UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3759 Revised

MEMORANDUM

To: Executive Committee of Faculty Council (November 14, 2023)
Faculty Council (December 7, 2023)

From: Professor Evan Bentz
Chair, Undergraduate Curriculum Committee

Date: November 7, 2023; last revised January 18, 2024

Re: Major Curriculum Changes for the 2024-2025 Academic Year

REPORT CLASSIFICATION

This is a major policy matter that will be considered by the Executive Committee for endorsement 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.

PROPOSED

This report summarizes course changes proposed for the 2024-2025 academic year.

CONSULTATION PROCESS

These changes have been reviewed and approved by the Undergraduate Curriculum Committee, which is comprised of teaching staff representatives from the Faculty's departments and institutes; undergraduate student representatives; the Vice-Dean, Undergraduate; the Vice-Dean, First Year; the Director, First Year Curriculum; the Associate Dean, Cross-Disciplinary Programs; the Assistant Dean and Director, Diversity, Inclusion and Professionalism; and the Faculty 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.

RECOMMENDATION FOR COUNCIL

THAT the proposed curriculum changes for the 2024-2025 academic year, as described in Report 3759 Revised, be approved.

PROPOSED CURRICULUM CHANGES

1. CHEMICAL ENGINEERING & APPLIED CHEMISTRY

1.1. Update course description for **CHE113: Concepts in Chemical Engineering**

CURRENT course description: This course provides first year students with an overview of the chemical industry, the chemical engineering profession, and introduces key concepts for the upcoming years of study. The chemical industry is the interface between natural resources (minerals, oil, gas, agricultural products, etc.) and the consumers of the higher value products derived therefrom. This diverse industry has both high volume-low unit value and low volume-high unit value products, and the manufacture of each type of product has its own challenges. The chemical engineering profession applies the scientific fundamentals through two key concepts: Unit Operations as well as Flux. The fundamental elements of stoichiometry and reaction kinetics are further extended to cover the concepts of yield, conversion and their specific applications to continuous and batch reactor systems. Analysis of electrical circuits is introduced, leading to nodal analysis of circuits. The application of resistance in series and capacitance is extended into chemical engineering problems involved, heat transfer, mass transfer and momentum transfer, as well as reaction engineering. The laboratory will reinforce these key chemical engineering principles.

PROPOSED course description: This course provides first year students with an introduction of the key concepts that underpin the chemical engineering discipline and their application to address global challenges. The course will introduce the chemical industry as the interface between natural resources (minerals, water, air, oil, agricultural products, etc.) and the wide range of higher value products (materials, energy, clean water, food, pharmaceuticals, etc.) utilized in our society and the challenges and opportunities for the industry as part of a sustainable future. The course will introduce four core concepts underpinning the discipline of chemical engineering: thermodynamics (driving force); transport phenomena (heat, mass, momentum); reaction kinetics (rates); and unit operations. Topics covered include: the control volume approach; material and energy balances; flux; and reaction yield and conversion, with applications to batch and continuous systems. The course will introduce the connections between these foundational concepts and how they relate to our understanding of chemical and biochemical systems at various scales. The laboratory will reinforce these key chemical engineering principles.

- *Course is being revised to focus on the four core concepts underpinning the discipline of chemical engineering and introduce the connections between these foundational concepts and how they relate to our understanding of chemical and biochemical systems at various scales. Content related to electric circuits is being removed.*

1.2. Update course description for **CHE223: Statistics**

CURRENT course description: Analysis of data using statistics and design of experiments. Topics include probability, properties of the normal distribution, confidence intervals, hypothesis testing, fitting equations to data, analysis of variance and design of experiments. The tutorial involves, in part, the application of commercial software to interpret experimental data, as obtained in Chemical Engineering laboratories.

PROPOSED course description: This course provides students with an introduction to statistical learning, namely the building of models from data. The course begins with foundational topics in elementary statistics. In the statistical learning portion of the course, the problem is formulated in terms of a system having input and output variables, the main goals of prediction and inference are presented, mean square error is defined, and the bias-variance trade-off is described in the context of overfitting the data. Statistical learning methodologies that are covered include K-Nearest Neighbours (KNN) regression, simple linear regression, multiple linear regression, and principal component analysis. Cross-validation is introduced as a popular method for model assessment and selection. The tutorial involves extensive computer-based simulation work to help students understand and appreciate the key concepts and to gain experience applying statistical learning to real data.

- *Course is being revised to give students an introduction to statistical learning.*

1.3. Update course description for **CHE311: Separation Processes**

CURRENT course description: Staged equilibrium and rate governed separation processes for gases and liquids. Topics include equilibrium stage calculations, cascade separation, binary distillation, gas absorption and stripping, liquid-liquid extraction, membrane processes, adsorption and ion exchange. Experiments in fluid mechanics, heat transfer and related unit operations.

PROPOSED course description: This course introduces students to fluid separations processes used in a variety of industries, such as (petro)chemical, (bio)pharmaceutical, carbon capture, water treatment and desalination, and mining and metals. The course will describe fundamentals of unit operations that comprise these separation processes. Staged-equilibrium processes such as distillation, absorption, and extraction will be discussed. Other unit operations that will be covered include membrane separations, adsorption, chromatography, ion exchange, crystallization, sedimentation, and centrifugation. Energy efficiency and minimum energy of separations will be discussed. Process modeling software will be introduced.

- *Course is being revised to focus more on modern separation processes.*

1.4. Update course description for **CHE322: Process Control**

CURRENT course description: The major goal of this course is to teach students how to design control strategies for chemical processes. The first part of the course focuses on the types of interconnections encountered in chemical engineering, namely feedback, parallel and series connections, and their effect on the process dynamics. The second part of the course looks at the design of feedback, feedforward, cascade and multivariable control strategies for these processes and interprets these types of engineered interconnections in terms of the effect they have on the performance of the overall system. This course makes extensive use of active learning through computer simulation based on MATLAB/Simulink and Aspen Plus Dynamics software.

PROPOSED course description: The major goal of this course is to teach students how to design control strategies for chemical processes. The first part of the course focuses on the process dynamics of different types of interconnections encountered in chemical engineering, namely feedback, parallel and series connections. The second part of the course focuses on the design of control strategies for these processes, with an emphasis on feedback controllers. Students will learn to interpret these engineered interconnections and controllers in terms of their impact on the overall system's performance and safety. Computer simulation of dynamic processes and controllers is extensively used in the course.

- *Mention of specific simulation software is being removed.*

2. CIVIL & MINERAL ENGINEERING

2.1. Redesign content of **CME321: Geotechnical Engineering I** & **CIV324: Geotechnical Engineering II**

CME321: Geotechnical Engineering I
AU– 75% Eng. Science/ 25% Eng. Design
GA– 1 – Knowledge Base: C

PROPOSED course description: Introduction to soil as an engineering material, its behaviour (stress-strain) and how behaviour is measured, and a brief introduction to geotechnical design. Topics include introduction and fundamentals such as soil types, and phase relations, principle of effective stress, groundwater flow and permeability, consolidation of clay, magnitude of settlement resulting from primary consolidation, consolidation history and compressibility parameters, behaviour of soil in shear, common laboratory tests, drained versus undrained shear, shear strength, peak vs residual friction angle, critical state soil mechanics, geotechnical field characterization, drilling and sampling methods, SPT and CPT, slope stability, analysis and design of a tailings dam. Laboratories are an essential part of this course and a number of labs will be scheduled for students.

