Carleton University Department of Electronics Engineering
ELEC 3105 Basic EM and Power Engineering
Course Outline
January 2017

Instructor: R. C. Gauthier, Room MC 7042, Email: gauthier@doe.carleton.ca

Course web page: click on ELEC 3105 at http://www.doe.carleton.ca/Courses/Undergrad_Courses/index.php this will then direct you to my web page at: http://www.doe.carleton.ca/~gauthier/ then select ELEC 3105 course web page.

Introduction: In this course you will learn the fundamentals of electromagnetics (EM) and its application to motors, generators and electric power distribution. Topics covered include: electrostatics and magnetostatics; solution of Poisson's and Laplace's equations; the Lorenz equation and force; time varying fields; magnetic circuits and transformers; DC motor and generator; induction motor; synchronous motor and generator; three-phase power. The course precludes additional credit for ELEC 2601 or ELEC 3504. Prerequisites are: MATH 2004 and (PHYS 1004 or PHYS 1002).

Textbook 1): The textbook for fundamentals of EM is: M. Sadiku, "Elements of Electromagnetics", 6th edition.

Textbook 2): The textbook for motors and generators is J. R. Cogdell, "Foundations of Electric Power", Prentice- Hall.

Course Grade:

Plagiarism is a serious instructional offense that will not be tolerated. It involves passing off someone else's original work as your own. Most cases of plagiarism can be avoided by carefully citing sources for any ideas, statements, results etc., that are not your own. Please refer to the section on instructional offenses in the Undergraduate Calendar for additional information.

http://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/acadregsuniv14/

- **To pass the course you need:**
  - **Minimum overall grade of 50%**
  - **Have completed all 5 labs**
  - **Complete the 2 phase generator requirements**
  - **Minimum of 40% on the final exam. (That is 24 out of 60 as the exam is worth 60% of your final grade)**

- 60% Final Exam (During normal exam period)
  - The final examination is for evaluation purposes only and will NOT be returned to the student. Student may request to see their exam. A copy will be made available with all grading information removed. The copy must be examined under supervision and will not

be taken away or copied by the student. The exam content will not be discussed. Should the student feel that the grade obtained from the exam (our course) does not reflect the student's expected grade, the university has a well-established appeals process in place to deal with such matters.

- Students who miss the final exam may be granted permission to write a deferred examination. See the Undergraduate Calendar for regulations on deferred examinations.

- 20% Quizzes during PA sessions.
  - If you miss a PA quiz due to documented illness (show me and your TA the original of the doctor's note), you must make arrangements with the TAs to write the quiz during another PA session within a week of the missed quiz. Otherwise, if you miss a quiz, you will lose the 5% allocated to the quiz.
  - Prior to the start of the quiz, the TA will have each student present sign the attendance sheet. A check mark next to each name will be added when you hand in your quiz. (Similar to the attendance format for final exams.)
  - NOTE: Quizzes are held in the last hour of a PA session. Ample time is given to write the quiz and thus no accommodations are made for students registered with PMC.
  - The purpose of the PA session is to go over the solutions to some of the assigned problems. Don't expect the TA to solve all the assigned questions. It is expected that each student will have tried and solved most of the questions prior to the commencement of the PA session. Assigned questions are to be handed in prior to commencement of the quiz. Students who have solved less than 75% of the assigned questions will have the corresponding quiz grade divided in two.
- 20% Laboratories
  - Attend each lab punctually. Absence (without permission of the instructor) means NO MARK for that lab. If you have a valid reason for missing a scheduled lab, the lab must be completed as soon as possible after the scheduled lab period (usually within a week of your missed lab period).
  - Be prepared for the lab experiment by reading the lab instruction sheets before entering the lab. You will be part of a lab group, but each student must submit his/her own lab report. The lab report is due at the end of the lab period. Late labs are worth zero.
  - NO FOOD or DRINK is permitted in the lab or computer rooms. Familiarize yourself with the health and safety rules regarding the labs. Know were the exits to the lab and building are. Know where to go in case of an emergency.
  - Some labs have a pre-lab exercise that must be completed before the start of your lab period. You are not permitted to do the lab unless the prelab is completed.
  - Labs are regularly updated and may vary from year to year.
  - Regardless of what the TAs may tell you each student must complete his/her own lab. Even if you work in a group, each student must write their own lab report. The TA will sign your lab book prior to starting the lab and verify that the pre-lab is completed.
  - When you hand in your lab-book for grading make certain to sign the attendance sheet. The attendance sheet is only signed when the lab-book is handed in, not before.

