UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3605 Revised

MEMORANDUM

To: Executive Committee of Faculty Council (November 29, 2018)
Faculty Council (December 18, 2018)

From: Professor Evan Bentz
Associate Professor and Chair, Undergraduate Curriculum Committee

Date: November 29, 2018

Re: **Major Curriculum Changes for the 2019-2020 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).

BACKGROUND

The Undergraduate Curriculum Committee is tasked with managing the curriculum change process for the Faculty. This report summarizes course changes proposed for the 2019-2020 academic year.

PROGRAMS AFFECTED

The proposed curriculum changes affect cross-disciplinary minors and certificates, and undergraduate programs in Electrical & Computer Engineering, Chemical Engineering & Applied Chemistry, Mechanical & Industrial Engineering, and Engineering Science. The impact on students in these programs has been considered.

CONSULTATION

The proposed curriculum changes have been reviewed and approved by the relevant programs' curriculum committees and the Faculty's Undergraduate Curriculum Committee, which is comprised of representatives from each undergraduate program; the Vice-Dean, Undergraduate Studies; the Vice-Dean, First Year; the Associate Dean, Cross-Disciplinary Programs; the Director, First Year Curriculum; the Registrar's Office; undergraduate students; the Faculty's Teaching and Learning Specialist; the Faculty's Scheduling Officer;

and representatives from IBBME, UTIAS, the Engineering Communication Program, and the Engineering and Computer Science Library.

MOTION

THAT the proposed curriculum changes for the 2019-2020 academic year, as described in Report 3605 Revised, be approved.

PROPOSED CURRICULUM CHANGES

1. <u>CROSS DISCIPLINARY PROGRAMS OFFICE</u>

1.1 **Advanced Manufacturing Minor:**

- Add MIE304 – Introduction to Quality Control to Requirement #1.
    - MIE364 was split last year, so that Indy students take MIE364 and Mech students take MIE304.
- Add MSE455 - Process Simulation and Computer Design as an Advanced elective

1.2 **Engineering Business Minor:**

- Add APS447 - Ethical and Equitable Decision Making to list of electives

1.3 **Environmental Engineering Minor:**

- Add CIV578 – Design of Building Enclosures as an Advanced elective
- Add CME500 – Fundamentals of Acid Rock Drainage as an Advanced elective

1.4 **AI Engineering Minor:**

- APS360H – AI Fundamentals – Specify probability pre-requisite courses: CHE223H, CME263H, ECE302H, MIE231H, MIE236H, MSE238H, STA286H/ESC286
- Add MIE4XX – Optimization in ML to Requirement 4 - See section 4.1 of this report

1.5 **Nanoengineering Minor:**

- Credit 2: Adjust wording – ECE442 – Introduction to Micro- and Nano-Fabrication Technology OR approved Thesis or Capstone project.
- Add MSE438H - Computational Materials Design as an Advanced elective

1.6 **Forensic Engineering Certificate:**

- Add MIE304 – Introduction to Quality Control to the list of courses (again, related to MIE364 Indy/Mech split)

1.7 **Global Engineering Certificate:**

- New options/deletions in red:

- Two of the following courses:
  - APS299Y0 Y: Summer Research Abroad
  - APS510H1 F: Innovative Technologies and Organizations in Global Energy Systems (CS elective)
  - APS420H1 S: Technology, Engineering and Global Development (HSS elective) (or previous course code APS520H1 S)
  - APS530H1 S: Appropriate Technology & Design for Global Development
  - Global Engineering themed capstone (APS490Y, ECE496Y, MIE490Y, MIE491Y, CIV498H) as approved by the Director of the Centre for Global Engineering

- One elective from the following courses:
  - ANT204H1: Anthropology of the Contemporary World (HSS elective)
  - ENV333H1: Ecological Worldviews (HSS elective)
  - ~~GGR216H1: Global Cities (HSS elective) (no longer offered)~~
  - GGR112H1: Geographies of Globalization, Development and Inequality (HSS elective)
  - JGI216H1: Globalization and Urban Change (HSS elective)
  - POL201Y1: Politics of Development: Issues and Controversies (HSS elective)
  - POL208Y1: Introduction to International Relations (HSS elective)
  - CDN268H1: Canada and Globalization (HSS elective)

