Updating the contents and structure of Computer Engineering – Part III

Larry Hughes, PhD
Electrical and Computer Engineering
Dalhousie University
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1   Introduction

In the two previous reports on Dalhousie Computer Engineering, its structure and contents was compared with the sample ACM-IEEE Computer Engineering program (ACM-IEEE, 2016).[1] Based on Departmental feedback and the contents of the ACM-IEEE Computer Engineering program, the reports recommended increasing the number of software-related courses in the Faculty of Engineering's core-program, reducing the course-load in Term 6, changing the contents of two existing courses, and introducing a new course in computer security.

This report considers a number of approaches to updating the contents and structure of Dalhousie Computer Engineering's Upper-Division program so that it approaches that described by ACM-IEEE.

The need for these updates is becoming more apparent as more students register for Computer Engineering. By adopting the changes described in this report, the Department of Electrical and Computer Engineering could justifiably argue for the reinstatement of the Computer Engineering degree, put into abeyance in 2012.

2   Existing Computer Engineering structure

In the existing Upper-Division Computer Engineering structure (Table 1), a total of 23 courses are taught, six courses per term, with the exception of Term 8, when only five courses are taught. The program is designed for co-op students, with three work-terms, each taken after the completion of an academic term (i.e., Terms 5, 6, and 7). However, the academic terms can be taken out-of-sequence, with Term 7 (Winter) between Terms 5 (Fall) and 6 (Summer), requiring the student to take all five terms without a break.

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[1] Since Dalhousie offers neither a degree nor an option in Computer Engineering, this report, as did the previous, simply refers to Dalhousie Computer Engineering.

Table 1: Existing Upper-Division Computer Engineering structure (from (ECED, n.d.))

Course	Description
Term 5 - Fall	
ECED 3003	Networks and Systems
ECED 3201	Introduction to Electronics
ECED 3204	Microprocessors
ECED 3401	System Analysis
ECED 3500	Signal Analysis
ENGM 3282	Data Structures and Numerical Methods
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	Real Time Systems
Technical Elective	

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.

ECED 2xxx: 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 would introduce students to Computer Engineering concepts, more complex

software design methods, and computer systems. This would need to replace an existing Term 4 course.

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 4xxx: 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.

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 1, with two exceptions (see Table 2):

- ENGM 3282 (Data Structures and Numerical Methods) is moved from Term 5 to Term 4.
- The course in Computer Security is added to Term 8.

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 2: 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.

4.2   Nine-term structure

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 3) teaches the same courses as the eight-term structure, in same order, with following exceptions:

- ENGM 3282 (Data Structures and Numerical Methods) is moved from Term 5 to Term 4.
- 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 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 3: 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.

4.3   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 4).

**Table 4: 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.

4.4   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 5). 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 5: 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   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 2. By 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.

If these changes are made and student interest remains strong, the Department should consider reinstating the Computer Engineering degree program.

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

ECED. (n.d.). *Undergraduate Students - Program Curriculum.* Retrieved August 10, 2017, from Department of Electrical and Computer Engineering, Dalhousie University: https://www.dal.ca/faculty/engineering/electrical/current-students/undergraduate-students/program-curriculums.html