 3030 (Engineering in Society II) is taught in Term 9 rather than Term 8. This ensures that students opting not to take the third Technical Elective (see below) take at least three courses per term.
- A third Technical Elective can be taken in Term 9. This is in keeping with the Electrical Engineering program which has three Technical Electives.
- The capstone (senior year) project is taught without the four-month summer break. This could be of interest to potential industrial partners.

As with the eight-term program, the nine-term program is designed for co-op, with work-terms between Terms 5 and 6, Terms 6 and 7, and Terms 7 and 8. Unlike the eight-term structure, no more than five courses are taught per term.

The opportunity to take a third Technical Elective may be of interest to some co-op students.

The proposed nine-term program could be adopted unofficially for interested students as Term 7 if the eight-term program is split into Terms 7 and 9 in the nine-term program.

A total of 24 courses are to be taken.

Table 6: Upper-Division nine-term structure
Changes are highlighted (Green: new or modified course; Blue: new term)

Course	Description
Term 5 - Fall	
ECED 3003	Networks and Systems
ECED 3201	Introduction to Electronics
ECED 3204	Microprocessors
ECED 3401	Introduction to Algorithms
ECED 3500	Signal Analysis
Term 6 - Summer	
ECED 3202	Analog Electronics
ECED 3403	Computer Architecture
ECED 3511	Communication Systems
ECED 3600	Modern Control Systems
ECED 3901	Electrical Engineering Design II
Term 7 - Winter	
CSCI 3120	Operating Systems
ECED 4404	Computer Networks and Communications
ECED 4502	Digital Signal Processing
ECED 4513	Communication Networks
Humanities Elective	
Term 8 - Fall	
ECED 4102	Electromechanics
ECED 4900	Senior Year Project I
ECED 4402	Embedded Systems
ECED 4xxx	Computer Security
Technical Elective	
Term 9 - Winter	
CPST 3030	Engineering in Society II
ECED 4901	Senior Year Project II
Technical Elective	
Technical Elective	

Advantages: The course-load in Term 6 is addressed. Each terms has a maximum of five courses. The opportunity to take an additional Technical Elective may be seen as an advantage to some students.

Disadvantages: Students take an extra term.

4.2 Nine-term structure without co-op

For students not registered in co-op, the nine-term structure can be reordered with Term 7 inserted between Terms 5 and 6. This requires Terms 5 through 9 to be taken without a break (Table 7).

Table 7: Reordered Upper-Division nine-term structure with Term 7 taken before Term 6 Changes are highlighted (Green: new or modified course; Blue: new term)

Course	Description
Term 5 – Fall	
ECED 3003	Networks and Systems
ECED 3201	Introduction to Electronics
ECED 3204	Microprocessors
ECED 3401	Introduction to Algorithms
ECED 3500	Signal Analysis
Term 7 – Winter	
CSCI 3120	Operating Systems
ECED 4404	Computer Networks and Communications
ECED 4502	Digital Signal Processing
ECED 4513	Communication Networks
Humanities Elective	
Term 6 - Summer	
ECED 3202	Analog Electronics
ECED 3403	Computer Architecture
ECED 3511	Communication Systems
ECED 3600	Modern Control Systems
ECED 3901	Electrical Engineering Design II
Term 8 - Fall	
ECED 4102	Electromechanics
ECED 4900	Senior Year Project I
ECED 4402	Embedded Systems
ECED 4xxx	Computer Security
Technical Elective	
Term 9 - Winter	
CPST 3030	Engineering in Society II
ECED 4901	Senior Year Project II
Technical Elective	
Technical Elective	

Advantages: Other than having no breaks between terms, there is no penalty for not being in co-op. There are no more than five courses per term. The course-load in Term 6 is addressed. The opportunity to take an additional Technical Elective may be seen as an advantage to some students.

Disadvantages: Students take an extra term.

4.3 Nine-term structure reduced to eight-terms

An eight-term structure is possible for students wanting to complete their studies at the end of Term 8 rather than Term 9 by taking terms out-of-sequence, notably, Term 5, Terms 7 and 9 combined, Term 6, and Term 8 (Table 8). However, taking this approach means:

- CPST 3030 is taught in Term 8.
- The third Technical Elective is not available.
- The humanities course must be taken in Term 6 to ensure that no more than six courses are taken per term.
- Terms 6 through 8 have six courses each.

A total of 23 courses are to be taken.

Table 8: Upper-Division eight-term structure with Terms 7 and 9 combined Changes are highlighted (Green: new or modified course; Blue: new term)

Course	Description
Term 5 - Fall	
ECED 3003	Networks and Systems
ECED 3201	Introduction to Electronics
ECED 3204	Microprocessors
ECED 3401	Introduction to Algorithms
ECED 3500	Signal Analysis
Terms 7/9 - Winter	
CSCI 3120	Operating Systems
ECED 4404	Computer Networks and Communications
ECED 4502	Digital Signal Processing
ECED 4513	Communication Networks
ECED 4901	Senior Year Project II
Technical Elective	
Term 6 - Summer	
ECED 3202	Analog Electronics
ECED 3403	Computer Architecture
ECED 3511	Communication Systems
ECED 3600	Modern Control Systems
ECED 3901	Electrical Engineering Design II
Humanities Elective	
Term 8 - Fall	
CPST 3030	Engineering in Society II
ECED 4102	Electromechanics
ECED 4900	Senior Year Project I
ECED 4402	Embedded Systems
ECED 4xxx	Computer Security
Technical Elective	

Advantages: The course of study can be completed in eight terms. Operating Systems has been removed from Term 6.