2. ELECTRICAL AND COMPUTER ENGINEERING

2.1 **MIE324H1 F** Introduction to Machine Intelligence

- Change course code to: ECE324H1 F

- Change course description from:

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.
To:

This course will provide students with **an introduction to machine learning engineering, as a software and engineering discipline. It focuses on the neural network method. Lectures will cover the basic mathematics and intuitions behind neural networks, in particular deep convolutional neural networks, and their application as classifiers and predictions using regression. There will be a focus on conveying known methods to make neural**

network training succeed. Other topics may include Natural Language Processing basics, recurrent neural networks, transfer learning and generative adversarial networks. There will be reflection on ethics in machine learning. A significant component of the course will be hands-on exposure to a machine-learning software framework, culminating in a design project.

2.2 **CSC326H1 F Programming Languages**

- Change course code to ECE326H1 F

2.3 **CSC444H1 F Software Engineering**

- Change course code to ECE444H1 F

2.4 **CSC467H1 F Compilers and Interpreters**

- Change course code to ECE467H1 F
    - These courses are ECE courses, and have been taught by the ECE faculty in the last decade (or longer). Changing the course code for these courses will avoid potential confusion to the students.

2.5 **CSC444H1 F Software Engineering**

- Change weighting from 3/1.5/1 to 3/3/0.
    - The course is currently taught with a heavy laboratory component, and it is preferable for students to get more lab hours per week, in exchange for eliminating the tutorial hour.

2.6 **ECE345H1 F Algorithms and Data Structures**

- Change pre-requisite to ECE244 or equivalent with the permission of the Chair of the AI certificate/minor
    - This is change to be compatible with the new AI certificate/minor.

2.7 **ECE352H1 F Computer Organization**

- Change course description from:

A continuation of some of the topics introduced in ECE253F, Digital and Computer Systems. Synchronous and asynchronous sequential circuits, pipelining, integer and floating-point arithmetic, RISC processors.

To:

A continuation of some of the topics introduced in ECE253F, Digital and Computer Systems. **Embedded system design: Input-output and the use of interrupts, peripherals and interfacing. Processor design:** pipelining, integer and floating point arithmetic, **cache hierarchies and memory organization. Design of combinational and sequential circuits in Verilog.**

- The existing course description is out of date, some topics are no longer taught. Updated to reflect the current course syllabus.

2.8 **ECE367H1 F Matrix Algebra and Optimization**

- Change course description from:

This course will provide students with 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. Prerequisite: AER201H1/MAT290H1, MAT185H1/MAT188H1

To:

This course will provide students with 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-, **spectral-,** 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, as well as basic classes of optimization problems are discussed. Applications from machine learning, signal processing, and engineering are used to illustrate the techniques developed.
Prerequisite: AER210H1/MAT290H1, MAT185H1/MAT188H1

- Change 3/-/1 to 3/-/2 (one hour tutorial to two hours)
  - Rationale: The course description contains a minor change that removes a topic ("first and second-order numerical computational techniques"). The additional tutorial hour will help students with a better preparation of the theoretical topics in this course.

2.9 **ECE368H1 F Probabilistic Reasoning**

- **Add exclusion** CSC412H1
  - Rationale: CSC412H1 is teaching very similar course material to this course.

2.10 **ECE412H1 S: Analog Signal Processing Circuits**

- Change course description from:

An overview of analog signal processing in both continuous-time and discrete-time. Analog signal specifications. The design of analog filters including transfer function approximation using Matlab and implementation using active-RC, transconductance-C, and switched-capacitor circuits. Other topics include phase locked loops.
Prerequisite: ECE331H1 or ECE354H1. Exclusion: ECE512H1

To:

An overview of continuous-time and discrete-time signal processing techniques, and the analysis and design of analog and mixed-signal circuit building blocks used in modern electronic systems. Topics covered include: analysis, specification, simulation, and design of continuous-time filters with linear transconductors and op-amps; phase-domain model, noise model, and design methodology for low phase noise Phase Lock Loops and associated building blocks (VCO, phase-frequency detector, charge pump); discrete-time signal analysis using z-transform; discrete-time filter design based on switched capacitors; as well as fundamentals, architectures, building blocks, and characterization techniques for digital-to-analog and analog-to-digital converters.
Prerequisite: ECE331H1 or ECE354H1. Exclusion: ECE512H1

- The existing course description did not provide a list of representative topics in this course. It is updated to reflect the current course syllabus.

