School of Electrical Engineering and Telecom.

ELEC3105 – ELECTRICAL ENERGY

Course Outline

Session 2, 2010

Staff Contact Details

<table>
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<tr>
<th>Position</th>
<th>Name</th>
<th>Email</th>
<th>Location</th>
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<tbody>
<tr>
<td>Course Convener/Lecturer</td>
<td>Dr Rukmi Dutta</td>
<td><a href="mailto:Rukmi.dutta@unsw.edu.au">Rukmi.dutta@unsw.edu.au</a></td>
<td>124 C</td>
<td>9385 7884</td>
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<tr>
<td>Tutor</td>
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Course details

Credit Points:
The course is a 6 UoC course; expected workload is 10–12 hours per week throughout the 12 week semester.

Contact hours:
The course consists of 3 hours lectures each week, 3 hours laboratory and 1- hour tutorial every two weeks.

Consultations:
You are encouraged to ask questions on the course material during the lectures and tutorials.

Objective and opportunity

The subject introduces the fundamental elements of generation, transmission, distribution and utilization of electrical energy. Circuits and devices associated with these tasks are analysed with a view to understand their design, performance and selection. Analyses of single and three-phase AC circuits, transformers for power transmission, energy conversion principles, various types of AC and DC machines for power generation and utilization are covered. Environmental impacts of electricity, its safety issues and methods of protection are also covered. Power loss, heat generation, insulation classes and management of these
are also dealt with. A brief introduction to power electronic circuits which transform the utility supply to the needs of utilization in industrial and domestic loads will also be included.

The subject is intended for those who may want to work in environments where all aspects of the design, application and maintenance of power apparatus, circuits and systems may have to be undertaken. The emphasis of the course will be a basic understanding of widely used devices and circuits in the power utility and utilization systems.

Relation to other courses

The course is a third year subject in the school of Electrical Engineering and Telecommunications at the University of New South Wales. It is a core subject for students following a BE (Electrical) or (Telecommunications) program.

Pre-requisites:
The pre-requisites for this course is ELEC2134, Circuits and Signals, ELEC3115, Electromagnetic Engineering. It is essential that students are familiar with basic circuit theory and electromagnetics.

Following courses
The course is a pre-requisite for all professional electives in the energy system group.

Student learning outcomes

At the end of the course you should:

- Be able to understand basic of generation, transmission and utilization of electric energy.
- Be able to analyse single and three phase AC circuits, principle of transformer, energy conversion and various AC and DC machines.
- Understand the practical aspect of various power apparatus.
- Be capable of designing, selecting and analyzing various devices, circuit and system of Power engineering.
- Have gained practical experience in the performance and operation of some important power engineering devices.

Graduate Attributes

- Analytical skills, critical thinking and creative problem solving will be developed by the laboratory experiments and interactive assessments during the labs.
- Self-assessment of independent and reflective learning is made available through a series of tutorials spanning the duration of the course. The tutorial problems also foster independent learning.
- Demonstration of the understanding of principles, and the effective use and communication of relevant information will be tested in depth in the mid-semester examination and the final examination.

