UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3725 Revised

MEMORANDUM

To: Executive Committee of Faculty Council (November 15, 2022)
Faculty Council (December 6, 2022)

From: Professor Evan Bentz
Chair, Undergraduate Curriculum Committee

Date: November 3, 2022; revised November 21, 2022

Re: **Major Curriculum Changes for the 2023-2024 Academic Year**

REPORT CLASSIFICATION

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

SUMMARY

The Undergraduate Curriculum Committee is tasked with managing the curriculum change process for the Faculty. This report summarizes course changes proposed for the 2023-2024 academic year.

PROCESS AND CONSULTATION

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 2023-2024 academic year, as described in Report 3725 Revised, be approved.

PROPOSED CURRICULUM CHANGES

1. MECHANICAL ENGINEERING

1.1. Update course description for **MIE519: Advanced Manufacturing Technologies**

CURRENT: This course is designed to provide an integrated multidisciplinary approach to Advanced Manufacturing Engineering, and provide a strong foundation including fundamentals and applications of advanced manufacturing AM. Topics include: additive manufacturing, 3D printing, micro and nanomanufacturing, intelligent manufacturing, Advanced Materials, lean manufacturing, AM in machine design and product development, process control technologies. New applications of AM in sectors such as automotive, aerospace, biomedical, electronic, food processing.

PROPOSED: This course is designed to provide an integrated multidisciplinary approach to Advanced Manufacturing Engineering, and provide a strong foundation including fundamentals and applications of advanced manufacturing (AM). Topics include: additive manufacturing, 3D printing, micro- and nano-manufacturing, continuous & precision manufacturing, green and biological manufacturing. New applications of AM in sectors such as automotive, aerospace, biomedical, and electronics.

- *The proposed course description better reflects the course content. New topics include continuous & precision manufacturing, and green and biological manufacturing. Topics removed include intelligent manufacturing, Advanced Materials, lean manufacturing, AM in machine design and product development, process control technologies.*

1.2. Update prerequisites for **MIE441: Design Optimization**

CURRENT: MIE341H1, MIE222H1 or equivalents

PROPOSED: MIE243H1, MIE222H1 or equivalents

- *MIE341 is no longer offered. The new course code is MIE243.*

1.3. Update program for the listing of **BME595: Medical Imaging**

CURRENT: Technical elective for the Winter Session - Year 4

PROPOSED: Technical elective for the Fall Session - Year 4

- *BME595 is offered in the Fall, not Winter.*

1.4. Update program for the listing of **BME440: Biomedical Engineering Technology and Investigation**

CURRENT: *Listing does not include BME440*

PROPOSED: Add BME440 to the list of approved technical electives for MEC (Fall Session - Year 4)

- *BME440H1 is taken by quite a number of MEC students as a technical elective substitute (MEC students make up about 20% of the class). Adding BME440H1 to the list of approved technical electives will ensure that it gets captured via the scheduling and enrolment process. This way, students who request it via pre-registration will not be excluded from the batch enrolment, and will not need to seek approval from the Department for a technical elective substitute.*

1.5. Update course title and description for **MIE563: Engineering Analysis II**

CURRENT: **Engineering Analysis II**
This course explores exact solution techniques for common engineering Partial Differential Equations (PDEs), such as separation of variables, superposition, eigenfunctions, orthogonal functions, complex functions. Other topics include: derivation of common engineering PDEs, introduction to methods of weighted residuals for deriving finite element formulations and limitations of exact solutions relative to approximate solutions.

PROPOSED: **Analytic and Numerical Solution of Engineering PDEs**
This course explores analytic and numerical solution techniques for heat/mass diffusion and vibration/wave equations. Emphasis is placed on intuitive derivation of these equations, and analytic solution techniques like separation of variations, eigenfunction expansions, Fourier analysis, integral transforms, coordinate transforms, and special functions. Numerical solutions are introduced via finite difference methods. A key learning outcome of this course is understanding the central role that analytic solutions play in developing intuition about engineering physics, and how this is a fundamental step in learning to verify, validate, and properly use advanced computational modelling tools.

- *There is a decline in enrolment over the past 2-3 years, and the MIE563 students themselves strongly encouraged the instructor to change the title of the course. Course material has not changed much, but instructor notes he is emphasizing more the connection to engineering practice and intuition, and some students won't be aware of that from the current title and description.*

1.6. Update program and course for thesis enrolment requirements for **MIE498H/Y1: Research Thesis**

CURRENT: Overall B average in second and third years

PROPOSED: 2.7 CGPA

- *Calendar will better reflect current practice.*

1.7. Move technical elective **MSE443: Composite Materials Engineering** from Winter to Fall session.

CURRENT: Winter Session - Year 4

PROPOSED: Fall Session - Year 4

- *MSE443 is offered in the Fall, not Winter*

2. ELECTRICAL & COMPUTER ENGINEERING

2.1. Add **ECE441: Interfacing and Modulating the Nervous System**

PROPOSED session: Fall 2023

PROPOSED instructors: Professor Xilin Liu and Professor Ervin Sejdic

PROPOSED course description: Provides an overview of the fundamental principles and clinical applications of neuromodulation. Topics include (i) overview of the human nervous system & neural oscillations, (ii) introduction to electrical-neural interfaces, (iii) fundamentals of neural recording, neural stimulation & signal processing as well as (iv) instrumentation and clinical applications of commonly used neuromodalities including Electroencephalography (EEG), Deep brain stimulation (DBS), Transcranial magnetic stimulation (TMS) and Functional electrical stimulation (FES).

- *Updated to match current content of course.*

2.2. Update math/science electives for ECE

CURRENT: *Electives do not include PHY365*

PROPOSED elective: **PHY365: Quantum Information**

PROPOSED course description: Introduction to quantum computing and other quantum information topics; Quantum states of multi-particle systems; Entanglement, Bell inequalities and Teleportation; Quantum Key Distribution; Quantum Computing Algorithms; Quantum Information Processing Technologies; other applications to metrology and illumination.

