UNSW COURSE OUTLINE

Faculty of Engineering

School of Electrical Engineering and Telecommunications

ELEC3115 - Electromagnetic Engineering

Session 1, 2013

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2. COURSE STAFF DETAILS
   Lecturers: Prof. Faz. Rahman, room EE 133, 9385 4893
             f.rahman@unsw.edu.au
             Prof. R. Ramer, room EE 305, 9385 4759,
             ror@unsw.edu.au

   Contact by email is usually the best way to make an appointment.

   Laboratory Demonstrators & tutors: TBA
3. COURSE DETAILS AND COURSE INFORMATION

- **Credits**
The course is a 6 UoC course; expected workload is 10-12 hours per week throughout the 12 week session.

- **Contact hours**
The course consists of 3 hours of lectures per week, 1 hour of tutorials per week, and 3 hours of laboratory session per fortnight. Details are given below.

  - **Lectures** (weeks 1-12)
    Tuesday 14-16, Biomed Th A
    Wednesday 10, Webst Th A

  - **Tutorials** (start from week 1)
    Thu 09am, ElecEng224
    Tue 12noon, CLB 2
    Wed 09am, ElecEng224

  - **Lab sessions** (start from week 3)
    Mon 11am-2pm & 3-16pm, Wed 12-3pm, Thu 3-6pm, Fri 1-4pm

  - **Consultations**
    Weeks 1-12. Students are encouraged to ask questions during the tutorial classes.

  Note. Guest visits form industry and/or research organizations partners are planned. The exact details will be provided during the session.

- **Context and Summary**
Electromagnetics is of fundamental importance to physicists and to electrical and computer engineers. Electromagnetic theory is indispensable in understanding electromechanical energy conversion devices, transmission and utilization, communication systems, RF/microwave devices, optical fibre communication, antennas, remote sensing, radio astronomy, and electromagnetic compatibility.

The course will start introducing the electromagnetic theory as a general theory that includes the standard electro- and magneto-statics. Then relationship between the electric and magnetic fields, and their links expressed through Maxwell’s equations, become the basis for introducing wave propagation. Finally, the course will cover several aspects of electromagnetic applications such as capacitors, inductors, transformers (at low frequencies) and transmission lines, Smith charts, impedance matching circuits, waveguides, and antennas (at high frequencies).

This course aims to convey to students a background for the design and analysis of both low frequency electrical devices and high frequency electronic components. Assumed knowledge of this course includes undergraduate physics (PHYS1231 Higher Physics – 1B), vector calculus (MATH2069 – Mathematics 2A), and basic circuit theory techniques.
• Aims
The goal of ELEC3115 is to introduce basic electromagnetics and establish the fundamentals of devices in electromagnetic applications as required by engineers in energy systems, telecommunications, computing and other technologies.

The course aims to make the student familiar with electromagnetic applications such as capacitors, inductors, transformers, transmission lines, Smith charts, impedance matching circuits, waveguides and antennas, that are used in the designs and implementations of electrical power systems and modern wireless communications systems.

• Student Learning Outcomes
For this course, we have identified the following specific Learning Outcomes: that students can
- use Gauss’, Ampere’s and Faraday’s Laws in the context of electrical devices
- design capacitors & inductors and analyse their characteristics
- solve simple boundary value problems, using the method of images and Poisson’s equation.
- Calculate the forces that develop in electromagnetic actuators used in energy conversion and energy storage devices
- define core loss in an electromagnetic device, and recognise & describe its effect
- describe the engineering uses of electromagnetic waves, by frequency band, and the respective hazards associated with them
- distinguish between materials, based on their electromagnetic properties
- analyse problems involving TEM-waves
- recognise the limitations of standard LF & RF circuits
- apply the distributed circuit concepts needed at HF, specifically to match impedances and design HF components
- use and interpret a Smith chart
- describe & recognise fundamental properties of waveguide modes
- use dipole, antennas in simple communication links
- recognize and describe dispersion and its effects

Additionally, students are expected to develop their communication skills by correctly using the appropriate terminology, and to demonstrate suitably professional skill and conduct in the context of an engineering laboratory.
More precise details about the learning objectives can be found in a separate document available in moodle.