## Syllabus

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
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| 1       | Introduction and Review of magnetic circuit:  
Overview of power generation, transmission and distribution of electrical energy systems,  
Review of magnetic circuits  
Model of magnetic circuit  
Magnetizing current  
Losses in a magnetic circuit  
Permanent magnet |
| 2       | Review of AC circuits  
Single phase circuit  
Computation of power  
Power factor correction  
Balanced three phase circuit  
Star-Delta connection  
Power in three phase |
| 3       | Transformers  
Ideal transformer  
Impedance transformation  
Practical or non-ideal transformer  
Equivalent circuit  
Transformer parameters  
Maximum efficiency condition  
Auto-transformer  
Three phase transformer  
Per Unit (PU) calculation |
| 4       | Electric Energy Conversion  
Principles of energy conversion,  
machine windings,  
MMF distribution,  
mechanism of torque and back-emf production, considerations for motor, generator applications  
Machine behaviour on load |
| 5       | The DC machine  
Working Principle  
Multi pole pair DC machine  
Torque and Back emf  
Steady-state  
Types of DC motor  
Armature reaction  
Limitations  
Generator |
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<tr>
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<th>Brief intro to brushless DC motor</th>
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<td>6</td>
<td>The induction machine</td>
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<td>Basic working principle</td>
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<td>Multi-pole winding</td>
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<td>Induced voltage</td>
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<td>Equivalent circuit</td>
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<td>Parameter measurements</td>
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<td>Motoring and generating</td>
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<td>Maximum torque condition</td>
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<td>Stator current and Power factor</td>
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<td>Classification</td>
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<td>Single-phase induction motor</td>
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<td>7</td>
<td>The synchronous machine</td>
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<td>Working principle</td>
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<td>Induced voltage and Synchronous speed</td>
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<td>Generator</td>
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<td>Equivalent circuit</td>
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<td>Parameters</td>
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<td>Phasor diagram</td>
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<td>Physical meaning of load angle</td>
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<tr>
<td>8</td>
<td>Introduction to power electronics</td>
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Teaching strategies

- Lectures = 3 hrs/week *(mandatory)*
- Tutorials = 1 hr/fortnight *(mandatory)*
- Labs = 3 hrs/fortnight *(mandatory)*

The rationale behind the teaching methods for this course:

- The course is structured such that the lecture classes provide an in depth understanding of the course material.
- The tutorials help to develop the required level of analytical skills that will be used in this course.
- Your class and final exams test your problem solving skills and give you the opportunity to effectively communicate and demonstrate your understanding of the principles in the course.
- Lab assessments test your ability to apply your theoretical knowledge and analytical skills in a practical situation.

*The learning in this course is intensive for all 12 weeks of the semester.*

Learning in this course

You are expected to attend all lectures, tutorials, labs and class exams in order to maximise learning. You should prepare your tutorial questions in advance of attending the tutorial classes. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes, you should read relevant sections of the recommended text books. Reading additional text book would further enhance your learning experience. Group learning is also encouraged.

Laboratory

The laboratory program is an integral part of this course. Through the laboratory component, you will encounter the elements of the syllabus. The aim of the laboratory component is to ground the analytical subject material in a practical problem, meaning that the skills and knowledge you learn throughout the course will be applied in real engineering work.

Throughout the semester you will focus on:

- Experiment 1: Balanced Three-Phase Circuits.
- Experiment 2: The Power Transformer.
- Experiment 3: The DC Motor.
- Experiment 4: The Three-Phase Induction Motor.
- Experiment 5: The Synchronous Machine.

*Because of the heavy pressure on laboratory resources, time and personnel, it will be very difficult for the School to reschedule laboratories once missed. The laboratory time-table and schedule produced by the School Office will therefore be followed strictly. LATE ENTRY BY*
MORE THAN 10 MINUTES INTO THE LABORATORY WILL NOT BE PERMISSIBLE.

You are advised to read the General Instructions for Laboratory carefully before coming to the laboratory for the first time.

You are also required to submit a declaration that you have read all safety related materials that were handed out to you or you were advised to read. Please bring this declaration to the laboratory the first time you attend the laboratory.

Tutorials:
The tutorial for this course will start in week 2. Tutorial sheets can be downloaded from the Lecture Notes website. Solutions of tutorial problems are also available from the Lecture Notes website which will be discussed in details during the tutorial.

Pre-requisite to pass the course
A satisfactory performance (50% or greater) in each of the following, is a necessary requirement to pass this course:
  - Mid-session test
  - Ongoing laboratory assessment
  - Final Exam

Assessment
The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the lab and the mid-session tests,

  50% from final examination.
  25% from laboratory experiments
  25% from a mid-session test
Mid –session test (25% total)
There will be one mid session test, to examine your understanding of the principles and your analytical skills.

