Note: Any section shaded blue **must** be completed for Engineering related courses **in addition** to the other sections

CURRICULUM COMMITTEE TEMPLATE
NEW COURSE PROPOSAL FORM

Faculty: Indicate all relevant Faculty(ies) i.e. LAPS/SC/LE	LE
Department: Indicate department and course prefix (e.g. Languages, GER)	EECS
Date of Submission:	
Course Number: Special Topics courses Include variance (e.g. HUMA 3000C 6.0, Variance is "C")	EECS3603
Var:	
Academic Credit Weight: Indicate both the fee, and MET weight if different from academic weight (e.g. AC=6, FEE=8, MET=6)	4.0

Accreditation Unit Breakdown:

Indicate the proposed accreditation unit breakdown as a percentage and unit(s) in the appropriate subject matter areas. Definitions are provided in Appendix A

	Math	Natural Science	Compl Studies	Eng. Science	Eng. Design
Percentage		25%		45%	30%
Units **(54 AUs)**		14		24	16

If the sum of engineering science and engineering design exceeds 50% of the total, indicate which P.Eng. faculty could be possible instructors for this course:

John Lam
Hany Farag

Course Title: The official name of the course as it will appear in the Undergraduate Calendar and on the Repository	Electromechanical Energy Conversion
Short Title: Appears on any documents where space is limited - e.g. transcripts and lecture schedules - **maximum 40 characters**	Electromechanical Energy Conversion

Brief Course Description: ***Maximum 300 words or 2000 characters.*** The course description should be carefully written to convey what the course is about. It should be followed by a statement of prerequisites and co-requisites, if applicable. This description appears in the calendar. For editorial consistency, and in consideration of the various uses of the Calendars, verbs should be in the present tense (i.e., "This course analyzes the nature and extent of...," rather than "This course will analyze...")	This course covers the basic construction and principles of operation of different types of electric machines; magnetic circuit analysis, single-phase and poly-phase transformers, principles of electromechanical energy conversion, DC machines, three-phase induction machines, synchronous machines, and special machines (stepper motors, linear motors and brushless DC (BLDC) motors). The transients and dynamics of machines are analyzed. Introduction of Solid-state control of motors.
Prerequisites:	***EECS2200: Electric Circuits and PHY2020: Electricity and Magnetism***
Co-requisites:	

Will this course be cross-listed? (Yes/No) **If *yes*, cross-listed to:** *(please complete details below)*

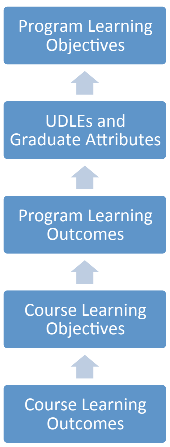
Faculty:		**Rubric:**		**Course #:**		**Weight:**	
Faculty:		**Rubric:**		**Course #:**		**Weight:**	
Faculty:		**Rubric:**		**Course #:**		**Weight:**	

Additional cross-listings (if applicable):

Generic Course Description: This is the description of the "Parent/Generic course" for Special Topics courses under which variances of the "Generic" course can be offered in different years (Max. 40 words). Generic course descriptions are published in the calendar. Please list all degree credit exclusions, prerequisites, integrated courses, and notes below the course description (these will be in addition to the 40 word brief course description).	Basic construction and principles of operation of different types of machines, single-phase, and poly-phase transformers, principles of electromechanical energy conversion, DC machines, three-phase induction machines, synchronous machines, special machines, transients and dynamics of machines, solid-state motors control.

Expanded Course Description:

Please provide a detailed course description, including topics/theories and learning objectives, as it will appear in supplemental calendars.



Expanded Description including topics and theories:

This is an introductory course for energy conversion. It covers the basic construction, principle of operations and solid-state control of different types of electric machines including both AC and DC machines. In particular, the following list of electric machines will be covered: DC machines, single-phase and ply-phase transformers, three-phase induction motors, synchronous machines and special machines (stepper, linear and servo motors).