CIV324: Geotechnical Engineering II
AU– 50% Eng. Science/ 50% Eng. Design
GA– 1 – Knowledge Base – C / 2 – Problem Analysis

PROPOSED course description: The second geotechnical engineering course expands the theoretical background developed in CME321 by introducing more practical topics and extending the theory to a few common examples of design. It discusses some applications of soil mechanics, introduces common geotechnical structures, classification of soils, compaction, engineering of water in ground, Internal erosion and filter criteria, stresses in soil, shear strength of soil, design of retaining structures, settlements, and design of shallow footings. Laboratories are an essential part of this course and a number of labs will be scheduled for students.

- *These two courses were taught in an unusual way previously and the goal is to move them back to a conventional course sequence.*

2.2. Add prerequisite of **CME270H1F – Fluid Mechanics, CIV250H1S: Hydraulics and Hydrology** for **CIV340H1S: Municipal Engineering**

2.3. Change the timing of classes for **CIV235H1F: Graphics**

CURRENT timing: 6 hours (2 hours of PRA, three times a week)

PROPOSED timing: 6 hours (2 hours LEC + 2 hours of PRA twice a week)

1. LEC: 2 hours per week for the entire class in one classroom.
2. PRA part 1 (Freehand drawing): 4 hours per week (2 x 2) for the entire class in one classroom.
3. PRA parts 2 and 3 (which require computers), we will divide the class into two sections due to the limited capacity of our computer lab. Each section will have 4 hours per week.

2.4. Add new technical elective: **CIV5XXH1S**

PROPOSED lecture timing: 3/0/2

PROPOSED course description: Specialized course in the design of timber structures. Topics include physical and mechanical behavioral analysis of wood and wood-based products, description of structural wood-based systems, limit state design concept in timber engineering, design and detailing of timber connections, elements, and components, computer-aided design approach for timber structures, digital fabrication concepts, and design of heavy timber structures.

- *This course has been taught as a 1000 level course for one year and the instructor wants to have it available for undergrads as well.*

3. ELECTRICAL AND COMPUTER ENGINEERING

3.1. Update course title and description for **MAT291: Calculus 3**

CURRENT course title and description: **MAT291: Calculus 3** - The chain rule for functions of several variables; the gradient. Multiple integrals; change of variables, Jacobians, line integrals, the divergence and curl of a vector field. Surface integrals; parametric and explicit representations, Divergence theorem and Stokes' theorem and applications from electromagnetic fields and Green's theorem.

PROPOSED course title and description: **MAT291: Introduction to Mathematical Physics -** The chain rule for functions of several variables; the gradient, directional derivative, tangent plane and small signal modeling and Jacobians. Multiple integrals; change of variables and Jacobians, line integrals: parametric and explicit representations. Surface integrals; parametric and explicit representations, multi-variable Dirac Delta distribution, superposition of vector fields, Helmholtz decomposition theorem, Divergence theorem and Stokes' theorem and applications from electromagnetic fields.

- *The course title does not adequately reflect the course content and the content has changed slightly.*

3.2. Update **ECE231: Introductory Electronics** course description.

CURRENT course description: Provides methods for the analysis and design of electrical circuits based on semiconductor nonlinear components (diodes, bipolar junction transistors and field effect transistors) and operational amplifiers. The course discusses basic physical operation of semiconductor devices, current-voltage characteristics, operating regions, DC modeling, small-signal modelling and biasing. Fundamental circuits are covered, such as rectifiers, limiting and clamping circuits and transistors amplifiers. Finally, operational amplifier non-idealities are addressed, including the impact on circuit applications.
PROPOSED course description: Provides methods for the analysis and design of electrical circuits based on semiconductor nonlinear components (diodes, bipolar junction transistors and field effect transistors) and operational amplifiers. The course discusses basic physical operation of semiconductor devices, current-voltage characteristics, operating regions, DC modeling, small-signal modelling and biasing. Fundamental circuits are covered, such as rectifiers, limiting and clamping circuits and transistors amplifiers. Finally, the operational amplifier ** is introduced and ** its non-idealities addressed, including the impact on circuit applications.

3.3. Change **ECE231: Introductory Electronics** course offering from Winter to Fall term.

- *ECE231 is needed in the fall semester. That ECE231 should be a pre-requisite for ECE295 is clear. More broadly, however, the move addresses the current imbalance of EE and CE students. The introduction of ECE295 in 2021-2022 has already had a significant impact in opening students minds toward electronics, communications, and hardware design. However, both ECE295 and ECE231 come*

too late as the ECE flexible curriculum requires students to select their kernel areas in the preceding fall semester of second year.

- *Through both the course material and its labs, ECE231 applies many areas of EE (electrical engineering), including semiconductor devices, signal processing, motors and actuators, and photonics. Moving ECE231 to the fall would expose students to these more 'EE' areas early enough to have an impact on their choice of kernel areas and their subsequent course choices in third and fourth year.*

3.4. Change **ECE212: Circuit Analysis** course offering from Fall to Winter term.

- *This is part two of the proposed plan to swap ECE231 and ECE212 in second year, and which has been presented on the system as two complementary course change requests.*

- *The effect of delaying ECE212 is manageable, and should not adversely affect the students or ECE curriculum. In fact, delaying ECE212 has the positive effect of freeing the course from being tied too closely to ECE110. Historically, ECE212 was the first circuits course and so necessarily preceded ECE231. However, that is no longer the case with the existence of ECE110 in first year; about half of ECE110 is basic circuit analysis, sufficient for students to proceed with ECE231.*

- *Delaying ECE212 gives students an additional course and semester to apply and hone their basic circuit analysis skills within ECE231. As such, less time will be necessary for the review of basic circuit analysis, and ECE212 will become more streamlined to focus on the analysis of circuits (and systems) in the frequency domain. Having ECE212 concurrent with ECE216 Signals and Systems also opens up opportunities to reinforce concepts that are common to the two courses (e.g. system concepts in ECE216 such as transfer functions can be tied to active filter design in ECE212 employing operational amplifiers).*

4. ENGINEERING SCIENCE

4.1. Change delivery and course description for **ESC204H1S: Praxis III**

CURRENT delivery: 1-5-1 (Lecture/Practical/Tutorials)

PROPOSED delivery: 3-2-2 (Lecture/Practical/Tutorials)

CURRENT course description: 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.

PROPOSED course description: Praxis III is the capstone course of the Engineering Science Foundation Design sequence. It challenges students to extend and apply the models of engineering design, communication, teamwork, and professionalism introduced and developed in Praxis I and II to engineering design in a complex collaboration setting. Students integrate the design, technical, and complementary knowledge gained across the Engineering Science Foundation curriculum in the context of a single, major, mechatronic design project.

Teams in Praxis III choose from a curated set of opportunity areas that integrate technical, complementary, and optionally, multidisciplinary, considerations. They are responsible both for framing a specific opportunity within their chosen area and for developing a valid design idea for the opportunity supported by a mechatronic prototype. Praxis III culminates in a public showcase where teams present their design process and outcomes to an external audience. 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.

- *To agree with current delivery format.*

4.2. Change AU distribution for **ECE253H1F: Digital and Computer Systems**

CURRENT AU distribution: 30% Engineering Design/70% Engineering Science

PROPOSED AU distribution: 40% Engineering Design/60% Engineering Science

- *ECE253 covers digital and computer systems. The course has a weekly 3-hour practical session. Over the course of the semester, students complete 9 practical assessments. Each assessment involves components of engineering design, such as open-ended design problems, consideration of alternative solutions and decision-making, implementation processes, testing, teamwork, and communication. As the semester progresses, the practical assessments increase in design complexity. Practical assessment constitutes 25% of each student's final grade in the course. In addition, design is also assessed on the midterm and final. Approximately 30% of the exams are composed of design questions where students are given a problem and must complete some aspect of the design process to solve the problem. These problems are often open-*

ended in nature with multiple feasible designs. Students are often required to consider some constraints such as cost of their designs. In lectures, the professor works through design examples regularly to illustrate the application of course concepts to the design of digital systems. A typical week of lectures will feature 1-2 design examples.