2.11 **ECE421H1 S Introduction to Machine Learning**

- Change to ECE421H1 F/S: Introduction to Machine Learning
  - By adding a fall term section to this course, more students can be accommodated. The course is now offering **four** sections, but still have a waitlist. The proposed change provides the flexibility to move a section (or even add one more section) to the Fall term.

3. CHEMICAL ENGINEERING & APPLIED CHEMISTRY

3.1 **New course: CHE399 Professional Engineering Consultancy, 0.25 credit weight, TEAL classrooms**

- Students are provided with an open-ended and iterative learning experience through a consulting engineering project. Students tackle an authentic design challenge with limited background knowledge, while being guided by instructors who simulate the client-consultant relationship. The project brings together technical and professional competencies from across eight graduate attributes to enable holistic learning: problem analysis; investigation; design; individual and team work; communication skills; professionalism; economics and project management; lifelong learning.

3.2 **CHE299 Communication**

- Change delivery hours from Y semester to F semester
- Change course description from:

Each student will learn to identify the central message they wish to communicate. They will learn to articulate this message through effective argumentation. Students will analyze their audience and purpose to select the most effective mode of communication. Students will summarize and synthesize information from external sources and effectively organize information and prioritize it in each mode of communication. They will apply effective strategies to the design of text, visuals and oral presentations.

To:

Students will analyze engineering writing in multiple genres, including briefing documents and consulting reports. Students will apply conventions of engineering writing to deliverables from their core technical curriculum, by: identifying their central message; analyzing their audience and purpose to select the most effective mode of communication; summarizing and synthesizing information from external sources; and organizing information to prioritize it in each mode of communication. Students will apply effective strategies to the design of text, visuals and oral presentations.

3.3 **CHE341H1F Engineering Materials**

- Change course code to CHE441H1F

3.4 **CHE334S Team Strategies for Engineering Design**

- Change credit weight unit from 1/0/2/0.25 to 1/0/2/0.5

3.5 **CHE113S Concepts in Chemical Engineering**

- Change delivery structure from 3/1/3/0.5 to 3/2/2/0.5

4. MECHANICAL & INDUSTRIAL ENGINEERING

4.1 **New Course: MIE4XX Optimization in Machine Learning 3/1/0/0.50, 25% Basic Science, 75% Eng Design**

- To enable deeper understanding and more flexible use of standard machine learning methods, through development of machine learning from an Optimization perspective.
- To enable students to apply these machine learning methods to problems in finance and marketing, such as stock return forecasting, credit risk scoring, portfolio management, fraud detection and customer segmentation.
- Prerequisites: MIE365 or MIE376 or equivalent

4.2 **MIE210H1 Thermodynamics**

- Change delivery from 3/1.50/1/0.50 to 3/0.75/1/0.50

4.3 **MIE250H1 Fundamentals of Object Oriented Programming**

- Change course description from:

Introduction to object-oriented programming using the Java programming language with heavy emphasis on practical application; variable types; console and file input/output; arithmetic; logical expressions; control structures; arrays; modularity; functions; classes and objects; access modifiers; inheritance; polymorphism; design and implementation of programs relevant to industrial engineering needs according to strict specifications.
Prerequisite: APS105H1/APS106H1 or equivalent

To:

Introduction to object-oriented programming using the Java programming language with heavy emphasis on practical application; variable types; console and file input/output; arithmetic; logical expressions; control structures; arrays; modularity; functions; classes and objects; access modifiers; inheritance; polymorphism; fundamental data structures; design and implementation of programs relevant to industrial engineering needs according to strict specifications.
Prerequisite: APS105H1/APS106H1 or equivalent

4.4 **MIE270H1 Thermodynamics**

- Change course description from:

Electrical, thermal, magnetic, optical properties of materials; Corrosion and degradation of materials; Phase transformation and strengthening mechanisms; Failure analysis and testing; Fatigue, creep, impact; Composite materials, special purpose materials.

