UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3570 Revised

MEMORANDUM

To: Executive Committee of Faculty Council (November 20, 2017)
Faculty Council (December 12, 2017)

From: Professor Evan Bentz
Chair, Undergraduate Curriculum Committee

Date: November 24, 2017

Re: **Major Curriculum Changes for the 2018-2019 Academic Year**

REPORT CLASSIFICATION

This is a major policy matter that will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for vote as a regular motion (requiring a simple majority of members present and voting to carry).

SUMMARY

The Undergraduate Curriculum Committee is tasked with managing the curriculum change process for the Faculty. This report summarizes course changes proposed for the 2018-2019 academic year.

PROCESS AND CONSULTATION

These changes have been reviewed and approved by the Undergraduate Curriculum Committee, which is comprised of faculty representatives from undergraduate programs; undergraduate student representatives; the Vice-Dean, Undergraduate Studies; the Vice-Dean, First Year Engineering; the Associate Dean, Cross-Disciplinary Programs; and the Registrar. The Committee meets regularly to review and approve proposed changes to the undergraduate curriculum. The impact of these changes on students in the relevant programs has been considered.

PROPOSAL/MOTION

THAT the proposed curriculum changes for the 2018-2019 academic year, as described in Report 3570 Revised, be approved.

PROPOSED CURRICULUM CHANGES

1. IBBME

1.1 Change in course timetable

BME4991Y1

- Change in BME499Y1 - Applied Research in Biomedical Engineering in the 2018-2019 academic year, to add one lecture hour per week.

1.2 Proposed New Technical Elective Course

Imaging Case Studies in Clinical Engineering (Winter 2019)

Objective: The main objective is the development of a senior undergraduate course to complement an existing course that serves as a short survey of the physics behind a few key medical imaging modalities (BME595-Biomedical Imaging). This new course will address the clinical *applications and limitations* of these clinical imaging modalities. To our knowledge, there are currently no similar courses available to undergraduate FASE students. We aim for engineering undergraduates to obtain combined broad-based clinical/medical, technological, and industrial training through a defined curriculum in the clinical setting of radiology using clinical equipment and, when possible, clinically relevant specimens. Hands-on labs (e.g., for MRI, CT, ultrasound and PET), conducted off-site and supported by the UofT Department of Medical Imaging, will be integrated into this course. This program will prepare students with skills to engineer new solutions to improve the health of patients worldwide, and for employment and graduate studies in the medical imaging environment.

Course Description: The course will introduce students to current practices in modern radiology – the detection and assessment of various human diseases using specialized imaging tools (e.g., MRI, CT, ultrasound, and PET) from the perspective of the end-user, the clinician. Course content will be composed of lectures, delivered by radiologists, describing the normal brain, heart, chest, lung, muscles, and bones, and various common characteristics of dysfunctional anatomy and physiology (i.e., disease) of these tissues and how they are visualized and characterized using medical imaging. The core lecture material will be complemented by several guest lectures from industry representatives who will outline challenges and opportunities in the development of new medical imaging technologies for niche applications.

An integral part of this course will be the lab component, where students will scan clinically relevant specimens within the clinical environment. After an initial period of hands-on training (3 hours for each modality) in the first month, student teams will be presented with a “real” clinical case representing a patient who is suffering from signs and symptoms of unknown cause (or causes). In their groups by using basic knowledge of tissue characterization, anatomy and physiology, the students will attempt to diagnose the patient using medical imaging scans of the patient complemented by the patient symptoms and

clinical history (simulating the experience in the clinic). This will simulate the complete diagnostic 'journey' exposing the students to many aspects of the diagnostic chain which may benefit from technical improvement. This will therefore not presuppose that we know where improvements may occur and allow the students their own interests, whether those are in image acquisition, image processing, image movement or perhaps the larger scale (e.g., Big Data and Artificial Intelligence). One month after receiving their case and through consultation with their radiologist mentors over this time, one team will present their diagnostic findings to a panel of radiologist "judges", whereas the remaining teams will submit a team report. This team will also be expected to use this case to explore how new engineering imaging and non-imaging technologies could have changed the outcome of their case.