Disadvantages: The Senior Year Project is delayed over the summer and taken out-of-sequence. Only two Technical Electives are available. The course-load increases in Term 6 to accommodate the Humanities Elective.

5 Reinstating the Computer Engineering program

If Dalhousie's existing Computer Engineering program is updated to meet more of the 2016 ACM-IEEE Computer Engineering curricula recommendations, it should be able to justifiably say that it has sufficient courses for an undergraduate degree in Computer Engineering.

Most, if not all, of the instructors teaching the Computer Engineering courses have a background in some area of information technology.

6 Summary

The changes described in this report are based on the 2016 ACM-IEEE Computer Engineering curricula recommendations. Although the entire set of ACM-IEEE recommendations cannot be implemented, the ones described in this report fulfill many of them:

- By moving the *Data Structures and Numerical Methods* course to second year, Dalhousie Computer Engineering students are exposed to intermediate-level software structures earlier in their training. This reduces the software-related course-load in Term 5 and prepares the Computer Engineering students for higher-level courses such *Introduction to Algorithms* in Term 5. It is also more in line with other Computer Engineering degree programs (although it would typically taught be in Term 2 rather than Term 4).
- The proposed *Introduction to Computer Engineering* course introduces software design, implementation, testing, and documentation techniques to Computer Engineering students in Term 4. It also examines selected topics in Computer Engineering, in ensures that the students understand the current state-of-the-art in the field.
- The proposed *Introduction to Algorithms* course introduces the Computer Engineering students to advanced data structures that will prove useful in developing software solutions to problems in subsequent courses and industry.
- The modified *Embedded Systems* course reflects the changes that are taking place in industry, especially in IoT (Internet of Things).
- The course in Computer Security is necessary for all Computer Engineering students as it recognizes both the importance of computer technology in today's economy and the need for skilled technical professionals able to understand and respond to cyber threats to critical infrastructure.
- The capstone (senior year) project can be completed over two consecutive terms with a four-month summer break.

In addition to the above, the changes give Computer Engineering students the opportunity to organize their courses so that their program of study can be completed in either eight or nine terms, with or without co-op.

The proposed program structure ensures there is no impact on Upper-Division courses offered to Electrical Engineering students. Moreover, unlike in previous reorganizations, there is no need to have a transition period from the old to the new program.

In the short-term, the Department should redouble its efforts to reinstate the Computer Engineering designation on student transcripts. By the next accreditation in 2019, the Department should update existing courses and introduce new ones, restructure the course offerings to make the workload less onerous, and offer students a degree in Computer Engineering.

Unless actions are take soon, student dissatisfaction will harm the Department's reputation, with students opting for other programs related to information technology, such as those offered in the Industrial Engineering, the Faculty of Computer Science, the Faculty of Management, and other institutions of higher learning, both in, and out of, the province.

7 References

ACM-IEEE. (2016, December 2016). *Computer Engineering Curricula 2016.* Retrieved June 22, 2017, from Association for Computer Machinery - Curricula Recommendations: http://www.acm.org/binaries/content/assets/education/ce2016-final-report.pdf

Appendix 1

A Proposal for a New Second Year Course:

Introduction to Computer Engineering

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Overview

Many students opting for Dalhousie Computer Engineering have an interest but limited knowledge of computer systems in general and computer engineering in particular. Their body-of-knowledge of computer systems and computer engineering is poor compared to that of Computer Engineering students completing their second year at other universities. The course, *Introduction to Computer Engineering*, is intended to address this.

The course has two components:

Design. The design component of the course focusses on software design, implementation, testing, and documentation. The importance of both the design and testing of software is emphasized through the development of a modular solution to a term-long project.

Concepts. The concepts component is an overview of different areas of computer engineering. It is intended to give the student an understanding of existing and possible future computer systems and applications, the need for life-long learning, and possible career paths.

The course is based on the course *ECE 101: Introduction to ECE*, described in the sample Computer Engineering program developed by ACM-IEEE for Electrical and Computer Engineering departments (ACM-IEEE, 2016).

Outcomes

At its conclusion, students completing this course should demonstrate:

A measureable improvement in their ability to take a problem, design a software solution, implement the solution in a programming language, apply a set of tests to demonstrate the correctness of their solution, and write the necessary documentation for the solution.

An understanding of the history of computers and computer engineering, the current state-of-the-art, and future of computers and computer engineering.

Course description

This course introduces second year Computer Engineering to software design, implementation, testing, and documentation. The course also examines selected topics in Computer Engineering. A multi-part term project applies concepts to a software solution to a problem.

Course contents

This course consists of two components: the design, implementation, and testing of a software solution to an application; and an introduction to Computer Engineering concepts. About 80%

of the course should be devoted to the design component. The design component can be approached in a top-down, bottom-up, or mixed fashion.

The project should be divided into multiple parts, corresponding to each part of the course, starting with the design concepts.

To give the students additional opportunity to practice their software design, implementation, and testing skills, the labs can be *programming labs*, in which the students are to develop a solution for a given problem. A possible source of these problems are past ACM Programming Contests.

Suggested contents:

1. Introduction to course
2. Basic software design concepts

Implementing the design

Testing techniques

The user interface

Writing technical documentation

Software maintenance

Course review

Final examination

Concepts component topics

The Concepts component can include topics such as:

Computer Engineering
Computer Systems
File Systems
Databases
Operating Systems
Programming Languages
Programming style
Communications
Computer Architecture
Computer graphics and imaging
Applications
Others, such as Artificial intelligence, Computer security, Embedded Systems, IoT (Internet of Things)

This part of the course can be team-taught with specialized topics taught by, for example, departmental members, academics from other faculties, local and regional experts, and on-line lectures.