To:

Corrosion and degradation of materials; Phase transformation and strengthening mechanisms; Mechanical failure, fatigue, creep, impact; Electrical, thermal, magnetic, optical properties of materials; Composite materials.
Prerequisite: APS110, APS164, or MSE101

4.5 **MIE301H1 Kinematics and Dynamics of Machines**

- Change course description from:

Classifications of mechanisms, velocity, acceleration and force analysis, graphical and computer-oriented methods, balancing, flywheels, gears, geartrains, cams. Introduction to Lagrangian Dynamics: Lagrange's equations of motion, Hamilton's equations, Hamilton's principle. Instruction and assessment of communication centered around course deliverables that will form part of an ongoing design portfolio.
Prerequisite: MIE100H1

To:

Classifications of mechanisms, velocity, acceleration and force analysis, graphical and computer-oriented methods, gears, geartrains, cams, flywheels, mechanism dynamics. Instruction and assessment of engineering communication that will form part of an ongoing design portfolio.
Prerequisite: MIE100H1

4.6 **MIE540H1 Product Design**

- Change course description from:

Integration of both business and engineering concepts through examples, case studies and a final project. Business concepts include identifying customer needs, project management and the economics of product design. Product design engineering tools include developing product specifications, concept generation, concept selection, Product Functional Decomposition (PFD) diagrams, Design of Experiments, noises, interactions, tolerance analysis and latitude studies. Specific emphasis will be placed on product optimization.
Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE243H1 or instructor's permission

To:

This course takes a 360° perspective on product design: beginning at the market need, evolving this need into a concept, and optimizing the concept. Students will gain an understanding of the steps involved and the tools utilized in developing new products. The course will integrate both business and engineering concepts seamlessly through examples, case studies and a final project. Some of the business concepts covered include: identifying customer needs, project management and the economics of product design. The engineering design tools include: developing product specifications, concept generation, concept selection, Product Functional Decomposition diagrams, orthogonal arrays, full and fractional factorials, noises, interactions, tolerance analysis and latitude studies. Specific emphasis will be placed on robust and tunable technology for product optimization.
Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE243H1 or instructor's permission.

4.7 **MIE465 Analytics in Action**

- Change course code from MIE465 to MIE3XXH1
- Change semester offered from

4.8 **3rd Year Fall Session Industrial Engineering Curriculum Changes**

- Removal of Natural Science requirement form the curriculum of Industrial Engineering
    - Based on evaluations for CEAB

5. ENGINEERING SCIENCE

Foundation Curriculum

5.1 **STA286H1 Probability and Statistics**

- Course Code/Ownership & Description Change to ECE286; make STA286 an exclusion
    - Probability and statistics for Engineering Science students focusing on building solid probabilistic and statistical foundations both mathematically and in terms of engineering application. Topics include: sample space, events, definitions of probability, conditional probability, Bayes' theorem, important classes of discrete and continuous random variables and their distributions, joint, conditional, and marginal distributions, expectation, moment generating and characteristic functions, transformations of random variables, central limit theorem and approximations. Graphical methods, quantile plots, point and interval estimation of population parameters, method of maximum likelihood. Hypothesis testing, simple and multiple regression, correlation analysis, and introduction to Bayesian statistics.
      Exclusion: CHE223H1, CME263H1, MSE238H1, MIE236H1, MIE237H1, MIE231H1 or STA257H1

    - Changes: added in the first line to emphasize “building on foundations”; removed the use of minitab software

    - Justification: A decision was made to bring the teaching of STA286 fully within the Faculty of Applied Science and Engineering, given lack of consistent instruction offered by the Department of Statistics.