1. Course topics and their detailed contents:

Topic	Detailed Contents
Introduction	Introduction to and explanation of the terms magnetic poles, magnetic fields, field lines and field intensity, Magnetic circuits analysis, theory of electromechanical energy conversion, concepts of fundamental Lorentz force, torque equation, EMF equation, rotating fields, and methods of Excitation.
DC Machines	Constructional details of dc machine, Amper turns calculations, Winding of dc armature, Classification of dc machines, Generator characteristics, Motor characteristics, starting and solid-state speed control of DC motors
Single-Phase Transformer	Construction of transformer, Principle of operation of transformer, Ideal transformer, No-load vector diagram, Equivalent circuit of transformer, Transformer operation (voltage regulation and efficiency), No-load and short circuit tests of transformers, parallel operation of single-phase transformers
Auto-Transformer	Constructional details , transformer voltage ratio, Power transfer, auto-transformer efficiency
Poly-Phase Transformer	Constructional details, Poly-phase connections , Parallel operation
Special types of transformers	Voltage transformer , Current transformer, Three-winding transformer
Three-phase induction motors	Construction, Principle of operation, Rotor types, Synchronous speed, Slip, Equivalent circuit, motor characteristics, starting and solid-state speed control of induction motors, No-load, short circuit (locked rotor) and load tests, Modes of operation of three-phase induction motor (motoring, braking, and induction generator).
Synchronous machines	Construction, Principles of operation of Synchronous Machine, Armature winding, Space harmonics, and Armature reaction of Synchronous machines, Vector diagram and Equivalent circuit of Synchronous machines, Power flow diagram and Fundamental characteristics of Synchronous machines, Voltage regulation and Circle diagram of Synchronous machines, Parallel operation of Synchronous generators, Salient-Pole Synchronous machines.
Special machines	**Stepper Motor:** Introduction to the design and function of stepper motors: Permanent-magnet stepper motors, reluctance and hybrid stepper motors, Identifying the advantages and disadvantages of various stepper motors, Introduction to the various principles for controlling stepper motors (unipolar und bipolar), Introduction to full-step and half-step operating modes, Introduction to various methods of current regulation for stepper motors, Introduction to customary applications of stepper motors. **Linear Motors:** Introduction to design and operating principle of a linear motor, Introduction to linear motor applications, Designs of linear motors, Advantages and disadvantages of linear motors in comparison to rotary motors, **BLDC Motor:** Introduction to common applications of BLDC motors, Introduction to design

	and function of BLDC motors, Advantages and disadvantages of BLDC motors, Introduction to various circuits for controlling BLDC motors: square and sine-wave current signals, Introduction to various methods of detecting rotor position: Hall sensors, back-emf, pole detection, resolvers and incremental sensors.

2. A description of the laboratory experience included in the course:

Topics	Experiment
Magnetism/Electromagnetism	Investigating the switch-on and switch-off response of an inductor, Lorentz force, Design and function of a transformer, Investigating the effect of an iron core on the transmission response of a transformer, Determining the transmission ratio of a transformer by measurement, Measuring the response of a transformer to various loads, Design of electromagnetic components: relays, reed switches, Experimental investigation of application circuits using electromagnetic components: control circuits with latching, Hall sensors
DC Machines	Measurement of current and voltage in armature and exciter and determining the armature and exciter impedances, Interpreting a rating plate, Connection and operation of DC machines in various operating modes, Speed measurement using a stroboscope, Experimental investigation of various methods for controlling speed and direction of rotation, Connection and operation of commutated machines with AC voltages: universal motors, Measurement of current and voltage when braking DC machines, Temperature measurement in the exciter winding when a machine is running using a semiconductor sensor
Transformers	Study of load characterists of single phase transformers, for one quadrant and four quadrant operation, Measurement of current and voltage under load / no-load conditions, Study of the transformation ratio, Equivalent circuit diagram, Study of various three-phase transformer circuits and their effects on load / no-load operation, Study of various circuits with unbalanced load, Determination of short circuit voltage
Induction Machines	Experimental demonstration of how torque arises and of the generator principle, experimental demonstration of a rotating magnetic field in the stator, Investigation by measurement of three-phase machines in star and delta configurations, Measurement of phase-to-phase and line-to-line voltage and current, Measurement of rotor voltage and current, Interpreting a rating plate, Investigation by measurement of a squirrel-cage rotor, frequency response characteristics, reversal of rotation, Investigation by measurement of the operating response of a capacitor motor, Measurement of winding temperature in running machines, Fault simulation (4 simulated faults activated by relay)
Synchronous and slip-ring machines	Introduction to circuit diagrams, terminal charts and nominal data for synchronous, slip-ring and reluctance machines, Interpreting a rating plate, Experimental investigation of the operating response of slip-ring rotor machines. Measurement of rotor voltages with open and shorted rotor windings, response to starting resistors, determining slip and speed by means of voltage measurements, Experimental investigation of the operating response of synchronous machines: run-up behavior, speed measurement, power factor determination with the aid of current and voltage measurements, Experimental investigation of the operating response of reluctance machines: creation of torque, run-up response, asynchronous and synchronous operation, reversal of rotation, power factor determination with the aid of current and voltage measurements
Special Machines	Stepper Motor:

	Experimental determination of step angle, maximum operating frequency and maximum start frequency of stepper motor, Investigation by measurement of control signals in half-step and full-step mode, Analysis of control signals when rotation is reversed, Experimental determination of the current regulation in use on the basis of control signals, Writing a program for positioning the stepper motor using relative or absolute positioning. <u>Linear Motor:</u> Determination of characteristic values for a motor, Positioning of a linear motor, Determining motor position with the help of encoders or Hall sensors, Determination of motor position using analog Hall sensors <u>BLDC Motor:</u> Introduction to various circuits for controlling BLDC motors: square and sine-wave current signals, Measurement and analysis of circuits, Measurement of position using Hall sensors, Experimental investigation of speed control, Setting parameters for speed control

Course Learning Objectives: Course learning objectives are statements of the overall learning and teaching intentions for the course and represent what the instructor would expect students to learn and retain in the course. They articulate what the teacher plans to achieve in the course.

1. Understand the basic concepts of magnetic circuits as applied to electric machines.
2. Understand the two basic principles (generation of force and emf) that govern electromechanical energy conversion.
3. Describe fundamental principles of energy conversion which are the analytical foundations for understanding all types of drives.
4. Identify the principles of operation of different machine types including: DC machines, transformers, induction machines, synchronous machines, stepper motors, linear motors and servo motors.
5. Derive the steady-state modeling (equivalent circuits) of different types of machines.
6. Analyze the steady-state performance and input-output operational characteristics of the different types of machines.
7. Learn to use space vectors presented on a physical basis to describe the operation of an Ac machine.
8. Describe solid-state control strategies for the different machine types.
9. Present some motor and generator application

Course Design: Indicate how the course design supports students in achieving the learning objectives. For example, in the absence of scheduled contact hours what role does student-to-student and/or student-to-instructor communication play, and how is it encouraged? Please detail any aspects of the content, delivery, or learning goals that involve "face-to-face" communication, non-campus attendance or experiential education components. Alternatively, please explain how the course design encourages student engagement and supports student learning in the absence of substantial on-campus attendance	1. The course is designed to provide the students with the opportunity to practice the topics which are theoretically covered in lecture via hands-on laboratory experience. 2. All labs are to be done independently for each group (two students/group) 3. Each group shall hand-out a single pre-lab and post-lab report for each experiment 4. To make sure that the core technical concepts are being absorbed by the students the course includes a mid-term and regular problem set. 5. To help maintain an active spirit of collaboration, participation will be given as well. 6. The final course grade is determined by the student's performance in laboratories, in quizzes, and on examinations. Students must complete all the laboratories in order to be eligible to receive a passing grade. 7. Attendance to a daylong field trip "generating power plant or transformers substation" is compulsory. The exact date and location will be announced well in advance. Lectures: 3 hrs lecture/week Laboratories: 3 hrs laboratory × 8 weeks Tutorials: 1 hr tutorial /2 weeks Field Trip: 6 hrs

Course Learning Outcomes: List the course learning outcomes/indicators that will be achieved by the end of this course, and map these to the appropriate CEAB graduate attributes and UDLEs. These course learning outcomes will be assessed and measured in the course for accreditation purposes.	***Please select those Degree Level Expectations that will be addressed in the course*** **Undergraduate Degree Level Expectations** ☒ Depth and breadth of knowledge ☐ Knowledge of methodologies ☐ Application of knowledge ☒ Communication skills ☐ Awareness of limits of knowledge ☐ Autonomy and professional capacity	***Please select those CEAB Graduate Attributes that will be addressed in the course (see appendix B for definitions)*** **Graduate Attribute** ☒ Knowledge base for Engineering ☒ Problem Analysis ☒ Investigation ☐ Design ☒ Use of Engineering Tools ☒ Individual and Team Work ☒ Communication Skills ☐ Professionalism