PROPOSED pre-requisites: PHY256H1/PHY294H1/CHM223H1/ECE330H1

PROPOSED co-requisites: None

PROPOSED Exclusions: None

PROPOSED recommended preparations: MAT223H1/MAT240H1

2.3. Update course description for **ECE244: Programming Fundamentals**

CURRENT: Provides a foundation in programming using an object-oriented programming language. Topics include: classes and objects, inheritance, exception handling, basic data structures (lists, tree, etc.), big-O complexity analysis, and testing and debugging. The laboratory assignments emphasize the use of object - oriented programming constructs in the design and implementation of reasonably large programs.

PROPOSED: Provides a foundation in programming using an object-oriented programming language. Topics include: classes and objects, inheritance, basic data structures (linked lists, binary trees, and hash tables), big-O complexity analysis, and testing and debugging. The laboratory assignments emphasize the use of object - oriented programming constructs in the design and implementation of reasonably large programs.

- *Updated to match current content of course.*

2.4. Update title and course description for **ECE411: Real-time computer control**

CURRENT**: ECE411: Real-time computer control**
Digital Control analysis and design by state-space methods. Introduction to scheduling of control tasks using fixed-priority protocols. Labs include control design using MATLAB and Simulink, and computer control of the inverted pendulum using a PC with real-time software.

PROPOSED**: ECE411: Adaptive Control and Reinforcement Learning**
An introduction to adaptive control and reinforcement learning for discrete-time deterministic linear systems. Topics include: discrete-time state space models; stability of discrete time systems; parameter adaptation laws; error models in adaptive control; persistent excitation; controllability and pole placement; observability and observers; classical regulation in discrete-time; adaptive regulation; dynamic programming; Rescorla-Wagner model; value iteration methods; Q-learning; temporal difference learning.

- *Updated to match current content of course.*

2.5. Update course description for **ECE212: Circuit Analysis**

CURRENT: Nodal and loop analysis and network theorems. Natural and forced response of RL, RC, and RLC circuits. Sinusoidal steady-state analysis. Frequency

response; resonance phenomena; poles and zeros; applications of the Laplace transform.

PROPOSED: Methods for the analysis and design of electrical circuits. Resistive circuits, KCL and KVL, nodal analysis and mesh analysis, circuit linearity and superposition, equivalent circuits, Thevenin and Norton theorems. Ideal operational amplifier analysis, review of differential equations, and dynamic RLC circuit analysis. For sinusoidal steady state analysis, topics include phasor analysis, impedance and admittance, induction and coupled inductors, ideal transformers, real and reactive power, power factor, complex power and power flow analysis. Frequency domain analysis, including the Laplace transform, poles and zeros, s-domain analysis, transfer functions, convolution, frequency response, Bode diagrams, low-pass, high-pass, bandpass, and bandstop filters.

- *Provides deeper explanation of the topics that are currently taught in the course; aiding students to understand the context and technical material.*

2.6. Update course description for **ECE231: Introductory Electronics**

CURRENT: An introduction to electronic circuits using operational amplifiers, diodes, bipolar junction transistors and field-effect transistors.

PROPOSED: Provides methods for the analysis and design of electrical circuits based on semiconductor non-linear 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.

- *Provides deeper explanation of the topics that are currently taught in the course; aiding students to understand the context and technical material.*

2.7. Update course description for **ECE331: Analog Electronics**

CURRENT: Transistor amplifiers, including: differential and multistage amplifiers, integrated circuit biasing techniques, output stage design and IC amplifier building blocks. Frequency response of amplifiers at low, medium and high frequencies. Feedback amplifier analysis. Stability and compensation techniques for amplifiers using negative feedback.

PROPOSED: Transistor amplifiers with an emphasis on integrated circuit (IC) design. Building blocks include differential and multistage amplifiers, IC biasing techniques, and output stage design. Frequency response of amplifiers at low, medium and high frequencies. Feedback amplifier analysis. Stability and compensation techniques for amplifiers using negative feedback.

3. *Provides deeper explanation of the topics that are currently taught in the course; aiding students to understand the context and technical material.*

4. ENGINEERING SCIENCE

4.1. Update BMS course requirements

CURRENT: **MIE439: Cellular and Tissue Biomechanics, core**

PROPOSED: One of **MIE439: Cellular and Tissue Biomechanics** or **BME530: Human Whole Body Biomechanics**

CURRENT calendar:

Fall Session Year 4
ESC499Y1
BME428H1
BME489H1
MIE439H1
CS/HSS Technical elective

Winter Session Year 4
ESC499Y1
CS/HSS Technical elective
CS/HSS Technical elective
CS/HSS Technical elective
CS/HSS Technical elective

PROPOSED calendar:

Fall Session Year 4
ESC499Y1
BME428H1
BME489H1
CS/HSS Technical elective

Winter Session Year 4
ESC499Y1
CS/HSS Technical elective
CS/HSS Technical elective
CS/HSS Technical elective
CS/HSS Technical elective

Students Must Also Take One of:
Fall Session Year 4
MIE439H1

Winter Session Year 4
BME530H1

Remove:
Note 1: Students who completed MIE439H1 in Year 3 are required to take a Technical Elective

- *MIE439 permanently moved from winter to fall term. This left only 1 fall elective and 4 winter electives in 4th year. Allowing BME530 as a substitution provides a better balance. Rodrigo suggested BME530 as the appropriate core substitution. Remove note as it is not adding useful information.*

4.2. Move **PHY484: Relativity Theory II** to Group B elective grouping and update Group A courses

CURRENT: **PHY484H1: Relativity Theory II** in Group A electives

PROPOSED: **PHY484H1: Relativity Theory II** in Group B electives.