Learning outcomes: By the end of the course, students will be able to describe the imaging pathway from acquisition to diagnosis and how medical imaging is used and the limitations in the diagnosis of patients in the clinical setting. Students will be able to understand the basics of using state-of-the-art imaging tools to image human disease. Students will also be able recognize bottlenecks and gaps in patient management and be equipped to undertake focused, efficient and more refined innovation to achieve relevant and novel clinical impact in the future.

Table 1: Tentative course schedule.

Wk	***Lecture component (2 hours/wk)***	***Lab/Tutorial (3 hours/wk)***
1	Introduction: clinical medical imaging modalities and their limitations (2 hours)	MR/CT/ultrasound/pathology hands-on lab (4 groups)
2	Challenges in imaging the brain (dementia, cancer, and PTSD) (4 hours)	MR/CT/ultrasound/pathology hands-on lab (4 groups)
3		MR/CT/ultrasound/pathology hands-on lab (4 groups)
4	Challenges in cardiothoracic imaging (heart attack, atherosclerosis, lung cancer, smoking related diseases) (4 hours)	MR/CT/ultrasound/pathology hands-on lab (4 groups)
5		Tutorial
6	Challenges in body imaging (liver cancer; alcohol and obesity related liver disease, inflammatory gastrointestinal diseases and cancer) (4 hours)	Clinical case study – Group 1
7		Clinical case study – Group 2
8	Challenges in musculoskeletal imaging (trauma and cancer) (4 hours)	Clinical case study – Group 3
9		Clinical case study – Group 4
10	Challenges of translating new medical imaging technologies into the clinic (health technology assessment, patenting, licensing, clinical acceptance, regulatory approval) (6 hours)	Group 1 case presentation
11		Group 2 case presentation
12		Group 3 case presentation
13	Course summary, exam prep (2 hours)	Group 4 case presentation

Prerequisites: This course is designed for mature and self-directed 4th year students across FASE. Specific prerequisites are not required but pending course rescheduling feasibility, BME595-Biomedical Imaging would be a useful prerequisite.

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Hours: 2/3/0
We plan on 2 hours/week of lectures, and three hours/week of labs. Part of the lab time will be used for student presentations and tutorial sessions.

Textbook: No specific textbook is required.

Course website: All required course material will be posted to the course Blackboard website.

Evaluation: The course will include practical assignments/quizzes (30%), a group presentation (30%), and a final exam (40%).

2. ENGINEERING SCIENCE

2.1 New courses and descriptions for Machine Intelligence Major – MIE3XXH1

- *ECE 367H1 F Matrix Algebra and Optimization 3/-/1/0.5*

A grounding in optimization methods and the matrix algebra upon which they are based. The first part of the course focuses on fundamental building blocks in linear algebra and their geometric interpretation: matrices, their use to represent data and as linear operators, and the matrix decompositions (such as eigen- and singular-vector decompositions) that reveal structural and geometric insight. The second part of the course focuses on optimization, both unconstrained and constrained, linear and non-linear, as well as convex and non-convex. Conditions for local and global optimality, first and second-order numerical computational techniques, as well as basic classes of optimization problems are discussed. Applications from machine learning, signal processing, and statistics are used to illustrate the techniques developed.
Pre-requisite: AER210H1 or MAT290H1 and MAT185H1 or MAT188H1
AU: 50% Mathematics, 50% Engineering Science
This course will also be offered as Math/Science Electives to ECE students.

- *ECE 368H1 S Probabilistic Reasoning 3/-/1/0.5*

Different classes of probabilistic models and how, based on those models, one deduces actionable information from data. The course will start by reviewing basic concepts of probability including random variables and first and second-order statistics. Building from this foundation the course will then cover probabilistic models including vectors (e.g., multivariate Gaussian), temporal (e.g., stationarity and hidden Markov models), and graphical (e.g., factor graphs). On the inference side topics such as hypothesis testing, marginalization, estimation, and message passing will be covered. Applications of these tools cover a vast range of data processing domains including machine learning, communications, search, recommendation systems, finance, robotics and navigation.
Pre-requisite: STA286H1 or ECE302H1
AU: 75% Mathematics, 25% Engineering Science
This course will also be offered as Math/Science Electives to ECE students.