5.2 **Course Code/Ownership & Description Changes; First Year Calculus**

- MAT194 (ESC194) - Calculus I
    - Topics include: theory and applications of differential and integral calculus, limits, basic theorems and elementary functions. An introduction to differential equations is also included.

- MAT195 (ESC195) - Calculus II
    - Topics include: techniques of integration, improper integrals, sequences, series, Taylor's theorem, as well as an introduction to vector functions, functions of several variables, partial derivatives and the optimization of multivariable functions.

    - Noted change: The intro to differential equations has been moved to MAT194, and explicitly added multivariable optimization to the MAT195

description, as this is one of the key learning outcomes identified for the course.

- Justification: A decision was made to bring the teaching of these courses fully within the Faculty of Applied Science and Engineering, and more specifically UTIAS who has already been providing co-instruction and curricular leadership. This decision was made based on a lack of consistent instruction offered by the Department of Mathematics.

5.3 **BME205: Biomolecules and Cells**

- Course Description Change for AND request to change title to: Fundamentals of Biomedical Engineering
    - Introduction to connecting engineering and biological approaches to solve problems in medicine, science, and technology. Emphasis is placed on demonstrating the connection between organ level function with cellular mechanisms. Topics may include, but are not limited to: design principles of biological systems, medical devices, overviews of anatomy and physiology, and cellular mechanisms as they relate to biotechnological and medical technology applications. Laboratories will provide hands-on experiences with selected concepts and encourage students to understand how to connect their own vital and physiologic signs to current medical technologies.

    - Noted change: increased focus on organ systems and whole-body biology, biomedical engineering applications and related device design, with decreased focus on cellular and molecular biology.

    - Justification: for several years, there have been concerns about student motivation for the course material. An increased focus on whole-body biology (i.e. at the organ/organ systems level) and on relevant applications is proposed to increase student motivation and interest.

5.4 **ESC101, ESC102, ESC203, AER201**

- Update to Design Stream Course Descriptions
    - Change/Justification: the goal is to streamline the course descriptions to demonstrate coherence in the learning around design, communication, teamwork, professionalism, ethics and equity. This is a direct result of the Graduate Attributes review process.

- ESC101 Praxis I
    - Praxis I is the cornerstone course of the Engineering Science Foundation Design sequence and introduces the foundational models and tools of engineering design, communication, teamwork, and professionalism that underlie design education within Engineering Science. In Praxis I students work both individually and in small teams to develop their knowledge and skills in through a combination of active lectures, structured interactive studios, and hands-on practical sessions. The design projects in Praxis I are scoped to the individual student and the broader University community. Each student and team is responsible for both defining and resolving their own opportunities. Praxis I also supports students as they transition into their engineering studies and into the Engineering Science learning community. This support integrates conceptual models, concrete techniques, and University resources, and addresses both academic and non-academic concerns. All courses within the Foundation Design sequence use engineering design to provide a context in which students integrate their knowledge, develop their emerging engineering identity, and codify their individual approach to engineering practice.

- ESC102 Praxis II
    - Praxis II develops the models and tools of design, communication, teamwork, and professionalism introduced in Praxis I. The course also introduces additional complementary considerations including ethics and equity. In Praxis II students work primarily in small teams to develop and refine their knowledge and skills in through a combination of active lectures, structured interactive studios, and hands-on practical sessions. The design projects in Praxis II are scoped to communities within the broader City of Toronto. Student teams are responsible for identifying and engaging with these communities, and for first framing and then resolving a collaboratively identified opportunity.

    - Praxis II culminates in a public showcase where teams present and demonstrate their designs to their stakeholders and to the general public. Praxis II also continues to support students as they integrate more fully into the Engineering Science learning community. All courses within the Foundation Design sequence use engineering design to provide a context in which students integrate their knowledge, develop their emerging engineering identity, and codify their individual approach to engineering practice.