- *Both assessment and lecture/tutorial content exceed 40% ED and the course is similar in nature to ECE241 which is assessed at 50% Engineering Design.*

4.3. Update course description for Aerospace, Math Stats and Finance, Energy, and Robotics major.

PROPOSED addition to course description: CHE374H1 may be taken in 4F to provide increased flexibility in 3F for Aerospace, Math Stats and Finance, Energy and Robotics major.

- *To increase flexibility in 3F.*

4.4. Update course description for **ESC103H1F: Engineering Mathematics and Computation**

CURRENT course description: This course is designed to introduce students to mathematics in an engineering context, while exposing students to computational techniques. Topics include: vectors, lines and planes; 3-D visualization; matrices and transformations; matrix inverses, eigenvalues and determinants; solving linear systems; curve fitting and least squares; numerical integration and numerical solutions to differential equations. Course content is complemented with the use of MATLAB computational software.

PROPOSED course description: Introduces students to mathematics in an engineering context, In particular, linear algebra and computational techniques. Emphasis is placed on developing students' ability to visualize in 2-D, 3-D, and higher dimensions. Linear algebra topics include: vectors, lines and planes, viewing systems of linear equations using row picture and column picture, independence, dependence and column space, matrix multiplication and factorization (A=CR), solving linear systems using elimination, connecting rank and shape of a matrix, and inverse matrices. Computational problems include numerical integration, solving the least squares problem, and numerical solutions to initial value problems (IVP) and boundary value problems (BVP). Course content is complemented with the use of computational software.

- *Revised to match current content and remove reference to specific software.*

4.5. Changes to Majors

4.5.1 Aerospace

AER525H1F: Robotics

Add **MIE301: Kinematics and Dynamics of Machines** as a prerequisite and **MIE404: Control Systems I** as a co- or prerequisite and "or equivalent" to prerequisites.

- *Provides a path for MIE students to take the course since this course is listed as a technical elective for MIE students and there are multiple control/dynamics courses they can take.*

4.5.2 Biomedical Systems Engineering

Add **APS360H1: Applied Fundamentals of Deep Learning F/S** as a technical elective.

- *Course has been requested as a substitute for a technical elective many times over past few years and always approved so officially add to tech elective list.*

4.5.3 Mathematics, Statistics and Finance

Add **APS360H1: Applied Fundamentals of Deep Learning F/S** as a technical elective.

Add **CSC384H1: Introduction to Artificial Intelligence F/S** as a technical elective.

- *Courses have been requested as technical elective substitutes many times over past few years and always approved so officially add to technical elective list.*

4.5.4 Electrical and Computer Engineering

Add **APS360H1: Applied Fundamentals of Deep Learning F/S** as a technical elective.

Add **CSC413H1S: Neural Networks and Deep Learning** as technical elective.

- *Courses have been requested as technical elective substitutes many times over past few years and always approved so officially add to tech elective list.*

4.5.6 Robotics

Add **APS360H1: Applied Fundamentals of Deep Learning F/S** as a technical elective.

- *Courses have been requested as technical elective substitutes many times over past few years and always approved so officially add to tech elective list.*

<u>Minor corrections to calendar to agree with actual delivery</u>

4.6 **ESC470H1S: Energy Systems Capstone Design**

Change delivery from 0/0/5 to 0/0/2

4.7 **ESC471H1F: Engineering Science Capstone**

Change delivery from 0/0/5 to 0/0/2

4.8 **ESC472H1S: Electrical and Computer Capstone Design**
Change delivery from 0/0/5 to 0/0/4

4.9 **ROB498H1S: Robotics Capstone Design**
Change delivery from 0/0/5 to 0/0/3

4.10 **MIE429H1F: Machine Intelligence Capstone**
Change delivery from 0/0/5 to 0/0/3

4.11 **MIE479H1F: Engineering Mathematics Statistics, and Finance Capstone Design**
Change delivery from 0/0/5 to 0/0/3

4.12 **BME489H1F: Biomedical Systems Engineering Design**
Change delivery from 1/0/4 to 2/3/0

5. MECHANICAL & INDUSTRIAL ENGINEERING

5.1. Add **MIE4XXH1: Fundamentals of Injury Biomechanics and Prevention**

PROPOSED course title**: MIE4XXH1 - Fundamentals of Injury Biomechanics and Prevention**

PROPOSED year and term: 4W, as a Technical Elective (TE)

PROPOSED course description: Injury biomechanics uses the principles of mechanical engineering to understand how injuries occur in various body regions and the main approaches to prevent them. In this course, we will review the injury mechanisms at the tissue level and the injury criteria for the lower extremities, upper extremities, head, neck, and trunk. Topics in injury prevention methods through safety devices and safely designing the equipment will be studied as well as engineering design considerations in treating a skeletal injury. The course also covers the computational (finite element analysis, and statistical analysis) and experimental (mechanical testing of crash test dummies, artificial bones, PMHS, and ex-vivo specimens) research methods used in injury and orthopedic biomechanics. Students will have the opportunity to apply their learning in forensic biomechanics case studies, and design and analysis of protective equipment.

PROPOSED learning objectives:
1. Identify the main mechanisms of sustaining injuries in major anatomical locations (e.g., lower extremities, upper extremities, head, neck, and trunk).
2. Explain the considerations in creating injury criteria for the human body.
3. Outline the main mechanisms in injury prevention.
4. Discuss the engineering considerations in the treatment of a skeletal injury.
5. Describe and apply the methodologies used in injury biomechanics.
6. Analyse the injuries from a motor vehicle collision and determine if the sustained injuries could have been prevented if the protective measures were used.

7. Design an engineering solution to overcome a limitation in a piece of protective equipment used in the transportation system or sport and develop a plan for testing its effectiveness.

PROPOSED textbook: A compilation of instructor notes and slides and additional readings. All teaching materials will be provided to the students (pre-lecture skeleton notes, completed post-lecture notes, and reading material). The resources to use during the course will be posted on the course website.

For extra readings students can use the following textbook: "*Biomechanics of Injury*", 3rd Edition, Ronald F. Zernicke, Steven P. Broglio, William C. Whiting, Human Kinetics.

PROPOSED AUs:
50% Engineering Science [ES]
25% Natural Sciences [NS]
25% Engineering Design [ED]

PROPOSED timing:
Lectures = 3 h / Lab = 0 h / Tutorials = 1 h. Total AUs = 42.7

PROPOSED prerequisites: CIV100, MIE100, MIE270, MIE222

PROPOSED exclusions: n/a

PROPOSED short course name: Injury Biomechanics

PROPOSED room requirements: Standard row seat, 50-student capacity

PROPOSED minors and certificates: Minor in Bioengineering (AEMINBIO)

- *Fills a current gap in the MEC 4th-year Bioengineering stream. Currently, MIE offers two core courses: (i) cell and tissue biomechanics, and (ii) biofluid mechanics. Bioengineering stream students must choose 1 of the 2 core courses. Cell and tissue biomechanics used to cover whole body movement, but no longer does. This has created a gap in our bioengineering stream. The current proposal for an injury biomechanics course was done in consultation with the "Mechanics and Materials" Teaching Group (TG Coordinator: Kevin Golovin) with direct input from mechanics and bioengineering faculty.*

- *In addition, there is potential synergy with the Faculty of Kinesiology and Physical Education (KPE), who in collaboration with MIE has interest in creating a "movement performance" certificate for engineering students as part of the Cross-Disciplinary Programs. KPE currently offers a course titled: KPE372 - Injury and Orthopaedic Biomechanics, but the proposed MIE course is more focused on forensic biomechanics and engineering aspects of injury biomechanics, including mechanical design of injury prevention equipment. All efforts will be made to*

coordinate with KPE372 instructors to avoid significant overlap if a Movement Performance certificate is established.