Lecture Outline (3 hours per week, Wednesday – Friday 10:05 am – 11:25 am Room ME 4499)

- Suggested knowledge for this course: Vector operations, vector calculus, basic physics. The following topics will be covered during the course lectures, approximately following the schedule shown below.
- Weeks 1-2: Basic electrostatics Coulomb's force law; sketching electric field lines; Gauss' law and divergence; electrostatic potential; Poisson's equation and Laplace's equation; gradient of electric field.
- Week 3: Solving electrostatic problems; method of images; numerical solution of Laplace's equation; energy stored in electrostatic field; principle of virtual work and electrostatic force.
- Week 4: Electric fields in matter, corona discharge; polarization and dielectrics; the displacement field; electrostatic problems with dielectrics; current flow: resistivity and conductivity.
- Weeks 5-6: Magnetostatics; Lorentz force law; Hall effect; Ampere's law; curl of a vector field; the magnetic vector potential; the Biôt-Savart Law; applications of the Biôt-Savart Law: current ring, solenoid; energy stored in magnetostatic field.
- Week 7: Magnetic fields in matter; magnetic dipoles; diamagnetic, paramagnetic and ferromagnetic materials; magnetic circuits.
- Week 8: Faraday's law and induced EMF; Lenz's law; Eddy currents; inductors.
- Week 9: Transformers and three-phase circuits; flux coupling and the ideal transformer; impedance transformation; losses in real transformers.
- Week 10: DC motors and generators; linear motors; typical DC rotating motor design; torque-speed characteristics.
- Weeks 11 - 12: Induction motors; synchronous motors and generators; single phase alternators; 3-phase alternators; the synchronous motor; three-phase power; power correction.
- Last lecture: The pn junction depletion region; the solar cell.

Laboratory and PA Sessions

- Lab and PA sessions are 3 hours in duration. Labs and PA sessions "alternate" from week to week and will be held according to the schedule shown on the course website and also found below. You must attend your lab and your PA session in the session you are assigned. Changing session is not allowed.
- Specific to Labs and PAs 1 and 2. See schedule below. Everyone in the section does the lab or PA at the same time.
- Specific to Labs and PAs 3, 4 and 5: Students with student number ending with (0, 1, 2, 3, 4) do the Lab first. The following week they do the PA. (Some slight adjustment may be required) Chose your lab partner to be in the same group. Students with student number ending with (5, 6, 7, 8, 9) do the PA first. The following week they do the Lab. (Some slight adjustment may be required) Chose your lab partner to be in the same group.
- If for some reason an entire Lab or PA session needs to be rescheduled OR a Lab or PA session falls on one of the University holidays, students in those sections must rearrange their schedule to make up the lab in another of the regularly scheduled lab sessions. If you miss a lab for valid reason it can be completed in another regularly scheduled lab period.

