ELEC9712
High Voltage Systems

COURSE OUTLINES - Session 2, 2009

1. Course Staff

Course convener: Trevor Blackburn, Room EE103, t.blackburn@unsw.edu.au

2. Course Details

Credits: This is a 6 UoC postgraduate course in the power engineering discipline. The expected workload is 10-12 hours per week throughout the 12 week session.

Contact hours: The course consists of 2.5 hours of lectures per week, and 1 hour of tutorials per fortnight:

Lectures: Mondays, 18-21, room EE222
Tutorials: Mondays, 20-21, room EE222

Consultations: Students are encouraged to use the open consultation hour (Mon-Fri 10-11) rather than contact by email. Students may seek consultation with the course convener at other times by appointment.

3. Course Information

Context: Power Engineering is concerned with the generation, transmission, distribution and utilization of electrical energy. Large power systems are interconnected physical networks of many different types of equipment and apparatus: synchronous generators for generating electricity, power transformers for changing voltage levels, overhead transmission lines, underground cables, metering and control equipment, switchgear for connection/disconnection, high-voltage insulators, etc. Each equipment type in turn comprises many different designs to suit different electrical operating conditions (voltage, current and power levels) and ambient constraints.

Aims: This course provides essential knowledge in the technology and testing techniques for high-voltage power system components and equipment. Particular emphasis is on current practices within Australian power utilities.

This course provides a detailed coverage of the common features of major items of power system equipment, including analysis of the field properties and its use in determining the electrical insulation design, thermal design and operation of equipment and the design of both static and dynamic contact systems for equipment; the design and operation of specific items of equipment.
including transformers (power and instrument), switchgear, protection systems, cables, overhead lines, surge arresters, earthing systems and condition monitoring and high-voltage testing.

**Relation to other courses:** This is one of the specialisation courses for a Master degree in Engineering Science (Energy Systems) at the University of New South Wales. Some of the topics in this course are covered at an introductory level in ELEC4611 (an undergraduate elective course).

**Assumed knowledge:** It is assumed that the students have completed all the core courses required in the first 3 years of a BEE degree, and in particular the ELEC3105 (Electrical Energy) course.

**Old courses:** The course replaces a previous course ELEC9214 (Power System Equipment).

### 4. Learning outcomes

After the successful completion of the course, the student will be able to:

- Have detailed knowledge the various types of insulating materials (gaseous, liquids, solids, vacuum, composites) and their applications in high-voltage equipment.
- Use field analysis methods to calculate electric stress, magnetic field and thermal aspects associated with high voltage high power equipment and their application in the design of high-voltage components.
- Understand practical techniques to generate and measure high-voltages (DC, AC, impulse).
- Have detailed knowledge the various types of electrical/physical/chemical diagnostic measurements for insulation assessment; in particular partial discharge detection, measurement, and characterisation.

The course delivery methods and course content address a number of core UNSW **graduate attributes**; these include:

- Development of in-depth knowledge and understanding in the discipline.
- Development of analytical and critical thinking, which is addressed by the tutorial exercises and class tests.
- Information literacy - the skills to appropriately locate, evaluate and use relevant information.
- The ability to engage in independent and reflective learning (via project assignment).
- Development of effective communication (oral presentation and written report).
- Team and collaborative working skills (via group project assignment).

Please refer to [http://www.ltu.unsw.edu.au/content/userDocs/GradAttrEng.pdf](http://www.ltu.unsw.edu.au/content/userDocs/GradAttrEng.pdf) for more information about graduate attributes.

### 5. Teaching strategies

The course consists of the following elements: lectures, home work, and tutorials:

**Lectures:**

Students are expected to attend the lectures and prepare themselves for them. The lectures provide the students with a focus on the core material in the course. Generic features and functions of various types of major equipment and apparatus required in a typical power system network are explained. This is further illustrated with practical examples from Australian power utility installations. Mathematical tools and computer-aided analysis are then used to convey a qualitative understanding of critical issues affecting the operation of power system equipment. This in turn
leads students to an appreciation of the equipment ratings, choice of particular insulation materials and designs. The basic principles covering the high-voltage testing and condition monitoring of equipment are presented and then illustrated by examining a wide array of diagnostic devices that are currently being used in the power industry.