5.2. Add **MIE5XXH1: AI for Social Good**

PROPOSED course title**: MIE5XXH1 – AI for Social Good**

PROPOSED year and term: 4F, 500-level (grad students eligible to enrol) as a CS/HSS Elective

PROPOSED course description: The issue of design and development of AI systems that have beneficial social impact will be discussed and analyzed. The focus will not be on the mechanics of AI algorithms, but rather on the implementation of AI methods to address societal problems. Topics to be covered will include: Safeguarding of human interests (e.g., fairness, privacy) when AI methods are used; partnering of humans and AI systems to implement AI effectively; evaluation of AI assisted interventions; practical considerations in the selection of AI methods to be used in addressing societal problems. The issues that arise in implementing AI for beneficial social impact will be illustrated in a set of case studies aimed at creating beneficial social impact. Class activities will include lectures, seminars, labs, and take-home assignments.

PROPOSED learning objectives:
1. Ability to evaluate risks associated with the use of AI in practical applications
2. Awareness of ethics and privacy standards that AI implementations should meet
3. Ability to evaluate overall effectiveness of AI implementations
4. Ability to design appropriate human roles in human-AI interaction

PROPOSED textbook: https://ai4sibook.org/ AI for Social Impact (Tambe, M., Fang, F. and Wilder, B., Editors).

PROPOSED AUs:
75% Complementary Studies [CS]
25% Engineering Design [ED]

PROPOSED timing:
3 hours per week Lectures
Four labs in total. Labs will run from weeks 3-6 of the course.

Lectures will be run as a one-hour lecture and then a separate 2-hour seminar each week. The lecture will provide an overview of the topic for the week and then the seminar will be a guided discussion of the reading. Labs will be 2-hour sessions.

Including labs total contact time will be 44.6 hrs total, or 3.66 hrs per week average (Total AUs = 40.6)

PROPOSED prerequisites: MIE223, MIE237, or Introductory Machine Learning or equivalent

PROPOSED exclusions: CSC 300 Computers and Society

PROPOSED short course name: Impactful AI

PROPOSED room requirements: TEAL room or Case study room

PROPOSED minors and certificates: Minor in AI Engineering (AEMINEAIEN)

- *An AI course that intersects with societal impact aligns well with the recent IND curriculum renewal that saw an increased emphasis on AI and applied ML. The proposal was developed by Prof. Mark Chignell, an expert in human factors and information technology, and was done in consultation with both our "Human Factors" and "Info Engineering" Teaching Groups. MIE is keen to provide leadership in the education of applied AI/ML, including its impact on society. Furthermore, the course is an ideal fit for the Minor in AI Engineering.*

5.3. Change course title, description, prerequisites, and recommended background for **MIE440: Design of Innovative Products**

CURRENT course title: **Design of Innovative Products**

PROPOSED course title: **Design of Effective Products**

CURRENT course description: Recently developed methods applied at different stages of the design process include: Identification of unmet/underserved user needs through a modified definition of lead users (those who experience needs in advance of the mainstream population) including identifying/studying lead users, identifying which lead-user needs are relevant to the general population; Roles of function and affordance in successful products; Obstacles of fixation and cognitive bias to creativity; Concept generation methods including TRIZ/TIPS (Theory of Inventive Problem Solving, use of unrelated stimuli and analogy (e.g., from biology); Configuration design methods including design for transformation, design for assembly and end-of-life, e.g., reuse, repair and recycling. Hands-on experience of these topics in lectures, tutorials, and labs support successful application of the methods for the course project, as well as future design activities.

PROPOSED course description: Products should be used as intended to be effective. Thus, a primary goal is to better align designer intention and user behavior. More specifically, sustainability-minded products should be technically efficient, but also support people to use them more sustainably. Finally, many products and systems nudge people to behave in ways contrary to the user's best interests. To address the above, the course focuses on design that increases intended product use, and pro-social / pro-environmental behaviors. For projects, students will develop, prototype and test

concepts that aim to increase desired behaviors. Methods relevant to the design of all products include: identification of unmet/underserved user needs through lead users; roles of function and affordance in effective products; fixation and cognitive biases as obstacles to creativity; concept generation methods (e.g., Theory of Inventive Problem Solving (TRIZ/TIPS), use of stimuli and analogy); configuration design methods (e.g., design for transformation, manufacture, assembly, reuse, repair, and recycling).

Add prerequisite: **MIE221H1: Manufacturing Engineering**, or with instructor permission.

Recommended Background Courses:
MIE240H1: Human Factors Engineering (IE core)
MIE242H1: Foundations of Cognitive Psychology (IE core)
MIE243: Mechanical Engineering Design (ME core)
MIE315: Design for the Environment (ME core)
MIE345H1: Case Studies in Human Factors and Ergonomics (IE elective)

- *The revised title and course description more accurately describes what the course currently is (and has been) for a few years now. The prerequisite is needed because introductory manufacturing topics are discussed. Many students who took MIE440 in the past did not expect the level of manufacturing presented in the course, so the prerequisite is important to manage expectations. The recommended courses are meant to give students a better idea of what the course is about.*

5.4. Update course description for **MIE414: Applied Fluid Mechanics**

CURRENT course description: This course builds upon the material introduced in Fluid Mechanics I and connects it to a wide range of modern technical applications of fluid flow. Applications include the design of pipe and microfluidic networks, transient flow phenomena, characteristics of pumps, open channel flow and an overview of flow measurement techniques. Lectures are complemented by laboratory experiments on topics such as centrifugal pumps, flow transients and fluid flow in microfluidic chips.

PROPOSED course description: This course builds upon the material introduced in Fluid Mechanics I and focuses on technical applications of fluid flow. Discussed topics include the pressure drop in pipe and channel flow networks, transient flow phenomena, external flows, performance characteristics of different pumps and turbines, systems of flow networks and flow machines, and an overview of modern flow measurement techniques. Lectures are complemented by laboratory experiments on topics such as pipe/channel networks, flow transients, and flow machines.

- *There is declining enrollment due to several possible contributing factors. One may be the current description, which is outdated and does not reflect current topics. The other factor may be that the course is currently listed as a technical elective in MIE's "bioengineering" stream. Relisting it as a technical elective for*

"Energy and Environment" is in better alignment with course content and will better target the students choosing the "Energy and Environment" stream.