Add the following to Group A electives:
APS360 (Applied Fundamentals of Deep Learning)
ECE358 (Foundations of Computing)
ECE421(Introduction to Machine Learning)
CSC384 (Introduction to Artificial Intelligence)
CSC413(Neural Networks and Deep Learning)

- *Machine learning/computing courses have been approved in the past for the physics major and it makes sense to add those courses given their use in many fields of physics (for example machine learning is used extensively in experimental particle physics).*

4.3. Update course description for **AER210: Vector Calculus and Fluid Mechanics**

CURRENT: The first part of this course covers multiple integrals and vector calculus. Topics covered include: double and triple integrals, derivatives of definite integrals, surface area, cylindrical and spherical coordinates, general coordinate transformations (Jacobians), Taylor series in two variables, line and surface integrals, parametric surfaces, Green's theorem, the divergence and gradient theorems, Stokes's theorem. The second part of the course provides a general introduction to the principles of continuum fluid mechanics. The basic conservation laws are derived in both differential and integral form, and the link between the two is demonstrated. Applications covered include hydrostatics, incompressible and compressible frictionless flow, the speed of sound, the momentum theorem, viscous flows, and selected examples of real fluid flows

PROPOSED: The first part covers multiple integrals and vector calculus. Topics covered include: double and triple integrals, surface area, multiple integrals in polar, cylindrical

and spherical coordinates, general coordinate transformations (Jacobians), Taylor series in two variables, line and surface integrals, parametric surfaces, Green's theorem, the divergence and Stokes's theorems. The second part of the course provides a general introduction to the principles of continuum fluid mechanics. The basic conservation laws are derived in both differential and integral forms using different fluid models, and the link between the two is demonstrated. Applications covered include: dimensional analysis, hydrostatics, flow visualization, incompressible and compressible frictionless flows, the speed of sound, the momentum principle, viscous flows and selected examples of real fluid flows. The students conduct two hands-on laboratory experiments involving microfluidics and flow visualization, which complement the fluid mechanics lectures and experience technical report writing.

- *More aligned with the material currently delivered.*

4.4. Update course description for **AER310: Gasdynamics**

CURRENT: Basic introduction to compressible gasdynamics. Includes some fundamental thermodynamics, thermal and caloric equations of state, derivation of Euler's equations by control volume approach. Also, includes the theory of steady flows in ducts with area changes, adiabatic frictional flows, duct flows with heat transfer, normal and oblique shock waves, Prandtl-Meyer expansion wave, moving shock and rarefaction waves, shock tubes, and wind tunnels. The lectures are supplemented by problem sets. Reference book: Anderson, J.D., Modern Compressible Flow with Historical Perspective.

PROPOSED: Fundamental thermodynamics for calorically perfect gases and derivation of Navier-Stokes and Euler equations by control volume approach. Also includes the theory of steady quasi-one-dimensional (1D) flows in flow tubes, pipes, and ducts with area variation, friction and drag, body forces, heat addition, and external work, reviewing isentropic flow and Fanno and Rayleigh lines solutions. Also covers the Rankine-Hugoniot equations and solutions for both steady normal shock waves and moving shocks and introduces theory of unsteady 1D constant-area flows and solutions for unsteady isentropic expansion and compression waves via characteristic analysis. Concludes with theory of steady two-dimensional (2D) supersonic flow including Prandtl-Meyer theory and solutions for oblique shock, expansion, and compression waves. The lectures are supplemented by problem sets.

- *More aligned with the material currently delivered.*

4.5. Update course description for **ROB501: Computer Vision for Robotics**

CURRENT: An introduction to aspects of computer vision specifically relevant to robotics applications. Topics include the geometry of image formation, basic image processing operations, camera models and calibration methods, image feature detection and matching, stereo vision, structure from motion and 3D reconstruction. Discussion of moving object identification and tracking as time permits.

PROPOSED: An introduction to aspects of computer vision specifically relevant to robotics applications. Topics include the geometry of image formation, image processing operations, camera models and calibration methods, image feature detection and matching, stereo vision, structure from motion and 3D reconstruction. Discussion of the growing role of machine learning and deep neural networks in robotic vision, for tasks such as segmentation, object detection, and tracking. The course includes case studies of several successful robotic vision systems.

- *More aligned with the material currently delivered.*

Program Changes

4.6. Addition of **MIE5XXH1: Data Mining** to technical electives list (Machine Intelligence major)

- *Course is a good fit and useful addition to Machine Intelligence major technical electives list.*

5. CHEMICAL ENGINEERING & APPLIED CHEMISTRY

5.1. Update course description for **CHE204: Chemical Engineering and Applied Chemistry – Laboratory I**

CURRENT: This laboratory course will survey aspects of inorganic, organic and analytical chemistry from a practical point of view in a comprehensive laboratory experience. Theory, where applicable, will be interwoven within the laboratories or given as self-taught modules. Topics to be covered are inorganic and organic synthesis and analysis and will include elements of process and industrial chemistry and practice (including Green Chemistry).

PROPOSED: This laboratory course surveys aspects of inorganic and analytical chemistry from a practical point of view in a comprehensive laboratory experience. In this course, students learn how to analyze known and unknown samples using qualitative and quantitative analysis. Emphasis is placed on primary standards, instrumental techniques (e.g., spectroscopy), classical volumetric techniques (e.g., titration), statistical treatment of data, and reliability and repeatability (i.e., accuracy and precision). The course includes elements of process and industrial chemistry and practice. Theory, where applicable, is interwoven within the laboratories or given as self-taught modules.

- *Better reflects what is currently being taught in this course.*

5.2. Update course description for **CHE205: Chemical Engineering and Applied Chemistry – Laboratory II**

CURRENT: This laboratory course will survey aspects of inorganic, organic and analytical chemistry from a practical point of view in a comprehensive laboratory experience. Theory, where applicable, will be interwoven within the laboratories or given as self-taught modules. Topics to be covered are inorganic and organic synthesis and analysis and will include elements of process and industrial chemistry and practice (including Green Chemistry).

PROPOSED: This laboratory course surveys aspects of organic chemistry from a practical point of view in a comprehensive laboratory experience. In this course, students explore the syntheses of different chemical reactions (substitution, elimination, condensation and hydrolysis), analyzing and characterizing the intermediates and major products formed using established processes and laboratory techniques (e.g., IR, RI, GC, TLC). The course includes elements of process and industrial chemistry and practice (including Green Chemistry).

