RYERSON UNIVERSITY

Faculty of Engineering, Architecture and Science
Department of Electrical and Computer Engineering

EES 612: Electrical Machines and Actuators

Prerequisites **EES 512 or ELE 202**

Required Text *Electric Machines and Drives*: Custom Edition for Ryerson University, 2014, Pearson Learning Solutions, **ISBN 978-1-269-62450-3.**

Reference Texts
1) *Electric Machines and Drives*, Gordon R. Slemon, 1992, Addison Wesley: **ISBN 0201578859**
2) *Principles of Electric Machines and Power Electronics*, P.C. Sen, 2nd Edition, 1997, John Wiley & Sons: **ISBN 9780471022954**

Calendar Description The single-phase transformer and its applications; DC and AC motor characteristics and their application in mechanical drives; Power electronic circuits, H bridges, PWM control, interfacing, power amplifiers; DC servo and stepper motors; AC synchronous and induction motors; Transformers; Introduction to typical speed and torque control techniques of motors.

CEAB Curriculum Category Content

Mathematics	0%
Natural Science	0%
Engineering Science	85%
Engineering Design	15%
Complementary Studies	0%
Others	0%

Learning Objectives

At the end of this course, the successful student will be able to:

1- Develop further knowledge of electricity and magnetism in support of applications to electric machinery problems (1a).
2- Use models to solve electric machinery problems and understand limitations of the models (2b).
3- Compare theoretical values with experimental values, to characterize the accuracy of the models and understand their limitations. (3b).
4- Verify and validate experimental results, using established theories and laws of physics (5b).

Course Organization
3 hours of lecture per week
2 hours of laboratory or tutorial per week

Course Evaluation

Labs	**30%**
Midterm exam	**30%**
Final exam	**40%**
Total	**100%**

Examinations **Midterm exam** will be **120 minutes** in duration and closed-book; the coverage will be announced before the exam.
Final exam will be written during the exam period at the place and time identified by the university; it will be **3 hours** in duration, closed-book, and comprehensive in coverage.

Course Content

Topic	Text Section	Hours	Details
Introduction, Fundamentals of Magnetisms and Actuators	Chapters 1 and 3	6	- Conventions and notations - Field strength, flux density, and B-H curve - Ampere's law and magnetomotive force (mmf) - Induction, flux, and Faraday's law - Lorentz's law and force on a conductor - Hysteresis loop and loss - Eddy currents and eddy current losses - Reluctance and magnetic circuits
DC (Commutator) Machines	Chapter 4	6	- Construction and principles of operation - EMF, commutation, and torque - Mathematical and circuit models - Types: separately excited motors; permanent-magnet motors; shunt motors; and series motors - Torque-speed characteristics of different motors - Speed control techniques

Course Content (cont.)

Single-Phase Transformers	Chapter 2	6	- Construction and principles of operation - Ideal transformer and polarity dots - Impedance transformation property - Practical (real) transformers - Circuit model of a real transformer and approximate models - Open-circuit and short-circuit tests for determination of circuit model parameters - Voltage regulation and efficiency
Induction (Asynchronous) Machines	Chapter 5	6	- Construction and principles of operation: - Types: squirrel-cage and wound rotors - Review of three-phase power - The concepts of rotating field and synchronous speed - The concepts of slip and slip frequency - Circuit model and approximate models - Mathematical model and torque-speed curve (characteristic) - Effects of rotor resistance and excitation frequency - Power flow within the induction machine - Classes and various load conditions - Speed control techniques
Power-Electronic Control of	Chapter 8	7	- The concepts of switched-mode power processing,

DC and AC Machines			Pulse-Width Modulation (PWM), and averaging - Power semiconductor switches: the diode, BJT, MOSFET, and IGBT - Two-quadrant chopper, and four-quadrant chopper (H Bridge) - DC-to-AC converters and sinusoidal PWM - Single-phase and three-phase diode rectifiers
Synchronous Machines	Chapter 6	2	- Construction and principles of operation - Types: round-rotor and salient-rotor - Circuit model and parameters - Brushless DC motors
Stepper Motors	Chapter 11	3	- Construction and principles of operation - Holding and pull-over torques - Effects of inertia and mechanical load - Start-stop stepping rates - Types and different driving techniques

Schedules of Lectures (approximate and subject to refinements without prior notice)

Week	Topic
1	Introduction (1 hr) + Magnetism (2 hrs)
2	Magnetism (3 hrs)
3	DC Machine (3 hrs)
4	DC machine (3 hrs)
5	Transformer (3hrs)
6	Transformer (3 hrs)
SW	Study Week (No Tutorial or Lab)
7	Midterm Test (No Lecture)
8	Induction Machine (3 hrs)
9	Induction Machine (3 hrs)
10	Power Electronics (3 hr)
11	Power electronics (3 hrs)
12	Power electronics (1 hrs) + Synchronous machine (2 hrs)
13	Stepper motors (3 hrs)

Lab Rules and Related Matters

Lab Rules	A comprehensive set of lab rules have been posted on Blackboard, under "Lab Rules" document. Note that **the Lab Rules will be strictly enforced**.
Lab Instructions	All "Lab Instructions" documents have been posted on the Labs section of Blackboard. It is students' responsibility to access the document prior to each lab, populate it with the required information (pre-lab assignment, experimental data, and conclusions), and submit it to the TA in charge as an individual lab report.

Important Notes

1. To achieve a passing grade, the student ***must pass both the theory and laboratory components*** of the course.

2. All of the required course-specific written reports will be assessed not only on their technical/academic merit, but also on the communication skills exhibited through these reports.

3. All lab reports must include the standard cover page which shall be signed by the student prior to submission of the work. Submissions without the cover pages **will not** be accepted.

4. Requests for accommodation of specific religious or spiritual observance must be presented to the instructor no later than two weeks prior to the conflict in question (in the case of final examinations within two weeks of the release of the examination schedule). In extenuating circumstances this deadline may be extended. If the dates are not known well in advance because they are linked to other conditions, requests should be submitted as soon as possible in advance of the required observance. Given that timely requests will prevent difficulties with arranging constructive accommodations, students are strongly encouraged to notify the instructor of an observance accommodation issue within the first two weeks of classes.

5. The results of the first test or mid-term exam will be returned to students before the deadline to drop an undergraduate course in good Academic Standing.

6. Students are required to adhere to all relevant University policies, including:
   - Undergraduate Grading, Promotion and Academic Standing, http://www.ryerson.ca/senate/policies/pol46.pdf
   - Undergraduate Course Management Policy, http://www.ryerson.ca/senate/policies/pol145.pdf
   - Student Code of Academic Conduct, http://www.ryerson.ca/senate/policies/pol60.pdf
   - Student Code of Non-Academic Conduct, http://www.ryerson.ca/senate/policies/pol61.pdf
   - Undergraduate Academic Consideration and Appeals, http://www.ryerson.ca/senate/policies/pol134.pdf
   - Examination Policy, http://www.ryerson.ca/senate/policies/pol135.pdf
   - Accom.of Student Relig., Abor. and Spir. Observance, http://www.ryerson.ca/senate/policies/pol150.pdf
   - Est.of Stud. Email Accts for Official Univ. Commun., http://www.ryerson.ca/senate/policies/pol157.pdf

7. Students are required to obtain and maintain a Ryerson Matrix e-mail account for timely communications between the instructor and the students.

Approved by _____ Date _____

Associate Chair, Program Director or Department Chair