• Graduate Attributes
The course delivery methods and course content address a number of core UNSW graduate attributes; they include:

1. The capacity for analytical and critical thinking and for creative problem-solving, which is addressed by the design task and tutorial exercises.
2. The ability to engage in independent and reflective learning, which is addressed by the design task.
3. Information literacy, which is addressed by the homework.

4. RATIONALE FOR THE CONTENT AND RELATIONS TO OTHER COURSES

This is a third year course offered to students in a BE course at the University of New South Wales. The course gives the foundation for electrical power systems and all conventional electronic communications (RF, mobile, microwave and optical communications). The course offers the background for students that plan to design building blocks of electrical power systems and communication systems.

- **Pre-Requisites:**
  Students taking the course ELEC3115 will have successfully completed the Stage 1 courses PHYS1131/1231 Higher Physics 1A/1B. The mathematics needed for electromagnetism is covered in the course MATH2069 Mathematics 2A. Students who have not previously undertaken MATH2069 may find it necessary to put in extra work to learn this basic mathematical material.

- **Assumed knowledge:**
  It is further assumed that students have good computer literacy and are able to use basic instruments such as an oscilloscope.

- **Following Courses:**
  This course provides essential basic understanding which is pre-requisite for the course ELEC3015 Electrical Energy Systems, which is a core course for specialization in Power Engineering. It also provides essential background to ELEC4604 RF Electronics, TELE4652 Mobile and Satellite Communications, and PHTN4661 Optical Circuits & Fibres.

5. TEACHING STRATEGIES

The course consists of the following elements: lectures, laboratory work, homework and tutorial work.

- **Lectures**
  The lectures, delivered in the class, will cover a range of engineering electromagnetics. There are 3 hours of lectures per week.

**Weeks 1 to 6 Part A.**
General field properties; Review of vector calculus and coordinate systems; static electric fields, static magnetic fields. Coulomb, Gauss, Biot-Savart & Ampere’s Laws. Magnetic vector potential. Boundary value problems & method of images. Materials: dielectric & magnetic materials, their properties, capacitance and inductance, applications. Introduction to electromagnetics in devices such as transformers and electrical machines: rotating magnetic fields, coupling in magnetic circuits, energy conversion, electrodynamic forces. Skin effect and skin depth, hysteresis and eddy current losses, dielectric losses.

**Weeks 7 to 12 Part B.**

- **Laboratory work**
  The laboratory work provides the student with opportunity to measure and characterize basic electromagnetic devices and applications. There are 5 labs over the session, one every second week, starting in week 3. Students will choose their laboratory time when they enrol in the subject. All laboratory work must be recorded in a lab book and not in loose sheets of paper. The lab work and the student’s performance will be marked by the demonstrator at the end of lab session. Students must comply with all OHS requirements and complete the relevant lab inductions before they may begin work.

  Experiment F: Faraday’s law and measurement of flux
  Experiment I: AC electromagnetic induction and inductance
  Experiment E: Hysteresis loop, Eddy current and core losses
  Experiment M: Microwave communications
  Experiment A: Antenna patterns

  Experiments need not be done in the above order. Students will be assigned a laboratory in their first week of attendance on a first come first served basis. Thereafter, students will be required to follow the sequence of experiments A-E-F-I-M. More details will be found in a separate document in moodle.

- **Home work**
  The lectures can only cover the course material to a certain depth; students must read the textbook and reflect on its content as preparation for the lectures to fully appreciate the course material. Students are encouraged to read the text book and reference materials. Home preparation for laboratory exercises provides the student with quantitative understanding of the experiment.

- **Tutorial classes**
  Tutorial classes provide students with an opportunity to discuss problems with others, while being guided by a staff member. More details are available in a separate document.

- **Self-guided tutorials**
  The self-guided tutorials provide the student with in-depth quantitative understanding of basics of electromagnetic engineering. The tutorials take the student through all critical course topics and aim to develop and exercise the students’ skills. The students are strongly encouraged to complete all the tutorials; the problems may be discussed in the tutorial sessions.