- *Better reflects what is currently being taught in this course.*

5.3. Update course description for **CHE221: Calculus III**

CURRENT: Introduces concepts used in developing mathematical models of common chemical engineering processes, concepts of process dynamics and methods for analyzing the process response to different perturbations, and the numerical methods required for solving and analyzing the mathematical models. The course will also introduce applications of modeling to biochemical engineering.

PROPOSED: This course introduces the basic concepts of multivariable calculus (partial derivatives, gradients, multiple integrals and vector analysis, etc.) and methods of solution of ordinary differential equations. The course places a strong emphasis on the application of these concepts to practical design and modeling problems in chemical engineering.

- *Better reflects what is currently being taught in this course.*

6. CIVIL & MINERAL ENGINEERING

Civil Program

6.1. Add a new **5XX** course: **Building Energy Performance Simulation**

PROPOSED timing: 2 Lecture, 2 Practical

PROPOSED calendar description: Building performance simulation (BPS) is the process of imitating/predicting aspects of building performance with computational building models. The models draw heavily upon the disciplines of heat and mass transfer,

thermodynamics, fluid mechanics, light transmission, and occupant behaviour. BPS allows improving the design and operation of buildings through quantitative analyses. This course will provide students with theoretical knowledge and practical skills to effectively apply BPS tools in design and analysis contexts focusing on building heating and cooling loads, building HVAC systems, and whole-building HVAC energy consumption. In addition, various building science research methodologies and examples based on BPS will be presented. As the course project, students will be required to either perform building thermal/energy analysis of real buildings with BPS or conduct research on building science topics with BPS.

Mineral Program

6.2. Add a new course at the start of 2nd year Mineral

PROPOSED title: **Mineral Engineering Field Excursion**

PROPOSED timing: Field based course during frosh week, start of second year 2-4 days long depending on how far away mine is.

PROPOSED calendar description: A field-based course introducing students to mineral engineering activities in open pit and underground mines, and mineral processing plants. The course will provide essential contextual experience for later courses in years 2 to 4 of the program, as well as highlight the key role of mineral engineers in developing safe, economical, and sustainable solutions for extracting and processing natural mineral resources. A mine operation in Ontario will be visited which, depending on the site location, will require one or two overnight stays in the nearest town/city. The mine operation will provide all personal protective equipment (PPE), and will ensure that students receive comprehensive safety induction training before entering the operation. The course will run in the first week of September immediately following Labour Day.

6.3. Update course code for **MIN450: Mineral Economics** and remove from 4th year options

CURRENT: **MIN450: Mineral Economics**

PROPOSED: **MIN350: Mineral Economics**

- *Current course MIN450 is now taken in 3rd year.*

7. INSTITUTE FOR STUDIES IN TRANSDISCIPLINARY ENGINEERING EDUCATION & PRACTICE

7.1. Update title and calendar description for **TEP321: Representing Science and Technology in Popular Media**

CURRENT: **TEP321: Representing Science and Technology in Popular Media**

This course analyzes popular scientific communication critically, starting by establishing a historical and theoretical foundation for understanding the complex relationship between science and the public. We apply this theoretical foundation to contemporary case studies in multiple media (mis)representations of climate, environmental, and biomedical sciences, as well as breakthroughs in engineering. We develop rhetorical strategies for delivering technical information to non-technical readers, including narrative and metaphor.

PROPOSED: **TEP321: Introduction to Science Communication**
This course introduces students to the history, theory and practice of communicating science to the public. We first establish a theoretical foundation for understanding the complex relationship between science and the public, closely examining techniques and strategies for communicating about science to non-technical readers with a variety of backgrounds and ideological perspectives. We apply these concepts to contemporary case studies in multiple media, focusing on (mis)representations of climate, environmental, and biomedical sciences, as well as breakthroughs in engineering. In doing so, we explore how the shift from traditional news to new media – including videos, podcasts, and social media – has changed how science is communicated to the public, as well as the implications of this shift for scientists and engineers.

- *Better represents how the course is currently taught.*

7.2. Remove enrolment cap in the **TEP444: Positive Psychology for Engineers** calendar description

CURRENT: Many disciplines have explored happiness - philosophy, anthropology, psychology, sociology, neurobiology, film, art and literature - to name a few. Why not engineering? During the first part of the course, we will play catch-up, examining the scholarly and creative ways that people have attempted to understand what makes for a happy life. Then we turn our attention to our own domain-expertise, applying engineering concepts like "balance", "flow", "amplitude", "dynamic equilibrium", "momentum" and others to explore the ways that your technical knowledge can contribute to a deep understanding of happiness. This course is designed to challenge you academically as we analyze texts from a variety of disciplines, but it is also designed to challenge you personally to explore happiness as it relates to yourself, your own personal development and your success and fulfillment as an engineer.

If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of an in-class assessment completed during the first class.

PROPOSED: Many disciplines have explored happiness - philosophy, anthropology, psychology, sociology, neurobiology, film, art and literature - to name a few. Why not engineering? During the first part of the course, we will play catch-up, examining the scholarly and creative ways that people have attempted to understand what makes for a happy life. Then we turn our attention to our own domain-expertise, applying

engineering concepts like "balance", "flow", "amplitude", "dynamic equilibrium", "momentum" and others to explore the ways that your technical knowledge can contribute to a deep understanding of happiness. This course is designed to challenge you academically as we analyze texts from a variety of disciplines, but it is also designed to challenge you personally to explore happiness as it relates to yourself, your own personal development and your success and fulfillment as an engineer.

8. MATERIALS SCIENCE & ENGINEERING

8.1. Update pre-requisites for **MSE431: Forensic Engineering**

CURRENT: MSE101H1/APS104H1/MSE260H1 or MSE160H1

PROPOSED: Remove all pre-requisites

- *Current pre-requisites are not only outdated, but the course has evolved over the years to be less focused on materials and pre-requisites in MSE courses are no longer required.*

8.2. Update MSE graduation requirements on program calendar

CURRENT: Unclear requirements

PROPOSED: Include statement “MSE students are required to complete 5 Technical Electives between Years 3 and 4. Of the 5 Technical Electives, at least 2 must be from the 400-/500- level.”