	Learning outcomes articulate what the student will achieve by the end of the course. They provide a framework for assessment by stating what you expect the learners to be able to demonstrate after completing the course. A succinct learning outcome specifies the tasks students are expected to be able to perform and the level of competence expected for the tasks. After finishing the course successfully, the student shall: 1. Recognize the Electromechnical energy conversion principles 2. Differentiate different schematic diagrams of the DC machines and derive the steady state modeling of electric machines 3. Carry out the open-circuit, short-circuit and load tests for different electric machines and calculate the parameters of their equivalent circuits from those tests. 4. Construct the phasor diagram of the different types of AC machines under different operating conditions 5. Calculate the efficiency and voltage regulation of the different types of electric machines.	☐ Impact of Engineering on Society and the Environment ☐ Ethics and Equity ☐ Economics and Project Management ☐ Life-Long Learning

Instruction:

1. Planned frequency of offering and number of sections anticipated (every year, alternate years, etc.).

2. Number of department/division members currently competent to teach the course.

3. Instructor(s) likely to teach the course in the coming year.

4. An indication of the number of contact hours (defined in terms of hours, weeks, etc.) involved, in order to indicate whether an effective length of term is being maintained OR in the absence of scheduled contact hours a detailed breakdown of the estimated time students are likely to spend engaged in learning activities required by the course.

1. The course will be offered once every year. The course contents are interested for electrical, computer and software engineering.
2. Two faculty members currently competent to teach the course
3. John Lam and/or Hany Farag
4. The course will be covered in a single term:

Lectures: 3 hrs lecture/week
Laboratories: 3 hrs laboratory × 8 weeks
Tutorials: 1 hr tutorial per week
Field Trip: 6 hrs

Evaluation:

A detailed percentage breakdown of the basis of evaluation in the proposed course must be provided.

If the course is to be integrated, the additional requirements for graduate students are to be listed.

If the course is amenable to technologically mediated forms of delivery please identify how the integrity of learning evaluation will be maintained. (e.g. will "on-site" examinations be required, etc.)

Component	Weight %	Methods of Feedback
Assignments	10%	F,S
Quizzes/ class participation	5%	F,S
Laboratories and Field Trip	15%	F,S
Mid-Term Test	20%	F,S
Final Examination	50%	S

*Methods of Feedback: F - formative (written comments and/or oral discussion), S - summative (number grades)

Bibliography:

A READING LIST MUST BE INCLUDED FOR ALL NEW COURSES

The Library has requested that the reading list contain complete bibliographical information, such as full name of author, title, year of publication, etc., and that you distinguish between required and suggested readings. A statement is required from the bibliographer responsible for the discipline to indicate whether resources are adequate to support the course.

Also please list any online resources.

If the course is to be integrated (graduate/ undergraduate), a list of the additional readings to be required of graduate students must be included. If no additional readings are to be required, a rationale should be supplied.

LIBRARY SUPPORT STATEMENT MUST BE INCLUDE

Textbook:

Electric Machinery Fundamentals, Stephen Chapman, 5th edition, 2012, McGraw-Hill Ryerson.

Other References:

Electric Machinery and Transformers, Bhag S. Guru and Huseyin R. Hizirogulu, Oxford University Press, 3rd edition.

Principles of Electric Machines and Power Electronics, P.C. Sen, Wiley, 2013, 3rd edition.