5.5. Change **MIE504: Applied CFD** Year 4 Technical Elective course offering from winter to fall term.

CURRENT term: Winter term

PROPOSED term: Fall term

- *The main reason for this is that our undergraduate cohort will benefit from taking CFD early in their 4th year so that they can properly use it in their Capstone project.*

5.6. Update prerequisites for **MIE311: Thermal Energy Conversion**

CURRENT Prerequisite: MIE210H1, MIE313H1

PROPOSED Prerequisite: MIE210H only (remove MIE313H1)

- *Students do not take MIE313 until 3W, the same time that they take MIE311, so MIE313 cannot be a prerequisite. MIE313 should either be removed or added as a co-requisite. Adding as a co-requisite is preferred if that option is available.*

5.7. Change course title and prerequisites for **MIE535H1 Electrification Through Electricity Markets**

CURRENT course title: Electrification Through Electricity Markets
PROPOSED course title: Electrification Via Electricity Markets

- *Previous title was too long and resulted in unnecessary abbreviation of words to fit into the character limits of the short title. The proposed shorter title eliminates the unnecessary abbreviation.*

CURRENT Prerequisite: MIE258 or equivalent

PROPOSED Prerequisite: CHE249 or CME368 or ECE472 or CHE374 or MIE358 or equivalent

- *Specifically listing the economics courses from other departments further clarifies to the students that any of these courses are acceptable as the prerequisite.*

5.8. Add exclusions for **MIE422: Automated Manufacturing**

PROPOSED exclusions: ECE470 and AER525

- *The Calendar currently states: "Students may take only one of MIE422H1 (Automated Manufacturing) or AER525H1 (Robotics)". However, this is currently listed as a footnote in the Calendar rather than a clear exclusion. Explicitly listing AER525 as an exclusion would make it clearer for students. In addition, AER525 is currently listed as an exclusion for ECE470. If AER525 is an exclusion for ECE470 and also an exclusion for MIE422 (as proposed), then ECE470 must also be an exclusion for MIE422, by extension.*

5.9. Add exclusion for **MIE245 Data Structures & Algorithms**

PROPOSED exclusion: CSC373

- *There is significant overlap between CSC373 and MIE245, and we want to avoid IND students requesting to use CSC373 as a Technical Elective substitute. This concern was raised because a recent MEC student used CSC373 as a Technical Elective substitute, and that request was approved since they are a MEC student and MIE245 is not a core course for them. Since MIE245 is core to IND, and IND student should not also be eligible to take CSC373.*

5.10. 2024-2025 Curriculum Changes from Industrial Engineering Curriculum Renewal

The following changes were proposed as part of the completed IE Curriculum Renewal Package presented in whole by Prof. Scott Sanner to the FASE UCC in Fall 2022. The IE Curriculum Renewal involves a multi-year phased approach to curriculum changes. In Fall 2022, after the whole package was presented to and approved by the UCC, the first phase of curriculum changes affecting second year courses in the IND program were brought forth to Faculty Council to be implemented in 2023-2024.

In this cycle, for Fall 2023, we are presenting the second phase of curriculum changes, which will affect third year courses in the IND program. These curriculum changes are to be brought forth the Faculty Council in Fall 2023, to be implemented in 2024-2025.

<u>Changes in the second phase:</u>

5.10.1. Add the following courses:

1. **MIE3XXH1(F): Introduction to Machine Learning** (New Course)
2. **MIE3XXH1(S): Data Modelling** (Moved from 2nd year)
3. **MIE304H1(S): Introduction to Quality Control** (New TE, currently a MechE and MSE TE)
4. **MIE3XXH1(S)/MIE459: Organization Design** (Moved from 4th year – taught as two separate sections, double coded / equivalent courses to

accommodate both cohorts, **MIE459: Organization Design** to be dropped only in 2026-27 due to PEY)

5.10.2. Drop the following courses:

1. **MIE335H1(F): Algorithms & Numerical Methods** (Moved to 2nd year) – submitted in 2022, effective 2023-2024
2. **MIE364H1: Quality Control and Improvement** (Replaced by MIE304)

5.10.3. Changes to the following courses:

1. **MIE258H1(F) relabel as MIE358H1(F)**: Engineering Economics (Moved from 2nd year to 3rd year, update Title and Description, notify MechE and MSE need to update their programs)
2. **CSC384H1(F): Introduction to Artificial Intelligence** (New Prerequisites) – submitted in 2022, effective 2023-2024
2. **MIE343H1(F): Industrial Ergonomics and the Workplace** (Now a Technical Elective)
4. **MIE344H1(F): Ergonomic Design of Information Systems** (New Description)
5. **MIE365H1(F): Advanced Operations Research** (New Title and Description)
6. **MIE350H1(S): Integrated Design: Human Factors and Information Systems** (New Term, Description)
7. **MIE354H1(S): Business Process Engineering** (New Term)
8. **MIE5XXH1(S): Electrification Through Electricity Markets** (Update Prereq: **MIE258: Engineering Economics and Accounting** to **MIE358**

5.11. Detailed Course Requests

5.11.1. Add new core course **MIE3XXH1(F): Introduction to Machine Learning**

PROPOSED year and term: 3F

PROPOSED course description: Intro to Machine Learning, Hypothesis Spaces, Inductive Bias. Supervised Learning: Linear and Logistic Regression. Cross Validation (CV). Support Vector Machines (SVMs) and Regression. Empirical Risk Minimization and Regularization. Unsupervised Learning: Clustering and PCA. Decision Trees, Ensembles and Random Forest. Neural Net Fundamentals. Engineering Design considerations for Deployment: Explainability, Interpretability, Bias and Fairness, Accountability, Ethics, Feedback Loops, and Technical Debt.

PROPOSED learning objectives:

1. Understand fundamental supervised and unsupervised machine learning from a mathematical perspective.
2. Understand how to properly evaluate machine learning algorithms to assess generalization performance.
3. Understand conceptual and mathematical fundamentals of neural networks.
4. Understand key learning and optimization algorithms commonly employed for machine learning.
5. Understand how to identify and address ethical concerns of bias and fairness in

machine learning systems.

6. Understand common deployment requirements and problems that may occur at the deployment stage of machine learning algorithms.
7. Obtain hands-on lab and assignment experience applying machine learning to real-world datasets.

PROPOSED *Mathematics for Machine Learning:* Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong. Cambridge University Press (2020).

PROPOSED AUs:
75% Engineering Science
25% Engineering Design

PROPOSED timing:
Lecture: 3 hours / Lab: 2 hours / Tutorial: 0 hours

PROPOSED prerequisites: **MIE236H1/ECE286H1/STA286H1/ECE302H1** or equivalent, **MIE237H1/STA286H1** or equivalent

PROPOSED exclusions: CSC311H1, ROB313H1, ECE421H1, ECE521H1

PROPOSED short course name: Intro to Machine Learning

PROPOSED room requirements: Windows or Linux Computer Lab for lab component

- *Machine Learning is a fundamental methodology in the use of data in the modern organization and is thus foundational to a modern IE curriculum.*

5.12. Change course code, description, year and term offering for **MIE253H1: Data Modelling**

CURRENT course code: **MIE253H1**

PROPOSED course code: **MIE3XYH1**

CURRENT year and term: 2S

PROPOSED year and term: 3F

CURRENT course description: This course provides an understanding of the principles and techniques of information modelling and data management, covering both relational theory and SQL database systems (DBMS), as well as entity-relation conceptual modelling. The course also familiarizes the student with analytical applications (OLAP) and provides an introduction to XML data modelling. The laboratory focuses on database application development using SQL DBMS, OLAP queries and entity-relation data modelling.

PROPOSED course description: This course provides an understanding of the principles and techniques of information modelling and data management, covering both relational theory and SQL database systems (DBMS), as well as entity-relation conceptual modelling. The course also provides an introduction to graph databases (RDF, SPARQL, and knowledge graphs), as well as UML class diagrams. The laboratory focuses on database application development using SQL DBMS, OLAP queries and data modelling.

- *The changes incorporate updated content on new technologies currently be used in industry.*

5.13. Add **MIE304H1(S): Introduction to Quality Control** as a technical elective option of Industrial Engineering

PROPOSED year and term: 3S/4S

- *This core course has been replaced by an existing MEC technical elective MIE304, in favour of more core content in higher demand data science areas.*

5.14. Change course code, description, year/term for **MIE459H1: Organization Design**

CURRENT course code: MIE459H1

PROPOSED course code: MIE3YYH1

CURRENT year and term: 4S

PROPOSED year and term: 3S

CURRENT course description: Study of work systems design in new and existing organizations. Consideration will be given to sociotechnical systems design methodology, division of labour, change management, teams, incentives, project management, safety culture, automation, equity, and union-management relations.