8.3. *This is currently not stated in the calendar and given the breadth of electives available to MSE students, we would like to ensure that students are taking some electives in the upper year/advanced categories.*

8.4. Remove courses no longer offered from MSE calendar

Remove:
MSE235: Materials Physics
MSE250: Materials Selection in Design I
MSE298: Communications
MSE342: Nanomaterials
MSE421: Solid State Processing and Surface Treatment
MSE451: Advanced Physical Properties of Structural Nanomaterials
MSE390: Communications II
MSE398: Materials Manufacturing and Design
MSE450: Plant and Process Design
MSE478: Materials Manufacturing and Design Laboratory II
MSE488: Entrepreneurship and Business for Engineers

MSE558: Nanotechnology in Alternate Energy Systems
MSE550: Advanced Physical Properties of Structural Nanomaterials

- *No longer offered by department.*

8.5. Update title for **MSE440: Biomaterial Processing and Properties**

CURRENT: **MSE440: Biomaterial Processing and Properties**

PROPOSED: **MSE440: Biomaterial Processing and Properties**

- *This is a typo on the calendar entry.*

8.6. Update Winter Session Year 3 Curriculum table

CURRENT:

Winter Session – Year 3		Lect.	Lab.	Tut.	Wgt.
MSE332H1: Heat and Mass Transfer for Materials Processing	S	3	-	2	0.50
MSE335H1: Materials Physics	S	3	-	1	0.50
MSE355H1: Materials Production	S	3	-	1	0.50
MSE397H1: Materials Manufacturing and Design II	S	3	1	2	0.50
CS/HSS or Technical Elective	S	-	-	-	1.00

PROPOSED:

Winter Session – Year 3		Lect.	Lab.	Tut.	Wgt.
MSE332H1: Heat and Mass Transfer for Materials Processing	S	3	-	2	0.50
MSE335H1: Materials Physics	S	3	-	1	0.50
MSE355H1: Materials Production	S	3	-	1	0.50
MSE397H1: Materials Manufacturing and Design II	S	3	1	2	0.50
CS/HSS or Technical Elective	S	-	-	-	0.50
CS/HSS or Technical Elective	S	-	-	-	0.50

8.7. Update course description for **MSE294: Communications I**

CURRENT: This is part I 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 designed to help students build engineering drawing skills with an emphasis on the SolidWorks package.

PROPOSED: This is part I 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.

- *Better reflects content of the course. SolidWorks is not necessarily the best fit in the communications course.*

8.8. Update course description for **MSE295: Communications II**

CURRENT: This is part 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 designed to help students build engineering drawing skills with an emphasis on the SolidWorks package.

PROPOSED: This is part 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.

- *The updated description better reflects content of the course as SolidWorks is not necessarily the best fit in the communications course.*

9. CROSS-DISCIPLINARY PROGRAMS

9.1. Add new course **APS5XX: Building Organizations: An Engineer's Business Toolkit (Engineering Business Minor)**

PROPOSED course description: This course develops simple, powerful tools and strategies for designing, starting, growing, managing, changing, fixing and evolving successful organisations in the engineering industry. It is highly practical, develops a model for analysing an organisation and then applies it in clear simple steps. The curriculum is designed for Engineers looking to lead organisations, commercialise product ideas or manage change in existing institutions.

9.2. Add new course **APS3XX: Interdisciplinary Studies for Sustainability & Innovation (Environmental Eng Minor, Global Eng Certificate)**

PROPOSED course description: This is an interdisciplinary and multi-university project-based course focused on positively impacting the complex sustainability challenges

faced by real-world communities around the world. Throughout this course, students work in small (three to five person) interdisciplinary and multi-university teams in order to (1) identify and understand a well-defined sustainability (social and/or environmental) problem faced by a real-world community, and then (2) devise, design and propose an implementable idea for positively impacting that problem. During the course, students are provided with multiple facilitated and structured opportunities to: engage directly with local stakeholders from the community their team is focused on; receive mentorship from a global network of experienced sustainability and innovation experts; and collaborate with a diverse array of students from other disciplines and institutions working on similar sustainability problems with other communities around the world.

9.3. Remove Complementary Studies course flag for **APS470: Engineering and Public Health**

9.4. Update course flag and description for **JRE420H1: People Management and Organizational Behaviour**

CURRENT course flag: CS

PROPOSED course flag: HSS

- *This was approved years ago but missed the update in the calendar text***.**

CURRENT course description: This module spans three inter-related topics: leadership, people management and organization behaviour. It provides students with both the theory and practice in how to design, lead and manage organizations. Topics include theories of leadership, strategy, ethics, designing organizations for rapid change and differing cultural environments, communication, job design, managing and motivating people, fostering creativity, and team work. In addition to traditional lectures, exercises and case studies will be used throughout.

PROPOSED course description: This course spans three inter-related topics within organizational behavior and human resources: individual behavior, group behaviour, and leadership. It provides students with both the theory and practice of how to work, lead, and thrive in organizations. Topics include theories of personality, learning, power, decision making, ethics, culture, communication, leadership, teamwork, and motivation teamwork. These topics are taught in three ways:

1. Case studies, role play & simulation exercises followed by class discussion
2. Surveys of Personality & Skills
3. Lectures, discussions, and readings based on the current research on the topic