- *ECE4XXH1: Machine Intelligence Capstone Design* 0/0/5/0.5

A half-year capstone design course in which students work in small teams to apply the engineering design, technical, and communication skills learned previously, while refining their skills in teamwork and project management. The course will take a "systems approach" to machine intelligence design, where students will identify, frame and design solutions to real-world problems in the field. Students will engage with industry partners, and work through a process that results in a functional prototype. The resulting designs are assessed on their engineering quality and design credibility. In addition, each student engages in individual critical reflection on their course activities, team performance, and on their growth as an engineering designer across their undergraduate program. Students are supported by a teaching team comprising both design and domain experts.
AU: 100% ED

- *MIE3XXH1F: Introduction to Machine Intelligence* 3/0/1/0.5

This course will provide students with an overview of the major, introduce them to some basic techniques, and illustrate those techniques through case studies. Techniques will include the basics of machine learning, e.g., linear regression, logistic regression, support-vector machines, neural networks, and the use of these techniques to improve decision making through improved predictions or directly in optimization models. A significant component of the course will be hands-on exposure to a state-of-the-art machine-learning software framework with a series of assignments, culminating in a design project where the students work in a team to build a larger-scale machine learning application, and communicate and demonstrate their accomplishments.
AU: 75%ES, 25%ED

- *ROB3XX: Artificial Intelligence* 3/0/1/0.5

This course introduces the fundamental principles of artificial intelligence, and will explore the subject matter in rigorous mathematical terms. Topics include the history and philosophy of AI, search methods in problem solving, knowledge and reasoning, probabilistic reasoning, decision trees, Markov decision processes, natural language processing and elements of machine learning such as neural-network paradigms.
Pre-requisites: ECE345; STA286
AU: 100% ES

2.2 Option Specific Changes

Aerospace

- Change "AER521H1: Mobile Robotics and Perception" to "ROB521H1: Mobile Robotics and Perception" for Year 4 Winter and in 2nd footnote.

  Updates calendar to reflect course code change.

- Update Y4 Fall ECE557H1 course title from "Systems Control" to "Linear Control Theory".

  Updates calendar entry to reflect course title change.

Biomedical Systems

- Remove "ECE557H1: Systems Control" from "Neuro Sensory and Rehab Engineering" technical elective list.

  Addresses lack of prerequisite(s) for Biomedical Systems students.

- Addition of prerequisite for BME350H1

- BME595H1: Move to Fall term; updated course description to better reflect curriculum; addition as prerequisite for new 'BME5XX: Imaging Case Studies in Clinical Engineering' (IBBME) to generate a two-course module that satisfies the "two technical electives from one focus area" requirement in this major program.

- Add BME5XXH1: Imaging Case Studies in Clinical Engineering to technical electives.

Electrical and Computer

- Remove "AER521H1: Mobile Robotics and Perception" from Technical Electives.

  Addresses lack of prerequisite(s) for ECE students

- ECE557H1: Systems Control - addition of prerequisite and course title change to "Linear Control Theory".

- ECE356H1: Linear Systems and Control - addition of prerequisite/exclusion and course title change to “Introduction to Control Theory”.

- BME595H1: Medical Imaging - move to Fall term from Winter term.

- Add BME5XXH1: Imaging Case Studies in Clinical Engineering to technical electives.

- ECE358H1: Foundations of Computing - move from Winter to Fall semester.

  Running this course in the fall semester will provide ECE Major students with an opportunity to develop skills relevant to potential PEY interviews. This also makes the course available to students in the Machine Intelligence Major.

Energy Systems

- Replace “Technical Elective” in Year 3 Winter Term with “CS/HSS or Technical Elective”.

  Many Energy Systems students request to take their CS/HSS in the Year 3 Winter term. This change will increase this flexibility for students and reduce substitution requests.

- Change AU's for MIE303 to 75% ES and 25% ED (given new integration of design).

Physics

- BME595H1: Medical Imaging – add as a Group A technical elective.