- A lab report will be submitted for each lab and by each student. This report should include the measurement set-up, a clear description of the measurement performed, data, sample calculations, discussion of results and conclusions. It is NOT a formal lab report with purpose, apparatus, and observations. Lab reports are due at the end of the lab session. Late labs are worth 0.
- You don't need a hardcover lab book. However, each lab should be written in a bound note book. So you will need 5 notebooks with about 30 pages in each. Also you need one additional notebook to record your prelab answers.
- There are five labs to perform
    - Lab 1: Numerical Solution of Laplace's Equation
    - Lab 2: Numerical Solution of Magnetostatic Problems
    - Lab 3: Magnetic circuit
    - Lab 4: Transformer
    - Lab 5: Stepping Motor / Induction Motor
- Design lab
    - Lab 6: 2 phase generator: During the term students will design and build a working 2 phase generator. Generators must be built from scratch (no kits are allowed). During the last two weeks of term students will demonstrate the operation of their generator to the TA(s) and/or Prof. and answer a few questions related to the design. A lab write up detailing the design and operation of your generator is to be handed in, along with the generator, when the generator is demonstrated. Specific details as to the generator requirements will be posted on the course web page.
- Laboratory / PA sessions times and locations
    - C1: Wednesday 14:35 pm – 17:25 pm (LAB ME 4275) (PA ME 4236) (# students 24*)
    - C2: Monday 14:35 pm – 17:25 pm (LAB ME 4275) (PA ME 4236) (# students 15*)
    - C3: Monday 8:35 am – 11:25 am (LAB ME 4275) (PA ME 4342) (# students 37*)
    - C4: Tuesday 11:35 am – 14:25 pm (LAB ME 4275) (Tory 204) (# students 34*)
    - (*) – as of Jan. 6, 2016
    - In order to pass ELEC 3105, it is necessary to complete all six labs and hand in all 6 lab reports. If you miss a lab due to illness you must arrange a time with your TA to complete a make-up lab. No labs can be done after the last day of class. The format changes to the lab write-ups will be discussed as needed in each lab session.
- PA sessions
    - Several problems will be assigned each week to help understand the lecture material, prepare for the quiz and final exam. Your solutions are submitted and examined. IT IS HIGHLY RECOMMENDED THAT YOU ATTEMPT SOLUTIONS FOR ALL PROBLEMS BEFORE GOING TO THE PA SESSION. Solutions to selected problems will be discussed during the PA session. As a rule, solutions to the assigned problems are NOT posted online. Solutions are available from your TA and only after the week's PA sessions are completed. A quiz will be held during the last hour of each PA session (except the first PA session "PA (0)".

Academic Accommodation: You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation: Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: http://carleton.ca/equity/accommodation/student_guide.htm

Religious obligation: Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: http://carleton.ca/equity/accommodation/student_guide.htm

Students with disabilities requiring academic accommodations: In this course you must register with the Paul Menton Centre for Students with Disabilities (PMC) for a formal evaluation of disability-related needs. Documented disabilities could include but are not limited to mobility/physical impairments, specific Learning Disabilities (LD), psychiatric/psychological disabilities, sensory disabilities, Attention Deficit Hyperactivity Disorder (ADHD), and chronic medical conditions. Registered PMC students are required to contact the PMC, 613-520-6608, every term to ensure that I receive your Letter of Accommodation, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you only require accommodations for your formally scheduled exam(s) in this course, please submit your request for accommodations to PMC by the last official day to withdraw from classes in each term. For more details visit the PMC website: http://www.carleton.ca/pmc/students/acad_accom.html

PROFESSIONAL ENGINEERING ACCREDITATION REQUIREMENTS:

CEAB Course Type: compulsory

Academic Units Math: 0%, 0 units
Academic Units Natural Science: 25%, 11.6 units
Academic Units Complementary Studies: 0%, 0 units
Academic Units Engineering Science: 75%, 34.9 units
Academic Units Engineering Design: 0%, 0 units

CEAB Graduate Attribute

Knowledge Base: Introduced / Applied / Used (*Mathematical Skills, Basic Science - Facts and Skills, Fundamental Engineering Concepts, Discipline Specific Concepts*)

Problem Analysis: Introduced / Applied / Used (*Problem Definition, Approach to the Problem, Use of Assumptions, Interpreting the Solution - Validity of Results*)

Investigation: Introduced / Applied / Used (*Research process and skills, Experimental design and Measurement, Synthesis and data interpretation, Parameters and Systems*)

Design: No significant content (*Clear Design goals, Detailed design specifications and requirements, Alternate solution(s) definition, Evaluation based on engineering principles, Design Solution, Design Implementation/Task(s) definition*)