<u>Minor/Certificate Updates</u>

Engineering Business Minor

9.5. Add new course **APS5XX: Building Organisations: An Engineer's Business Toolkit to electives**

Advanced Manufacturing Minor

9.6. Add **MIE243: Mechanical Engineering Design** as an Introductory Elective (for 3rd year MSE students only)

AI Engineering Minor

9.7. Change **MIE335H1** to **MIE2XXH1(S): Data Structures and Algorithms** in Requirement 2

9.8. Add **MIE5XXH1: Data Mining** to Requirement 5

9.9. Add **MIE567H1: Dynamic & Distributed Decision Making** to Requirement 5

9.10. Add **CME538H1: Intro. To Data Science for Civil and Min. Engineering** to Requirement 5

9.11. Add **CHE408H1: Data Analytics for Prediction, Control, and Optimization of Chemical Processes** to Requirement 5

9.12. Add **MSE403H1: Data Sciences and Analytics for Materials Engineers** to Requirement 5

9.13. Add **MSE465H1: Application of Artificial Intelligence in Materials Design** to Requirement 5

Sustainable Energy Minor

9.14. Add **MIE550H1: Advanced Momentum, Heat and Mass Transfer** as Advanced Elective

9.15. Add **CIV5XX: Building Energy Performance Simulation** as Advanced Elective

Bioengineering Minor

9.16. Update course code for **BCH441: Bioinformatics** to **MGY441: Bioinformatics**

9.17. Add **ECE441: Interfacing & Modulating the Nervous System** to Clinical Pathway electives (new ECE course)

Environmental Engineering Minor

9.18. Add **APS3XX**: **Interdisciplinary Studies for Sustainability & Innovation** as Introductory Elective

Robotics and Mechatronics Minor

9.19. Add **CSC263: Data Structures and Analysis** to Introductory Electives

Global Engineering Certificate

9.20. Add **APS3XX: Interdisciplinary Studies for Sustainability & Innovation**

10. BIOMEDICAL ENGINEERING

10.1. Remove **BME499Y: Applied Research in Biomedical Engineering** from calendar

- *Removed as course not needed for new bioengineering minor.*

11. INDUSTRIAL ENGINEERING

Industrial Engineering is currently implementing a new curriculum renewal and this set of changes represents the start of a multi-year set of changes to implement this.

11.1. Add new course **MAT2XXH1: Differential Equations and Discrete Math**

PROPOSED year and term: 2F

PROPOSED course description: Ordinary differential equations. Equations of first order and first degree. Linear equations of order n. Systems of simultaneous equations. Difference equations. Forecasting. Business dynamics. Basic Set Theory. Counting, Cartesian Product, Combinations, Permutations. Basic Propositional Logic and Proofs. Throughout the course: formulating and analysing differential equation, difference equation, and discrete mathematical models for real-world problems.

PROPOSED learning objectives:

1. Understand the basic principles of differential and difference equations including how to represent them and solve them.

2. Understand the basic principles of discrete mathematics including counting, combinatorics, and logic.

3. Understand how to apply all principles taught in the course to model real-world applications and problems in Industrial Engineering.

PROPOSED Textbooks:

1. Differential Equations – An introduction to Modern Methods and Applications, 2nd Edition, by Brannan & Boyce, Wiley (2011).
2. Discrete Mathematics and its Applications, sixth edition, by Kenneth H. Rosen (2007).

PROPOSED AUs: 75% Mathematics and Natural Science / 25% Eng Science

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

PROPOSED prerequisites: None

PROPOSED exclusions: None

PROPOSED short course name: Diff Eq and Discrete Math

PROPOSED room requirements: Standard lecture and tutorial rooms

- *Both differential equations and discrete math are important mathematical foundations of our IE curriculum, but the existing curriculum lacks any discrete math component. Rather than introduce an entirely new course for discrete math, it has been determined that the necessary foundational material for both differential equations and discrete math can be provided in a single course that is divided into two distinct sections.*

11.2. Add new course **MIE2XXH1: Data Science**

PROPOSED year and term: 2S

PROPOSED course description: Introduction to the methods of Data Science. Exploratory data analysis and visualization; tools for reproducible analysis. Principles and tools for data collection; awareness of bias in collection methods. Data cleaning. Descriptive statistics and feature analysis. Assessment of data with respect to scientific theories. Data interpretation fallacies. Geographical data representation and manipulation. Text processing, the natural language processing pipeline, and sentiment analysis. Fundamentals of social network analysis and centrality measures. Cloud-based data processing.

PROPOSED learning objectives:

1. Understand the role of the scientific method in analyzing and interpreting data.

2. Understand the role of exploratory data analysis and visualization in data science methodology.

3. Understand sources of bias and error in data collection and data science methodology.

4. Become proficient in tools (local machine and cloud-based) that facilitate reproducible analysis.

5. Become proficient in methodology and tools for working with a variety of data formats (tabular, time series, geospatial, text, network) and application domains (public health, ecommerce, social media).

PROPOSED Textbook: None (online readings provided)

PROPOSED AUs: 25% Natural Science / 75% Eng Science

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

PROPOSED prerequisites: APS105H1/APS106H1 or equivalent; MIE236H1/ECE286H1/ECE302H1 or equivalent

PROPOSED exclusions: None

PROPOSED short course name: Data Science

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

- *This new course is foundational to the data science component of our new curriculum to provide exposure to a variety of types of data and how to work with them to solve practical problems in the modern organization.*

11.3. Add new course **MIE5XXH1: Data Mining**

PROPOSED year and term: 4F

PROPOSED course description: Introduction to data mining and machine learning algorithms for very large datasets; Emphasis on creating scalable algorithms using MapReduce and Spark, as well as modern machine learning frameworks. Algorithms for high-dimensional data. Data mining and machine learning with large-scale graph data. Handling infinite data streams. Modern applications of scalable data mining and machine learning algorithms.

PROPOSED learning objectives:

1. To understand the role of modern distributed computing and machine learning frameworks in creating scalable algorithms for large datasets.
2. To understand the algorithmic principles behind popular scalable data mining and machine learning approaches.
3. To be familiar with widely used, real-world applications of such approaches.
4. To become proficient in tools that support the development of scalable data mining and machine learning algorithms (MapReduce, Spark, and modern machine learning frameworks).
5. To become proficient in the methodology and tools for working with different types of data (high-dimensional, graph data, infinite data streams).