- BME5XXH1: Imaging Case Studies in Clinical Engineering – add as a Group A technical elective.

Robotics

- Remove “BME350H1: Biomedical Systems Engineering I: Organ Systems” from Application Courses Technical Elective list.

- ROB521H1: Mobile Robotics and Perception - Addition of prerequisite.

Other Changes

- ROB3XYH1: Introduction to Learning from Data – creation of new course for several Engineering Science options.

3. MECHANICAL AND INDUSTRIAL ENGINEERING

3.1 New Course Proposal for MIE 567 Dynamic and Distributed Decision Making

- The course introduces new material of contemporary interest in operations research and information engineering.
- Its introduction creates new choices for undergraduate technical electives.

4. ELECTRICAL AND COMPUTER ENGINEERING

4.1 Changes to ECE 521H1 F Inference Algorithms and Machine Learning

- Change course code to: ECE 421H1 F.
- Change course title to: Introduction to Machine Learning.
- Change course description from:

Squared error and the Gaussian probability distribution. Maximum likelihood estimation. Logistic regression, neural networks, radial basis function networks. Occam's razor, validation, bagging, Bayesian techniques. Auto-encoders, principal components analysis, clustering. The EM algorithm. Matrix factorization. Markov models, hidden Markov models, the forward-backward algorithm, the Viterbi algorithm. Factor graphs, Bayesian networks, variable elimination, the sum-product algorithm, the max-product algorithm. Learning graphical models. Applications to image classification, image processing, object tracking, speech recognition, telecommunications and genomics. Prerequisites: STA286H1 S or ECE302H1 F/S

To:

An Introduction to the basic theory, the fundamental algorithms, and the computational toolboxes of machine learning. The focus is on a balanced treatment of the practical and theoretical approaches, along with hands on experience with relevant software packages. Supervised learning methods covered in the course will include: the study of linear models for classification and regression, neural networks and support vector machines. Unsupervised learning methods covered in the course will include: principal component analysis, k-means clustering, and Gaussian mixture models. Theoretical topics will include: bounds on the generalization error, bias-variance tradeoffs and the Vapnik-Chervonenkis (VC) dimension. Techniques to control overfitting, including regularization and validation, will be covered.
Pre-requisites: STA286H1 or ECE302H1
Exclusion: CSC411H1

The probabilistic reasoning portion of ECE 521 has been moved to the new course, ECE 368 H1F "Probabilistic Reasoning," and ECE decided that the remainder of the course should be revamped to focus entirely on an introduction to machine learning.

4.2 Move ECE 437H1 S VLSI Technology to ECE 437H1 F.

Its pre-requisite, ECE335 H1F, Introduction to Electronic Devices, is offered in the Fall term.

4.3. Changes to control system courses.

ECE 311H1 F/S: Dynamic Systems and Control

- Change the course title to: Introduction to Control Systems.

ECE 356H1 F: Linear Systems and Control

- Change the course title to: Introduction to Control Theory.
- Remove ECE 355H1 F Signal Analysis and Communication as its pre-requisite.
- Add MAT 292H1 as its pre-requisite.

ECE 410H1 F: Control Systems

- Change the course title to Linear Control Systems.

ECE 557H1 F: Systems Control

- Change the course title to Linear Control Theory.
- Add "ECE356 or AER372" as its pre-requisite.

The new titles are designed to better reflect the relationship across these courses, as well as the theory/systems nature of these courses.

4.4 Add 5 courses to Area 5 as Technical Electives: Computer Hardware and Computer Networks.

- ECE 302H1 F/S – Probability and Applications
- ECE 537H1 F – Random Processes
- ECE 464H1 S – Wireless Communication
- ECE 462H1 S – Multimedia Systems

- ECE 568H1 F/S – Computer Security

Area 5 traditionally has much fewer courses in its list of technical electives compared to the other areas, especially Area 4 and Area 6, which are the most similar to Area 5. These courses are added as Technical Electives in Area 5 to expand the range of selection in this area.

5. CIVIL ENGINEERING

5.1 Change MIN430 to MIN330

- Course is now taught in 3rd year and thus number should be updated.