Thursday, 19 August (Week 5), 5:00-6:00pm, Room: Webster Theatre.

Covers material from section 1 & 2

You should also take this test as feed back on your knowledge of electromagnetic and circuit theory. If you can not do well in this test, it is an indication that you may find later sections very hard to understand. You should take it as precaution and spend more time on the study materials if you want to pass the course in one go.

If for medical reasons you are not able to attempt the test, you must provide a valid medical certificate.

Laboratory Assessment (25%)
Attendance of and performance in laboratory classes will be assessed by laboratory demonstrators. The lab demonstrator will also sign your logbook after this assessment. Your notes, experimental results, graphs produced using these results and your explanation of these will be examined by the demonstrators at the end of each laboratory period.

Final Exam (50%)
There will be one final examination, testing your understanding of the principles and your analytical skills through a number of set problems
The final exam will be 3 hours long
The final exam consists of 6 questions (with many parts) and five of them must be answered.
The final exam will cover all sections

Academic honesty and plagiarism

Plagiarism is the unacknowledged use of other 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: http://www.lc.unsw.edu.au/plagiarism

Other matters

Continual Course Improvement
Students are advised that the course is under constant revision in order to improve the learning outcomes of its students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process.
Administrative Matters
On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School policies: http://scoff.ee.unsw.edu.au/

Important Points

Please note the following:

All lecture notes, PowerPoint presentations, tutorial and laboratory sheets for this subject can be found on the school webpage, via Current Students → Study Notes →Lecture Notes →ELEC3105.

You may have to supply username: your student ID #, e.g., z1234567 and password: ee&tview, in order to access these pages. Students will be expected to bring the printed lecture notes, tutorial sheets and laboratory sheets into the lecture/tutorial/lab classes as appropriate.

Please ask the School Office if you have difficulty in accessing the notes.

- During your lab sessions, you will be assigned to a lab demonstrator, who will be able to guide you in your laboratory-based learning.

- It is vital that you attend all tutorials, labs and the lectures. Less than 80% attendance in lectures may affect outcome of special consideration if you have to apply for so later.

- Guidelines on learning that inform teaching at UNSW are available at: www.guidelinesonlearning.unsw.edu.au

Course schedule

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Overview of power generation, transmission and distribution of electrical energy systems, Review of magnetic circuits</td>
<td>3</td>
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<tr>
<td>2</td>
<td>Review of AC circuits</td>
<td>3</td>
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<td>3</td>
<td>Transformers</td>
<td>6</td>
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<tr>
<td>4</td>
<td>Principles of energy conversion, machine windings, mmf distribution, mechanism of torque and back-emf production, considerations for motor, generator applications and machine behaviour on load.</td>
<td>3</td>
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<tr>
<td>5</td>
<td>The DC machine</td>
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<tr>
<td>6</td>
<td>The induction machine</td>
<td>6</td>
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<tr>
<td>7</td>
<td>The synchronous machine</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Introduction to power electronics</td>
<td>4</td>
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<td>Total hours</td>
<td>36</td>
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Resources for students

Textbooks:

2 Principles of Electric Machines and Power Electronics (2nd *ed, prescribed*) Author: P. C. Sen Publisher: John Wiley and Sons
3 Electromechanics and Electrical Machinery Authors: J. F. Lindsay and M. H. Rashid Publisher: Prentice-Hall
4 Electric Machines and Power Systems Author: V. D. Toro Publisher: Prentice-Hall

Further Reading:

The following books may be consulted for further reading by those who really want to explore further.

1 Alternating Current Machines by M. G. Say for sections 1-4
2 Electric Machines and Drives by G. R. Slemon for sections 1-7
3 Power Electronics by Daniel W. Hart for section 8
4 Analysis of Electric Machinery by Paul Krause for sections 1-4