PROPOSED Textbook:

1. Mining of Massive Datasets 3rd Edition. Leskovec, Rajaraman, and Ullman. Cambridge University Press. 2020.

PROPOSED AUs: 75% ES / 25% ED

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

PROPOSED prerequisites: MIE350 or equivalent; MIE236H1/ECE286H1/ECE302H1 or equivalent; MIE2XX (Data Structures and Algorithms) or equivalent

PROPOSED exclusions: None

PROPOSED short course name: Data Mining

PROPOSED room requirements: Windows or Linux Computer Lab

- *This new course will provide students with critical knowledge and skills to successfully apply data mining and machine learning techniques on large real-world datasets.*

11.4. Add new course **MIE5XXH1: Electrification Through Electricity Markets**

PROPOSED year and term: 4S

PROPOSED course description: Challenges of Meeting Net-Zero, Fundamentals of Markets, Structures and Participants, Spot Markets, Economic Dispatch, Day-Ahead Markets, Optimal Unit Commitment, Forward Markets, Settlement Process, Storage

and Demand Management, Renewable and Distributed Energy Resources, Trading over Transmission Networks, Nodal Pricing, Reliability Resources, Generation and Transmission Capacity Investment Models, Capacity Markets.

PROPOSED textbook:

1. Fundamentals of Power System Economics, 2nd Edition by Daniel S. Kirschen and Goran Strbac. 2018. Wiley. ISBN: 978-1-119-21324-6.

PROPOSED software: https://pesd.fsi.stanford.edu/research/energy-market-game

PROPOSED AUs: 100% ES

PROPOSED timing: 3 hours / Lab: 1 hour / Tutorial: 1 hour

PROPOSED prerequisites: MIE358 or equivalent

PROPOSED exclusions: None

PROPOSED short course name: Electrification Through Markets

PROPOSED room requirements: ECF Lab

- *Increased Electrification and Net Zero targets are driving significant increases in electrical supply. This course addresses the market mechanisms in place to allow the private sector to invest in satisfying this demand, within net zero constraints. It complements the new EV minor program.*

11.5. Remove **MAT231H1: Modelling with Differential and Difference Equation**

- *This course is being replaced by MAT2XX which provides more foundation for the computational and optimization aspects of the program.*

11.6. Remove **MIE253H1: Data Modeling**

- *This course is being replaced by MAT3XX that will be introduced in 2024-25.*

11.7. Update course description for **MIE236H1: Probability**

CURRENT course description: Introduction to probability (the role of probability, exploratory data analysis and basic graphical methods). Sample space and events, Venn diagram. Definitions of probability. Axiomatic definition and basic rules. Conditional probability and Bayes' rule. Concept of random variables. Discrete, continuous, and joint distributions. Probability mass functions, density function, cumulative distribution function. Expectation, variance, and covariance. Important

discrete and continuous distributions. Multivariate normal distribution. Functions of random variables. Moment Generating functions. Central limit theorem, laws of large numbers, Markov and Chebyshev's inequalities, types of convergence. Fundamental sampling distributions, Chi-square, t, and F distributions. One sample estimation and hypothesis testing.

PROPOSED course description: Introduction to probability (the role of probability and data in engineering; concepts of population vs. sample). Sample space and events. Definitions of probability. Conditional probability and Bayes' rule. Concept of random variables. Discrete, continuous, and joint distributions. Statistical independence. Expectation, variance, covariance, and correlation. Important discrete and continuous distributions that explain engineering-related phenomena. Brief introduction to the homogeneous Poisson process and related distributions. How to derive distributions. Transformation of random variables. Fundamental sampling distributions, Chi-square, t, and F distributions. Central limit theorem, laws of large numbers. One sample estimation (methods of maximum likelihood, bootstrapping, and jackknife) and hypothesis testing.

- *No major changes. The new description flows better than the older description and follows the syllabus more closely. It also highlights where content will be briefly covered so not to significantly overlap with other courses in the program and introduces new estimation techniques of bootstrapping and jackknife.*

11.8. Update course description for **MIE237H1: Statistics**

CURRENT course description: Two sample estimation and hypothesis testing. Least squares estimation. Simple linear regression and correlation. Multiple linear regression. Linear models. Model building and model assessment. Design and analysis of single and multi-factor experiments. Analysis of variance. Randomization and blocking. Fixed and random effects models. Multiple comparisons. Sample size calculations.

PROPOSED course description: Data gathering motivation and methods (observational vs. experimental). Modeling for inference vs. prediction. Data visualizations. Two sample estimation and hypothesis testing. Choice of sample size. Fitting distributions to data. Goodness of fit tests. Simple linear regression and correlation. Multiple linear regression. Model building and model assessment. Design and analysis of single and multi-factor experiments. Analysis of variance. Fixed and random effects models. Multiple comparisons.

- *No major changes. The new description flows better than the older description and follows the syllabus more closely. It also highlights the importance of an introduction to data gathering motivation and method.*

11.9. Update title and course description for **MIE240H1: Human Centred Systems Design**

CURRENT: **MIE240H1: Human Centred Systems Design**
Introduction to principles, methods, and tools for the analysis, design, and evaluation of human-centred systems. Consideration of impacts of human physical, physiological, perceptual, and cognitive factors on the design and use of engineered systems. Basic concepts of anthropometrics, work-related hazards, shiftwork, workload, human error and reliability, and human factors standards. The human-centred systems design process, including task analysis, user requirements generation, prototyping, and usability evaluation. Design of work/rest schedules, procedures, displays and controls, and training systems; design for error prevention and human-computer interaction; design for aging populations.

PROPOSED: **MIE240H1: Human Factors Engineering**
Introduction to principles, methods, and tools for the analysis, design, and evaluation of human-centred systems. Consideration of impacts of human physical, physiological, perceptual, and cognitive factors on the design and use of engineered systems. Basic concepts of anthropometrics, work-related hazards, shiftwork, workload, human error and reliability, system complexity, and human factors standards. The human-centred systems design process, including task analysis, user requirements generation, prototyping, and usability evaluation. Design of work/rest schedules, procedures, displays and controls, and information and training systems; design for error prevention and human-computer interaction; design for accessibility and aging populations.