- ESC203H1F: Engineering and Society
    - Students will examine the relationship between engineering and society, emphasizing a humanities and social sciences perspective. Building on the Praxis courses, students will develop and apply an understanding of ethics

and equity to broader sociotechnical systems and challenges. Using models of critical thinking, active learning activities and discussion seminars, students will develop an understanding of the social and environmental impacts of technology. Students will further develop their communication, teamwork and professional skills through persuasive writing, facilitation and formal debate. Upon completion of the course, students will have an appreciation for the complex interaction between human society and technology, and will be able to analyze and evaluate the social, technological, political, and ethical dimensions of technology.

- ESC2XX Praxis III
    - Praxis III is the capstone course of the Engineering Science Foundation Design sequence and challenges students to apply the models of engineering design, communication, teamwork, and professionalism introduced and developed in Praxis I and II to the design and testing of a functioning product prototype. The course requires students to integrate the design, technical, and complementary knowledge gained across the Engineering Science Foundation in the context of a single, major, full-term design project. Teams in Praxis III choose from a curated set of opportunities that integrate technical and complementary considerations. They are responsible both for framing the opportunity and for designing and testing a product prototype that addresses the opportunity. Praxis III culminates in a public showcase where teams present and demonstrate their designs to their stakeholders and to the general public. All courses within the Foundation Design sequence use engineering design to provide a context in which students integrate their knowledge, develop their emerging engineering identity, and codify their individual approach to engineering practice.

Major Curriculum

5.5 **Course Code/Ownership & Description Changes; Partial Differential Equations**

- APS384 change course code to ESC384
    - Introduces analytical techniques for partial differential equations (PDEs). Concepts covered include Fourier series, Sturm-Liouville theory, Green's functions, characteristics, and Laplace transform method. Applications are in model PDEs in continuum mechanics: diffusion, transport, heat, and wave equations.

    - Changes: clarification on content listed and the nature of applications reviewed

    - Justification: A decision was made to bring the teaching of this course fully within the Faculty of Applied Science and Engineering, and more specifically

UTIAS. This decision was made based on a lack of consistent instruction offered by the Department of Mathematics, and the strengths and interests of faculty within UTIAS, who will have a special interest in ensuring strong integration with the Major curriculum.

5.6 **MIE324H1 Introduction to Machine Intelligence**

- Course Code & Description Change
    - Provides students with an introduction to machine learning engineering, as a software and engineering discipline. It focuses on the neural network method. Lectures will cover the basic mathematics and intuitions behind neural networks, in particular deep convolutional neural networks, and their application as classifiers and predictions using regression. There will be a focus on conveying known methods to make neural network training succeed. Other topics may include Natural Language Processing basics, recurrent neural networks, transfer learning and generative adversarial networks. There will be reflection on ethics in machine learning. A significant component of the course will be hands-on exposure to a machine-learning software framework, culminating in a design project.

    - Changes: emphasize “discipline”; stronger focus on neural networks; added focus on underlying mathematics; added natural language processing basics; recurrent neural networks; transfer learning; generative adversarial networks; ethics in machine learning; removed “illustrating techniques through case studies” and “support vector machines”. Removed some notes about assignments.

    - Justification: the course is currently being offered for the first time, and the original description reflected more tentative plans. ECE will staff this course moving forward.

5.7 **ECE429 (Machine Intelligence Capstone Design) – change to MIE course code**

- Course Code/Ownership Change
    - Justification: MIE will staff this course moving forward.

5.8 **ESC472: Electrical and Computer Engineering Capstone Design**

- Course Description Change
    - 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. Each team is expected to design a complex engineered system, implemented (a) fully in software, (b) fully in hardware or (c) in a mixture of hardware and software, using concepts drawn from the ECE Major curriculum and resulting in a functional prototype. Teams are expected to integrate their design, technical, and complementary knowledge, to design for safety, and to

consider relevant interdisciplinary factors such as economic, health, environmental, social, and similar concerns.

- In addition, each student will complete an individual critical reflection on their course activities, team performance, and on their growth as an engineering designer across their undergraduate program. This reflection is intended to prepare the student for the next stage of their engineering career.

- Changes: provides option to work on hardware or software (or both); updated need to integrate knowledge and professional skills; made reflection more forward-looking.