PROPOSED course description: Study of work systems design in new and existing organizations. Consideration will be given to fundamental organizational theory topics such as structure, lifecycle, culture, and ethics. These concepts will be the foundation for an understanding of concepts such as bureaucracy, incentives, innovation, international business, trends in technology, and hiring. An emphasis will be placed on applying these concepts to real-world organizational examples and case studies.

- *No major changes, instead the description now includes a sense of fundamental concepts and applied topics. A focus on applications and examples is now included.*

5.15. Change course code, title, description, year/term for **MIE258H1: Engineering Economics and Accounting**

CURRENT course code and title: **MIE258H1: Engineering Economics and Accounting**

PROPOSED course code and title: **MIE358H1: Engineering Economics**

CURRENT year and term: 2F

PROPOSED year and term: 3F

CURRENT course description: Engineering economic and accounting concepts needed in the design of engineering systems. Financial analysis topics include: financial statements, depreciation, income tax, and basic accounting techniques. Project analysis topics includes: time value of money, evaluation of cash flows, defining alternatives, analysis of independent projects, acceptance criteria, buy or lease, make or buy, replacement analysis, economic analysis in the public sector, project risk and uncertainty. Inflation concepts.

PROPOSED course description: This course provides students with knowledge and skills for understanding, analyzing, and solving decision making problems which involve economic concepts. These problems deal with deciding among alternatives in engineering projects with respect to costs and benefits over time. The overarching goal of the course is preparing engineers with the skills and knowledge for analyzing economic decisions quantitatively and making suitable decisions by acknowledging and incorporating the ramifications of factors like interest, depreciation, taxes, inflation, and risk in engineering projects.

- *This course has been revised with guidance from a new edition of a textbook, thus integrating some previously taught topics in modern decision-making needs. Emphasis is placed on quantitative analysis methods.*

5.16. Change **MIE343H1(F): Industrial Ergonomics and the Workplace** from a core course to a technical elective and update course description

CURRENT type: Core

PROPOSED type: Technical elective

CURRENT course description: The Biology of Work: anatomical and physiological factors underlying the design of equipment and workplaces. Biomechanical factors governing physical workload and motor performance. Circadian rhythms and shift work. Measurement and specification of heat, light, and sound with respect to design of the work environment.

PROPOSED course description: The Biology of Work: anatomical and physiological factors underlying the design of equipment and workplaces. Biomechanical factors governing physical workload and motor performance. Circadian rhythms and shift work. Measurement and specification of heat, light, and sound with respect to design of the work environment. The influence of practical and psychosocial factors on workplace ergonomic decision-making.

- *Minor changes reflecting evolving emphasis of the course material.*

5.17. Update course description for **MIE344H1(F): Ergonomic Design of Information Systems**

CURRENT course description: The goal of this course is to provide an understanding of how humans and machines can be integrated with information systems. The focus will be on the design of human-machine interfaces, and on the analysis of the impact of computers on people. The course will also include coverage of usability engineering and rapid prototyping design, analysis of user mental models and their compatibility with design models, and quantitative modelling of human-computer interaction.

PROPOSED course description: Application of information and interaction design principles in interactive systems. Focus on design and methods for understanding user needs, making sense of user research, prototyping, evaluation methods and iterative design. The course will include in depth coverage of rapid prototyping, scenario-based design, usability inspection methods, summative and formative usability evaluation, and comparison tests. Eye tracking, remote testing and experience/ journey mapping will be introduced.

- *New course description better adheres to guidelines for course descriptions and reflects new course content and emphasis on an iterative design process.*

5.18. Change course title and description for **MIE365H1(F): Operations Research III: Advanced OR**

CURRENT course title: **Operations Research III: Advanced OR**

PROPOSED course title: **Advanced OR**

CURRENT course description: Design of operations research models to solve a variety of open-ended problems. Linear programming extensions are presented: goal programming, column generation, Dantzig-Wolfe decomposition, and interior point solution methods. Non-linear programming solution methods are developed: optimality conditions, quadratic programming and bi-level programming. Solutions to advanced stochastic models: stochastic programming, 2-person and n-person game theory, and Markov Decision Processes.

PROPOSED course description: Linear programming extensions: goal programming, column generation, interior point solution methods, game theory applications, quadratic programming, bi-level programming, stochastic programming. Mathematical Programming formulation choices. Evolution of dynamic programming into Markov decision processes and reinforcement learning.

- *Natural evolution of course content with recognition to changes in MIE262 and MIE263.*

5.19. Change term offering and course description for **MIE350H1(s): Design and Analysis of Information Systems**

CURRENT year and term: 3F

PROPOSED year and term: 3S

CURRENT course description: Provides students with an understanding of the methods of information system analysis and design. These include methods for determining and documenting an organization's structure (FDD), activities, behaviours and information flows (DFDs, decision tables and trees, network diagrams, etc.); model acquisition (data repositories), verification and validation. Methods such as SADT, RAD and prototyping will be covered. Students will acquire a working knowledge of various frameworks for analysis (e.g., information technology categories, system and application classifications, decision types, data vs information). Throughout the course, emphasis is placed on the importance of systems thinking and organizational culture in the analysis and design process. In the laboratory, students will use a CASE-based computer program (Visible Analyst) for the analysis and design of information systems for selected organizations. Students will be asked to work in teams to create a web-based information site and to document and present their development progress through the use of a structured project log.

PROPOSED course description: The course covers the software lifecycle of user-centered, computer-based information systems. Topics include software development methodologies, requirement engineering, use case analysis, process modelling, data flow diagrams, UML, design, model-driven architecture, and implementation. The course will emphasize user-centered perspectives and effective communication across the software lifecycle of information systems.

- *This change is proposed as part of the larger changes in the IE curriculum. Course specific rationales: (i) more emphasis on human-centered aspects of systems design for increased integration of human factors perspective, (ii) update description to reflect recent tools and platforms. This proposal came out of discussions with Eldan Cohen (current instructor), Michael Gruninger and Chris Beck (previous instructors), and Greg Jamieson. There was a suggestion to change the name but after re-examining the proposed new curriculum, we now propose to keep the old one as it is still accurate.*

5.20. Change term offering, prerequisites, and course description for **MIE354H1(S): Business Process Engineering**

CURRENT year and term: 3F/4F

PROPOSED year and term: 3S/4S

CURRENT Prerequisite: **MIE253H1**
PROPOSED Prerequisite: **MIE3XYH1** (new course code for what was formerly **MIE253H1: Data Modelling**)

CURRENT course description: This course focuses on understanding multiple perspectives for grouping, assessing, designing and implementing appropriately integrated and distributed information systems to support enterprise objectives. The emphasis is on understanding how Business Process Management techniques and tools can contribute to align an organization's business and information technology perspectives, as well as the characteristics of application and system types and the implications for their design, operation and support of information needs, including those associated with different platforms and technology infrastructure e.g., legacy systems, client/server, the Internet and World Wide Web including the emergence of a web-service-based service oriented architecture. Students will work in the laboratory to develop business processes that can be specified and executed by information systems supporting BPEL, a widely supported standard for describing web-service-based business processes.

PROPOSED description: This course focuses on understanding and applying multiple perspectives for organizing, assessing, designing, and implementing integrated distributed information systems to support an organization's objectives. The emphasis is on 1) understanding how Business Process Management techniques and tools can contribute to align an organization's business and information technology perspectives; 2) designing, developing, and deploying Business Processes as information systems. The course introduces blockchain technologies, an emerging class of distributed information system providing the foundation for Web3 decentralized applications. Students will work in the laboratory to develop business processes that integrate blockchain smart contracts, specified using the BPMN industry standard notation. Students will implement and test executable BPMN business processes using an open source BPMN engine together with additional Java programming.