5.2 Remove APS304 from calendar

- Has not been taught in a number of years and Prof. Vanderburg, who taught it, has retired.

5.3 Change CIV362 to CIV262

- Course is now a 2nd year course, so update the course code.

5.4 Remove prerequisite CIV531H1F from CIV577H1

- This requirement was felt to be unduly impacting enrollment, and students get sufficient background from a core civil course and the other prerequisite for CIV577.

5.5 New course CIV5XX Design of Building Enclosures

- A new course that builds on the basic science of CIV375/575 Building Science to provide better practical training on the application of these theoretical materials. Proposed calendar entry:

A brief summary of the science involved in controlling heat, moisture and air movement in buildings is presented at the outset of the course. With this background, methods of designing enclosures for cold, mixed, and hot climates are examined. Design principles related to the design of walls, windows and roofs are presented and applied. In particular, topics related to the control of rain penetration, air movement, and interstitial condensation are studied in detail. Emphasis is placed on developing designs based on fundamentals which can be verified with computer modelling solutions.
Prerequisite: CIV375 or CIV575

4.7 Calendar entry changed for CME321

- Update to match current teaching practice for this course.

6. CHEMICAL ENGINEERING

6.1 Rename CHE221 Calculus and Numerical Methods to Calculus III.

- The title has been changed to clearly indicate that this course is a natural progression from Calculus I and II offered in first year with a strong emphasis on practical modelling and design problems encountered in chemical engineering appropriate for second year.

6.2 Rename CHE222 Applied Differential Equations to Process Dynamics: Modeling Analysis and Simulation.

- Previously, CHE221 was a blend of analytical calculus and some computational tools. All of the computation has been removed from CHE221 and placed in CHE222. CHE222 is a course that focuses now on both analytical and computational techniques for studying process dynamics. A computer lab has been added to enhance students' understanding and appreciation for process dynamics via simulation. The title has been chosen to reflect these changes made to the course.

6.3 Rename CHE322 Process Dynamics and Control to Process Control.

- With the change to the course title for CHE222, it was decided to remove the reference to process dynamics in the title for CHE322. Process dynamics is still part of CHE322 but given that the reason for studying process dynamics in CHE322 is solely for its application to process control, it was felt that it could safely be dropped from the course title.

7. CROSS DISCIPLINARY PROGRAMS OFFICE

7.1 Curriculum Changes for Minors and Certificates

Minor in Engineering Business

The Engineering Business Minor includes a number of courses from outside the Faculty as electives in the program. ECO100Y1 Y has been a popular elective in the minor for a number of years. This past year, the Department of Economics has split the full-year course into two half courses: ECO101H1 F/S – Principles of Microeconomics and ECO102H1 S – Principles of Macroeconomics. Both of these courses will be added to the list of electives for the minor in place of ECO100Y1 Y.

Minor in Robotics and Mechatronics

There are courses that have recently been proposed/created for Engineering Science programs that are suitable for the minor: ROB3XXH1 – Artificial Intelligence and ROB3XYH1 - Introduction to Learning From Data are proposed to be included as Introductory electives in the minor for Eng Sci students only.

ROB310H1 – Mathematics for Robotics was created for the Robotics Major in Engineering Science. While this Major is excluded from pursuing the minor, the course is also an elective in the Aerospace Major. Including this course will make the Robotic Minor more accessible for Aerospace students.

Certificate in Forensic Engineering

We propose to add MIE320H1 S – Mechanics of Solids II as an elective in the certificate. The course description is appropriate for the certificate, and is very similar to CIV510 – Solid Mechanics II, which is already included in the list of electives. Adding this course will make the certificate more accessible for Mech students

7.2 Course Changes

APS540H1 S – Making Sense of Accidents

Renumber to APS440H1 S

When this course was approved last year, the original plan was that it would replace (at the grad level) a similar course already taught by the proposed instructor. Subsequently, a decision was made at the graduate level to keep APS1034H – Understanding Technological Catastrophes as a separate course, so the 500-level was never approved for grad students, thus the need to renumber to a 400-level course level.