- **On-line activities**
  This course has an on-line presence on the UNSW moodle site. Access this via [https://moodle.telt.unsw.edu.au/login/index.php](https://moodle.telt.unsw.edu.au/login/index.php)
  This will provide you with all the documents for the course, as well as discussions, revision activities, and the Revision Quiz.
6. ASSESSMENT

Final mark will be calculated as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class tests (1 and 2)</td>
<td>20 %</td>
</tr>
<tr>
<td>Laboratory</td>
<td>20 %</td>
</tr>
<tr>
<td>Final Exam</td>
<td>60 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100 %</strong></td>
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</tbody>
</table>

- **Class test**
  Two short class tests will be held in weeks 5 and 10 will to provide student feedback on their progress. Exact date, time and location and format will be announced closer to these weeks.

- **Laboratory work:**
  The laboratory component will run for 6 weeks. The lab work will be marked by the demonstrator during the lab session.

- **Final Exam:**
  The exam in this course is a 3 hr written examination. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Assessment is a graded mark according the correct fraction of the answers to the exam questions.

7. ACADEMIC HONESTY AND PLAGIARISM

Plagiarism is the unacknowledged use of others peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply. For more information on plagiarism, please refer to: [http://www.lc.unsw.edu.au/plagiarism](http://www.lc.unsw.edu.au/plagiarism).

8. COURSE SCHEDULE

This is subject to change. Check moodle for the up-to-date version.

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Tue (2-4pm)</th>
<th>Lecture Wednesday (10-11am).</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Course introduction, em spectrum, review of fields, etc</td>
<td>Electric fields: Coulomb’s Law</td>
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<tr>
<td></td>
<td></td>
<td>Gauss’ law</td>
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<tr>
<td>2</td>
<td>Electric Potential Dielectric Boundary interface</td>
<td>Capacitance</td>
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<tr>
<td></td>
<td></td>
<td>Electro-static force</td>
</tr>
<tr>
<td>3</td>
<td>Method of image Boundary value problems</td>
<td>Steady-electric current</td>
</tr>
<tr>
<td>4</td>
<td>Static magnetic field and laws associated with it.</td>
<td>Inductance</td>
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<tr>
<td></td>
<td></td>
<td>Force in magnetic field</td>
</tr>
<tr>
<td>5</td>
<td>Time varying electro-magnetic field</td>
<td>Skin effect, Iron losses</td>
</tr>
<tr>
<td>6</td>
<td>Skin effect, Iron losses</td>
<td>Revision</td>
</tr>
<tr>
<td>7</td>
<td>General background: Maxwell’s equations, vector magnetic potential etc.</td>
<td>General background: Maxwell’s equations, vector magnetic potential etc. continued.</td>
</tr>
</tbody>
</table>
9. EXPECTED RESOURCES FOR STUDENTS

- Lecture notes and all relevant course announcements can be found:  
- The following textbook is prescribed for the course:  

The lecturer may specify other titles in class.

- **Reference books**
  
  The following books are also good additional resources for topics on Electromagnetics Engineering

- **On-line Resources**
  
  Some additional on-line resources relevant to the course:  
  Library resources
  http://info.library.unsw.edu/web/services/teaching

- **Video Lectures**
  
  Lectures of Part A were recorded in Session 1, 2010 and remain available at
  http://eemedia.ee.unsw.edu.au/

10. COURSE EVALUATION AND DEVELOPMENT

- **Continual Course Improvement**
  
  Students are advised that this course is under constant revision in order to improve the learning outcomes of students. Please forward any feedback (positive or negative) to the course convener(s) or via the Course and Teaching Evaluation and Improvement Process (CATEI). The following changes are being undertaken to improve the course based on the previous students’ feedback on the course:
  - A new lab component has been introduced from 2012 with a focus on engineering applications. The labs replace those run previously by School of Physics.
  - The course now has more tutorial hours: one per week.
  
  We are trying to better integrate the various parts of the course in a more cohesive way. Student’s views at the end of the session are welcome.
11. OTHER INFORMATION

- **Administrative Matters**
  For general expectations, rights, responsibilities such as attendance and workload of students please refer to the School policies, see [http://www.eet.unsw.edu.au/information-for/current-students/current-undergraduates](http://www.eet.unsw.edu.au/information-for/current-students/current-undergraduates).

  *Student equity and diversity issues could be found via Student Equity Officers (Disability) in the Student Equity and Diversity Unit (9385 4734). Further information for students with disabilities is available at,*

  [http://www.studentequity.unsw.edu.au](http://www.studentequity.unsw.edu.au).