- *Blockchain and Web3 have been incorporated into the course content as a recent (disruptive) addition to the distributed information systems technologies that organizations can integrate with their Business Processes. The term has moved to accommodate the year change of the Data Modeling prerequisite.*

6. MATERIALS SCIENCE & ENGINEERING

6.1. Update course description for **MSE202: Thermodynamics I**

CURRENT course description: The three laws of thermodynamics, Heat capacity theory and Debye's law. Calculations of enthalpy, entropy, and free energy of pure materials and reactions. Reversible and irreversible processes. Gibbs free energy, chemical equilibria, and phase rule. Introduction of Ellingham, and pre-dominance area diagrams. Binary and ternary phase diagrams and their applications to materials processing and materials properties.

PROPOSED course description: Fundamental Thermodynamics Laws. Thermodynamic Variables and Relationships. Understanding Reversible and Irreversible Processes. Thermodynamic Equilibrium and the Gibbs Phase Rule. Exploring the Clausius-Clapeyron Equation. Practical Thermodynamic Applications for Unary Phase Diagrams. Multicomponent Multiphase Reacting Systems in Standard State. Analyzing the Ellingham Diagram and Pre-dominance Diagrams. Binary Phase Diagrams for Materials Processing and Properties.

- *Course description is being updated with new professors teaching the course.*

6.2. Update course description for **MSE302: Thermodynamics II**

CURRENT course description: Introduction to statistical thermodynamics. The concept of chemical potential and its application in solution thermodynamics. Solution models. Equilibrium in multi-component, multi-phase systems. Thermodynamics of surfaces and interfaces. Applied thermodynamics with examples of industrial applications. Computational thermodynamics.

PROPOSED course description: Ternary Phase Diagrams for Materials Processing and Properties. Introduction to Statistical Thermodynamics. Exploring the Concept of Chemical Potential in Solution Thermodynamics. Understanding Solution Models. Equilibrium in Multi-component Multi-phase Systems. Utilizing Thermodynamic Models for Creating Binary Phase Diagrams. Practical Applications of Thermodynamics with Industrial Examples. Analyzing Equilibrium Conditions in Electrochemical Systems and Their Practical Uses. Computational Thermodynamics for Advanced Understanding.

- *Course description is being updated with new professors teaching the course.*

6.3. Change course title and description for **MSE401: Materials Information in Design**

CURRENT title: Materials Information in Design

PROPOSED title: Materials Selection for Sustainable Product Design

CURRENT course description: This course presents approaches to composite and structural design, and optimization, for components and products. Tools for optimization, material property data analytics, and structural simulation will be used. We will apply advanced materials selection (and the CES materials database) to product and component design, and hybrid (composite) materials design. Composite mechanics theory and topology optimization will be developed for structural optimization. Finally, modern techniques including AI and machine learning will be presented for aspects of materials selection, composite design and structural optimization. Component design decisions will include both material properties and the capabilities of applicable fabrication processes, to identify the material and process which best satisfy the design requirements. Course objectives: (1) dene the role that materials play in product design (properties, performance), (2) establish a rational, systematic means of comparing materials, and materials selection by applying design constraints and optimize mechanical performance, (3) learn to apply software tools (CES) for materials selection, (4) find compromise with multiple constraints, (5) perform iteration in the optimization of product design, considering materials, shape and processing, (6) design new products based on multiple components, considering optimal performance, manufacturing and environmental sustainability.

PROPOSED course description: Provides a rationale for materials selection in the design of engineered components and commercial products, with a general aim towards structural optimization and sustainability. Defines concepts of life cycle analysis and embodied energy, reviews material recycling technologies and methods, and environmental issues associated with materials in manufactured products, and waste. Develops a rationale for advanced materials selection, using the Ansys Granta CES materials software (a database for thousands of materials), for component design, based on an identification of the functional requirements. Develops a method for 'eco-audit' estimation of the total embodied energy of products. Altogether, materials selection includes structural and material processing considerations, and a range of case studies provide examples of optimized and sustainable design. Hybrid (composite) materials design and options for sustainable bio-composites discussed, including basic composite mechanics and topology optimization for structural optimization. There are two main design projects associated with proposed products, involving materials selection and multiple component design, to demonstrate an optimization of material usage and overall product sustainability. Course objectives: (1) Define the role that materials play in product design (properties, performance); (2) Define the embodied energy and sustainability of materials and products; (3) Establish a rationale for materials selection (a material index) by defining a design objective and constraints to optimize structural efficiency and sustainability; (4) Learn to apply software tools (Ansys CES) for materials selection; (5) Find compromise with multiple constraints; (6) Perform iteration in the optimization of product design, considering materials, shape and processing; (7) Design a device/product with multiple components, considering optimal performance, manufacturing and environmental sustainability.

- *Course description is being updated with new professors teaching the course. Course title is being updated to better reflect actual course content.*

6.4. Change **MSE343: Biomaterials** Year 3 Elective and **MSE443: Composite Materials Engineering** Year 4 Core course offering from Fall to Winter Term.

As a result of the change to **MSE443: Composite Materials Engineering**, a Winter Term Technical Elective will shift to Fall Term

- *In hopes of increasing enrolment due to limited elective spaces in current term offered (MSE343) and to return course offering to its historical term (MSE443).*

6.5. Remove one GA from **MSE332: Heat and Mass Transfer for Materials Processing** course information.

CURRENT GAs: 1C Knowledge Base for Engineering – Developed
1D Knowledge Base for Engineering – Developed
2A Problem Analysis – Developed

PROPOSED GAs: 1C Knowledge Base for Engineering – Developed
1D Knowledge Base for Engineering – Developed

- *Removing a GA from current course information to better reflect actual course content.*

6.6. Change course code for **MSE443/MSE1043: Composite Materials Engineering**

CURRENT course code: **MSE443/MSE1043**

PROPOSED course code: **MSE543**

- *For administrative purposes, changing double coded course to 500-level.*

6.7. Expand elective offering for **MSE465: Application of Artificial Intelligence in Materials Design** to Year 3 Students

CURRENT elective offering: Year 4 Fall Term.
No recommended preparation listed.

PROPOSED elective offering: Year 3 and Year 4 Fall Term.
Recommended preparation: strong background in math, programming, AI, and machine learning.

- *To provide students with more elective options in Fall Term and responding to students' requests, and addition of recommended preparation term.*

6.8. Increase tutorial time for **MSE335: Materials Physics**

CURRENT course offering: 3 LEC hours and 1 TUT hours each week.
Two separate TUT sections.

PROPOSED course offering: 3 LEC hours and 2 TUT hours each week.
One TUT section.

- *Currently two separate 1-hr tutorial sections, however, students expressed benefits in having more contact hours/longer tutorial sessions.*

6.9. Remove **MIE364: Quality Control and Improvement**

- *Course will no longer be offered.*

6.10. Change course code for **CHM325: Introduction to Inorganic and Polymer Materials Chemistry** to **CHM355: Introduction to Inorganic and Polymer Materials Chemistry**

- *Course code change from FAS.*

6.11. Correct course weight of **MSE353:** from 0.25FCE to 0.5 FCE

- *This error was a typo in the system.*

6.12. Combine two low weighted courses into one in each term.

- **MSE296: Materials Paradigm at a Glance I** - 0.15 credits plus **MSE294: Communications I** – 0.25 credits in Fall and
- **MSE297: Materials Paradigm at a Glance II** – 0.15 credits plus **MSE295: Communications II** – 0.25 credits in Winter

PROPOSED weighting of combined courses: 0.5 credit each semester

PROPOSED Timing:
1/0/2 – One hour of lecture, two hours of seminar/workshop

PROPOSED Title: **Materials Thinking and Communication I & II**

PROPOSED Prerequisites: MSE29X should be prerequisite for MSE29Y

CURRENT course description for **MSE294/295: Communications I/II:** This is part I/II of two laboratory, tutorial, and lecture courses building on the communication principles students learned in first year. Students will work in teams on open-ended design projects, and scaffolded assignments will provide students the opportunity to report on their projects in written reports, podium presentations, and poster presentations. The projects in this course are supported by laboratory exercises and tutorial activities.