Use of Engineering Tools: Introduced / Applied / Used (*Diagrams and engineering sketches, Document-processing and graphics packages, Tools for design, experimentation, visualization and analysis, Information from relevant publications, Limitation of such tools and the assumptions inherent in their use*)

Individual and team work: Introduced (*Personal and group time management, Group Culture, group dynamic, Leadership: Initiative and mentoring, areas of expertise and interdisciplinary teams*)

Communication Skills: Applied / Used (*Instructions, Professional documents (writing, design notes, drawings, attributions and references), Oral presentations, Technical reading, Listening skills*)

Professionalism: No significant content (*Codes of ethics, Codes of Practice, Protection of public interest, Professional certification requirements, Self-Awareness, Health and Safety at work (statutory and other), Interaction with other engineering fields*)

Impact of engineering on society and the environment: No significant content (*The place of Engineering in society, Sustainable design; life-cycle planning, Interactions (engineer <-> society and stakeholders), Health, safety and risk*)

Ethics and Equity: No significant content (*Equitable practice, Professionalism, accountable and ethical conduct*)

Economics and project management: No significant content (*Project definition techniques, Engineering Economics, Project management techniques, Risk and change management*)

Life-long learning: No significant content (*Self-awareness, Professional certification requirements, Information from relevant publications, Research Process and skills, the place of engineering in society*)

COURSE SCHEDULE

Lecture 0: January 6 – Welcome – Course outline	**No PA – No quiz**
Lecture 1: January 11 – Coulomb's law	**PA [0] review of vectors – No quiz**
Lecture 2: January 13 – Electric field	**PA [0] review of vectors – No quiz**
Lecture 3: January 18 – Electric potential	**PA [1] – Quiz [1]**
Lecture 4: January 20 – Poisson and Laplace's equations	**PA [1] – Quiz [1]**
Lecture 5: January 25 – Images and electric energy	**Lab [1] – Numerical (E)**
Lecture 6: January 27 – Electric dipole	**Lab [1] – Numerical (E)**
Lecture 7: February 1 – Boundary conditions – RC	**PA [2] – Quiz [2]**
Lecture 8: February 3 – Magnetostatics introduction	**PA [2] – Quiz [2]**
Lecture 9: February 8 – Biot - Savard law	**PA – 2 Phase / Primer for labs 3-5**
Lecture 10: February 10 – Ampere's law	**PA – 2 Phase / Primer for labs 3-5**
Lecture 11: February 15 – Magnetic dipole	**Lab [2] – Numerical (H)**
Lecture 12: February 17 – Magnetization	**Lab [2] – Numerical (H)**
---------- Break ----------	
Lecture 13: March 1 – Magnetic circuits	**PA [3] – Quiz [3]; Lab [3] – Magnetic circuits**
Lecture 14: March 3 – Faraday's law of induction	**PA [3] – Quiz [3]; Lab [3] – Magnetic circuits**
Lecture 15: March 8 – Ideal transformer	**Lab [3] – Magnetic circuits; PA [3] – Quiz [3]**
Lecture 16: March 10 – Real transformer	**Lab [3] – Magnetic circuits; PA [3] – Quiz [3]**
Lecture 17: March 15 – Stepping motor	**PA [4] – Quiz [4]; Lab [4] – Transformer**
Lecture 18: March 17 – Linear motor	**PA [4] – Quiz [4]; Lab [4] – Transformer**
Lecture 19: March 22 - DC Motor (Part 1: Mechanical)	**Lab [4] – Transformer; PA [4] – Quiz [4]**
Lecture 20: March 24 – DC Motor (Part 2: Electrical)	**Lab [4] – Transformer; PA [4] – Quiz [4]**
Lecture 21: March 29 – Synchronous and induction motors	**PA [5] – Quiz [5]; Lab [5] – Motors**
Lecture 22: March 31 – Three phase power	**PA [5] – Quiz [5]; Lab [5] – Motors**
Lecture 23: April 5 – PN junction / End of classes lecture	**Lab [5] – Motors; PA [5] – Quiz [5]**
Lecture 24: April 7 – Review	**Lab [5] – Motors; PA [5] – Quiz [5]**

TA Information