- Justification: based on student interests and program goals, we would like to emphasize the choice of working on hardware, software or both. Reflects integration of design and related competencies across the curriculum, as per the Graduate Attributes review.

5.9 **Add CSC412 (Probabilistic Learning and Reasoning) as an exclusion to ECE368 (Probabilistic Reasoning)**

5.10 **BME358: Molecular Biophysics**

- Course Description Change
  - Topics to be covered will include: Building blocks of the living cell; thermodynamics of living systems: interactions and kinetic energy, equilibrium and non-equilibrium processes, entropy, temperature, free energy and chemical potential ; diffusion and friction in liquids, Brownian motion; membrane potential, ion pumps and nerve cells; light and molecules: photon absorption and fluorescence; light microscope, fluorescence as a window into cells, optogenetics and fluorescent reporters; two-photon excitation and fluorescence resonance energy transfer; the eye, image formation, and color vision; structural color in animals.

  - Change/Justification: New description provides a more accurate description of the course.

5.11 **AER406: Aircraft Design**

- Course Description Change
  - Teams of 3 or 4 students design, build, and fly a remotely piloted aircraft. The aircraft is designed and built to maximize a flight score, which is a complex function of many factors – payload fraction, payload type, flight time, takeoff distance, etc. Teams are provided with identical motors, batteries, radio equipment, and flight instrumentation. Weekly sessions

consist of a combination of lectures and one-on-one meetings with the tutors and professor to discuss each teams' progress. Evaluations are based on the weekly reports, preliminary and final design presentations and reports, an as-built report, and measured flight performance.

- Change/Justification: New description provides a more accurate description of the course.

5.12 **AER503: Aeroelasticity**

- Course Description Change
  - Static aeroelastic phenomena are studied, including divergence of 2D sections and slender 3D wings, as well as control reversal of 3D wings. Various methods of solution are considered such as closed form, discrete element, and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters that affect flutter speed. Classical, k, and p-k methods for flutter estimation are presented.

  - Change/Justification: New description provides a more accurate description of the course.

5.13 **AER336: Scientific Computing**

- Course Description Change
  - Introduces numerical methods for scientific computation which are relevant to the solution of a wide range of engineering problems. Topics addressed include interpolation, integration, linear systems, least-squares fitting, nonlinear equations and optimization, initial value problems, and partial differential equations. The assignments require programming of numerical algorithms.
  - Change/Justification: New description reflects practice and removes mention of specific software programs and languages to provide flexibility.

5.14 **Proposed Changes to the Energy Major**

- Justification: The proposed changes reflect four key goals: (1) Eliminate overlap between courses; (2) Emphasize technical rigour/specialization through the addition of a few courses; (3) Respond to student and industry interest in adding optimization as a core competency; and (4) Support better technical elective pathways. Current students, alumni, the Engineering Science Advisory Board and instructors were consulted in the creation of the following modifications. New courses to the Major (or elective courses that have been made core) are indicated with an asterisk.

- 3F:
  ECE367F (Matrix Algebra & Optimization)*
  CHE374F (Engineering Economics)
  ECE349F (Energy Systems)
  MIE303F (Mechanical and Thermal Energy Conversion Processes)
  Technical Elective* – One of: ECE360F (Electronics) OR CHE566 (Elements of Nuclear Engineering) or CIV375 (Studies in Building Science)
  ESC301Y (Option Seminar)

Removal of: CHE308 (Energy Systems and Fuels: Global Needs, Challenges and Technological Opportunities) and ENV346 (Terrestrial Energy Systems).

- 3S:
  AER372S (Control Systems)
  ECE413S (Energy Systems & Distributed Generation)
  ECE463S (Electric Drives)
  APS305S (Energy Policy)
  CHE469S (Fuel Cells and Electrochemical Conversion Devices)*
  ESC301Y (Option Seminar)

- Year 4:
  CIV401F (Design of Hydro Systems)
  MIE515F (Alternative Energy Systems)*
  ESC470S (Energy Systems Capstone Design)
  ESC499Y (Thesis)
  1 HSS or CS elective
  1 free elective
  3 technical electives