PROPOSED course description for **MSE294/295: Communications I/II:** Materials come in all sorts of forms and exhibit a wide range of behaviours, yet there is more in common to their explanation than there is difference. Materials thinking involves recognizing how various ways of understanding materials work together in a holistic materials paradigm. MSE29X & MSE29Y will put the threads from the second year curriculum into a common informational framework more reflective of the emerging state-space based approach to materials thinking. In addition to supporting students in building a holistic understanding of materials science, these courses also build on the principles of engineering communication students learned in first year. We challenge students to develop their understanding of materials science through assignments that use key forms of engineering communication (writing, oral presentations, visual representations). We use critical self-reflection and analysis to help students learn materials thinking, improve their communication and teamwork skills, and develop metacognitive and self-regulated learning skills.

CURRENT course description for **MSE296/297: Materials Paradigm at a Glance I/II:** Materials come in all sorts of forms and exhibit a wide range of behaviors, yet there is more in common to their explanation than there is difference. MSE296 & MSE297 will put the threads from the second year curriculum into a common informational framework more reflective of the emerging state-space based materials paradigm. This course will meet on a biweekly basis. Credit is obtained by participating in in-class exercises.

PROPOSED course description for **MSE296/297: Materials Paradigm at a Glance I/II:** As above.

7. INSTITUTE FOR STUDIES IN TRANSDISCIPLINARY ENGINEERING EDUCATION & PRACTICE

7.1. Add new course **TEP 4XX**

PROPOSED course title: **To Engineer is Human**

PROPOSED course description: Behind every engineering feat is a human story. Students will learn to examine this often-overlooked aspect of engineering and its implications for engineering work. Engineering is at its core a humanist enterprise: a human activity geared at helping to attain human goals, which requires the integration of many viewpoints, technical and non-technical. The course begins by examining the human condition, starting from the complexity of individuals and leading to how certain social dynamics manifest. It then builds a foundation for appreciating and engaging in the interdisciplinary work that engineering entails by examining conceptions of engineering, as well as the humanities and social sciences (e.g. sociology, anthropology, history) and their intersections with engineering. These themes are then integrated to explore the core topic of engineering as a human activity and its implications for engineering work.

PROPOSED level of instruction: Undergraduate (with dual code Graduate)

PROPOSED delivery: Fall term
3 Lecture, 1 Tutorial
In Person

8. CROSS-DISCIPLINARY PROGRAMS

8.1. New Courses:

APS441H1 S - System-Theoretic Accident and Risk Analysis for Winter 3/0/1/0.5

AECERFORE
Provides new perspectives on safety and human error and shows how to incorporate humans in complex automated systems using systems thinking. Risk assessment of a sociotechnical system identifies hazards that can result in human, material or environmental losses, the likelihood of such hazardous events, and their consequences. This project-based course combines theory and practice to present a system-theoretic approach to risk assessment.

APS495Y1 Y - Summer Research for Visiting Students ….(As discussed at Oct 7 mtg, this course will ONLY be for incoming summer exchange students)

An independent research project conducted in an engineering laboratory for students from an approved partner institution for 10-16 weeks in the summer term. This course is intended for students who will have completed their 2nd or 3rd year of study by the time they take the course. Students must apply for this program through their home university and will be approved via the Centre for International Experience if they are accepted. For more information, please contact URIE@engineering.utoronto.ca

APS500H1 – Negotiations in an Engineering Context
Changing Recommended Preparation to Pre-Requisite - "JRE420 or equivalent, or instructor permission"

APS330H1 – Interdisciplinary Studies for Sustainability and Innovation:

Changes to calendar entry regarding application process:
Current: Admission to this course will be by application conducted in the Fall. The schedule for this course will be determined in the Fall in consultation with the participating universities. Students will be able to select the section that best fits their schedule.
New: Admission to this course will be by online application, which will be available starting in June. Initial round of applications will be reviewed prior to the course enrollment date and on a periodic basis after that if spaces become available.

Current Prerequisite: Must have completed at least 10.0 FCE in their current engineering degree program prior to the start of the course. Approval of department

New: Must have completed at least 10.0 FCE in their current engineering degree program prior to the start of the course. Approval of the student's application for the course.

APS521H1 - Building Organizations: An Engineers Business Toolkit
Removing pre-req of JRE300, JRE410; Adding JRE300 as Recommended Preparation

APS440H1 – Making Sense of Accidents
Term switch from Winter to Fall, to provide better sequencing with new APS441H1 S

APS360H1 – Applied Fundamentals of Deep Learning
Changing delivery from 3 LEC / 1 TUT to 3 LEC / 1 PRA (requested switch based on room usage and current course delivery)

APS510H1 – Innovative Technologies and Organizations in Global Energy Systems
Remove exclusion of APS310, which no longer exists and has been removed from the calendar.

8.2. Changes to existing programs:

Bioengineering Minor
Add to "As Needed" category:

- HPS346H1 - Modifying and Optimizing Life: on the Peculiar Alliance between AI, Biology, and Engineering – accidentally left out when minor was modified last year
- MIE4XXH1 – Fundamentals of Injury Biomechanics and Prevention (new course MIE)

Environmental Engineering Minor
Add as Advanced Elective:

- MSE401 - Materials Selection for Sustainable Product Design (as discussed with MSE, approved by Director)

AI Engineering Minor
Add to Requirement 5 (Focused electives)

- HPS340H1 – The Limits of Machine Intelligence (approved by Director)
- CSC412H1 – Probabilistic Learning and Reasoning (approved by Director)
- MIE5XXH1 – AI for Social Good (new course MIE)

Engineering Music Performance Minor and Music Technology certificate
Changes to the wording with respect to MUS elective courses – The Faculty of Music has different MUS course offerings each year (revolving list) offered through the Faculty of Arts & Science. Their course offering are determined after our calendar change deadline, thus we are

continually out of date. We will allow any MUS as an elective course except MUS vocal and instrumental performance courses.
Current entry: lists individual MUS courses.

New entry:

Elective Courses
HMU111H1: Introduction to Music and Society
TMU131H1: Music Theory 2
Any cultural or historical MUS course (excluding vocal and instrumental performance courses).
Course offerings are updated annually in the Faculty of Arts and Science calendar.

Engineering Business Minor, Engineering Business Certificate and Entrepreneurship Certificate
Remove MIE258 in place of MIE358 (Engineering Economics updates from MIE)

Forensic Engineering Certificate
Add to electives:
APS441H1 - System-Theoretic Accident and Risk Analysis (new course from CDPO)

Renewable Resources Certificate
Add to electives:
CIV5XXH1 – Design of Timber Structures (new course from CIV/MIN)

Justice Equity Diversity and Inclusion Certificate
Add to Technology and Society elective group:
TEP4XXH1 – To Engineer is Human (new course from ISTEP)

Engineering Leadership Certificate
Add to electives:
TEP4XXH1 – To Engineer is Human (new course from ISTEP)