- *Minor changes reflecting change in emphasis in the discipline.*

11.10. Update title and course description for **MIE242H1: Psychology for Engineers**

CURRENT: **MIE242H1: Psychology for Engineers**
Introduction to neuroanatomy and processes that are core to perception, cognition, language, decision making, and action. Use of experiments to test hypotheses concerning brain activities and computations. Conducting and reporting experimental research, use of elementary statistics, and satisfaction of research ethics requirements.

PROPOSED: **MIE242H1: Foundations of Cognitive Psychology**
Introduction to neuroanatomy and processes that are core to perception, memory, executive functions, language, decision making, and action. Introduction to stress and emotions, regulation of thought and behaviour, and reward processing. Case studies in Addiction, Depression, Dementia, ADHD, and Dyslexia. Role of neuroimaging and brain

lesions in demonstrating the functioning of different pathways and regions of interest within the brain. Use of experiments to test hypotheses concerning brain activities and computations. Conducting a literature review and reporting experimental research, use of elementary statistics, and satisfaction of research ethics requirements.

- *Expanded description to reflect evolution in course content over 12 years since introduction.*

11.11. Update course description for **MIE250H1: Fundamentals of Object-Oriented Programming**

CURRENT course description: 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.

PROPOSED course description: 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; common data structures; regular expressions; GitHub; Java Swing; unit testing; introduction to complexity analysis; introduction to parallel computing; design and implementation of programs relevant to industrial engineering needs according to strict specifications.

- *Explicit inclusion of current course content (common data structures, regular expressions, complexity, parallel computing); addition of new content (GitHub, Java Swing, unit testing) to provide real-world implementation experience.*

11.12. Update title course description, and term for **MIE262H1: OR I: Deterministic OR**

CURRENT: **MIE262H1: OR I: Deterministic OR**
Introduction to deterministic operations research. Formulations of mathematical models to improve decision making; linear and integer programming; the simplex method; the revised simplex method; branch-and-bound methods; sensitivity analysis; duality; network models; network simplex method; Dijkstra's algorithm; basic graph theory; and deterministic dynamic programming.

CURRENT year and term: 2S

PROPOSED: **MIE262H1: Deterministic Operations Research**
Introduction to deterministic operations research. Formulations of mathematical models to improve decision making; linear and integer programming; the simplex method; the revised simplex method; branch-and-bound methods; sensitivity analysis; duality; network models; network simplex method; Dijkstra's algorithm; Prim's and Kruskal's algorithms; deterministic dynamic programming; applications of deterministic OR in machine learning; common metaheuristics.

PROPOSED year and term: 2F

- *Explicit inclusion of current course content (Prim's and Kruskal's algorithms); addition of new content (deterministic OR in ML, common metaheuristics) to demonstrate interaction of optimization and ML.*

11.13. Update title and course description for **MIE263H1: OR II: Stochastic OR**

CURRENT: **MIE263H1: OR II: Stochastic OR**
Modeling and analysis of systems subject to uncertainty using probabilistic methods. Introduction to decision analysis. Derivation and application of Bernoulli and Poisson processes, Markov chains, and queuing models. Stochastic optimization and extensions. Applications to engineering, games of chance, health care, and management.

PROPOSED: **MIE263H1: Stochastic Operations Research**
Modeling and analysis of systems subject to uncertainty using probabilistic methods. Derivation and application of Bernoulli and Poisson processes, Markov chains, Markov decision processes, Monte Carlo simulation, and queuing models. Applications to engineering, health care, finance, and management.

- *Removed decision analysis and added Markov decision processes.*

11.14. Update title course description, and term for **MIE335H1: Algorithms & Numerical Methods**

CURRENT: **MIE335H1: Algorithms & Numerical Methods**
Algorithmic analysis, big-O asymptotic analysis; numerical linear algebra, solution techniques for linear and non-linear systems of equations; matrix factorization, LU and Cholesky factorization, factorization in the revised simplex method; Newton's method, Gale-Shapley method, greedy methods for combinatorial optimization, branch-and-bound search methods; graph theory and graph theoretic algorithms; design and implementation of algorithms to optimize mathematical models.

CURRENT year and term: 3S

PROPOSED: **MIE2XXH1: Data Structures and Algorithms**
Introduction to algorithms (principles involved in designing, analyzing, and implementing algorithms). Basic data structures (lists, sets, maps, stacks, queues). Graphs and graph search. Decision algorithms (greedy methods and approximation algorithms). Sorting, divide-and-conquer, and recursive algorithms. Trees, heaps, and priority queues. Hashing and hash tables. Algorithmic analysis: big-O complexity. Numerical methods as examples of algorithms and big-O analysis (matrix inversion, matrix decomposition, solving linear system of equations).

PROPOSED year and term: 2S

- *Data structures allow efficient storage of and access to data. Moreover, they are crucial in efficient implementation of algorithms. Therefore, the data structure component is added to the course. This integration will not only help students to learn the true power of algorithms but also help them grasp better the algorithm design process as well as efficiency analysis also taking the appropriate choice of data structures into account. In order to be able to accommodate this major change, the following topics are removed: (i) NP-hard problems: This is in fact an advanced topic, as such had been only introduced at a very high level in the course. After learning about algorithmic complexity, students will already develop an idea about difficult problems. Without going into details, they would not benefit much from an NP-hardness discussion, nor gain skills to apply the relevant concepts themselves. (ii) Modular arithmetic and RSA encryption: The former was mostly introduced for the sake of the latter which is a nice application area for algorithms. In the revised course, the main algorithms used in this application (namely the Extended Euclidean algorithm and the modular exponentiation algorithm) will be nevertheless used as fitting examples of recursive algorithms. (iii) Unconstrained optimization (steepest descent method, and Newton's method): They had been used as applications of numerical methods. As the motivation of numerical methods is already clear, and high-level classification of the examples has been provided regardless, this particular application had been adding a very marginal value to the course.*