Other Resources: A statement regarding the adequacy of physical resources (equipment, space, etc.) must be appended. If other resources will be required to mount this course, please explain **COURSESWILL NOT BE APPROVED UNLESS IT IS CLEAR THAT ADEQUATE RESOURCES ARE AVAILABLE TO SUPPORT IT.**	The course requires an electric machines lab. The equipment is under the procurement process and it will be housed in Williams Lab.
Course Rationale: The following points should be addressed in the rationale: - How the course contributes to the educational objectives of the **program/degree/Faculty**. -The relationship of the proposed course to other existing offerings, particularly in terms of overlap in objectives and/or content. If inter-Faculty overlap exists, some indication of consultation with the Faculty affected should be given. - The expected enrolment in the course.	This course is one of the fundamental courses for electrical engineering and it is very useful for computer and software engineering. Also, the course is the first building block for the electric power-engineering stream. There is no overlap in objectives and/or content between this course and other courses offered in the electrical engineering curriculum. This course is a basic course in the electrical engineering curriculum. It is expected that the enrolment in the course will be high.

Faculty and Department/ Division Approval for Cross-listings:

If the course is to be cross-listed with another department/division this section needs to be signed by all parties. In some cases there may be more than two signatures required (i.e. Mathematics, Women's Studies). In the majority of cases either the Undergraduate Director or Chair of a unit approves the agreement to cross-list. All relevant signatures must be obtained prior to submission to the Faculty curriculum committee.

Dept.: ______________________________ ______________ __________
Signature (Authorizing cross-list) Department Date

Dept.: ______________________________ ______________ __________
Signature (Authorizing cross-list) Department Date

Dept.: ______________________________ ______________ __________
Signature (Authorizing cross-list) Department Date

APPENDIX A: Accreditation Units

Accreditation Units (AUs) are defined on an hourly basis for an activity which is granted academic credit and for which the associated number of hours corresponds to the actual contact time between the student and the faculty members, or designated alternates, responsible for delivering the program:

1 AU = One hour of lecture (corresponding to 50 minutes of activity)
0.5 AU = One hour of laboratory or scheduled tutorial

Engineering design integrates mathematics, basic sciences, engineering sciences and complementary studies in developing elements, systems and processes to meet specific needs. It is a creative, iterative and often open-ended process subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may relate to economic, health, safety, environmental, social or other pertinent interdisciplinary factors.
[The primary feature distinguishing engineering science from engineering design is the open ended nature of the problems. A design question runs along the lines of "design a system that meets the following specifications" whereas an engineering science question is "for the following example, calculate X, Y, and Z"]

Engineering science subjects normally have their roots in mathematics and basic sciences, but carry knowledge further toward creative applications. They may involve the development of mathematical or numerical techniques, modelling, simulation and experimental procedures. Application to the identification and solution of practical engineering problems is stressed. Such subjects include the applied aspects of strength of materials, fluid mechanics, thermodynamics, electrical and electronic circuits, soil mechanics, automatic control, aerodynamics, transport phenomena and elements of materials science, geoscience, computer science, environmental studies and other subjects pertinent to the discipline. In addition, the curriculum should include engineering science content which imparts an appreciation of important elements of other engineering disciplines.

[i.e. the subject may be science, but the aim is towards practical applications, with practical examples.]

The basic (natural) sciences component of the curriculum must include elements of physics and chemistry; elements of life sciences and earth sciences may also be included in this category. These subjects are intended to impart an understanding of natural phenomena and relationships through the use of analytical and/or experimental techniques.

Mathematics includes appropriate elements of linear algebra, differential and integral calculus, differential equations, probability, statistics, numerical analysis and discrete mathematics.

Complementary studies in humanities, social sciences, arts, management, engineering economics and communication that complement the technical content of the curriculum.

[If a course is to include a complementary studies component, a portion of the grading must be allocated accordingly, e.g. part of the grade is for the grammar of a report.]

APPENDIX B: CEAB GRADUATE ATTRIBUTES

Section	Graduate Attribute	Description
3.1.1	Knowledge base for Engineering	Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
3.1.2	Problem Analysis	An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.
3.1.3	Investigation	An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.
3.1.4	Design	An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.
3.1.5	Use of Engineering Tools	An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.
3.1.6	Individual and Team Work	An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
3.1.7	Communication Skills	An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.
3.1.8	Professionalism	An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.
3.1.9	Impact of Engineering on Society and the Environment	An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.
3.1.10	Ethics and Equity	An ability to apply professional ethics, accountability, and equity.
3.1.11	Economics and Project Management	An ability to appropriately incorporate economics and business practices including project, risk, and change management into engineering practice and to understand their limitations.
3.1.12	Life-Long Learning	An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.