**Tutorials:**

The tutorial sessions provide personal assistance to students in solving problems. A total of 5 problem sets will be presented throughout the semester and some of these will be worked through during the tutorials. The tutorials take the student through all critical course topics and aim to exercise the students’ analytical and critical thinking skills. Students are strongly encouraged to complete all the tutorial problems as these help to develop in-depth quantitative understanding of the course materials. During tutorials, students will also be invited to raise any concepts or topics covered in lectures with which they are experiencing difficulty and required another explanation. Tutorials are also opportunities for interactive discussion on any questions, issues or topics relevant to the course.

**Home work:**

The class lectures can only cover the course material to a certain depth; students must download the lecture notes (from the course website) and reflect on its content as preparation for the lectures to fully appreciate the course material. Further research and reading from the recommended list of text/reference books are also required. The ability to read the literature, identify relevant parts and extract critical information with the aid of the lectures is regarded as an essential component of this course. Also, a significant component of home work is preparation for tutorials, and researching on a group project assignment.

**6. Assessment details**

The assessment activities and their allocated marks are detailed in the table below. Note that there are no marks awarded for tutorial work.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Mark</th>
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<tbody>
<tr>
<td>Quiz 1 (week 5)</td>
<td>10%</td>
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<tr>
<td>Quiz 2 (week 10)</td>
<td>10%</td>
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<tr>
<td>Group assignment (due week 12)</td>
<td>10%</td>
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<tr>
<td>Final examination</td>
<td>70%</td>
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**Quizzes:** There are two quizzes, each is of one hour duration and closed-book, held during the lecture time through the semester. They are provided in order to get early feedback on student performance. The quizzes test the students general understanding of the course material covered in the previous 4-5 lectures.

**Assignment:** This is a group project whereby each group is to carry out a literature survey or a real-life case study on a topic relevant to this course, and in the end give an oral presentation and submit a detailed written report. The assessment criteria equally address your research and communication skills. The report is due on the due date by 5pm. Late submissions carry a 50% penalty for the first week and will not be accepted beyond one week delay. Delays on medical grounds are accepted. The reports should be dropped into the school assignment box next to room EEG12A.
**Final examination:** The exam in this course is a standard closed-book 3 hours written examination, covering all aspects of the course that have been presented in the lectures and tutorials. The exam format will be similar to the previous years’ examinations. Some questions are of a descriptive nature (e.g. explaining a concept) and the rest are problem-solving. 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 the correct fraction of the answers to the exam questions. A satisfactory performance (50% or greater) in the final exam is a necessary requirement to pass this course, irrespective of the marks obtained in the other components.

7. **Course Schedule**

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<thead>
<tr>
<th>Week no.</th>
<th>Topics to be covered</th>
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<tr>
<td>1-3</td>
<td><strong>Coverage of fundamental materials common to the design and operation principles of electrical power equipment.</strong>&lt;br&gt;Topics include: Fields and materials, power loss generation, electrodynamic force calculations, thermal behaviour and ratings calculations, electrical contact behaviour.</td>
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<tr>
<td>5-6</td>
<td><strong>Transmission/distribution Lines and Cables</strong>&lt;br&gt;Overhead lines, cables, gas insulated systems and busbars. Design and operation. Transient ratings. Electric and Magnetic Fields and their effect on design and operation. Sag and tension of OH lines, insulation aspects. GIS design and operation.</td>
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<tr>
<td>7</td>
<td><strong>High voltage circuit breaker and surge arrester design</strong>&lt;br&gt;Arc properties. Design principles for low and medium voltage devices. Switching transients and their effects and control. Switchboard arcing effects. Testing. Diagnostic and monitoring techniques for switchgear.</td>
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<tr>
<td>8</td>
<td><strong>Power transformers</strong>&lt;br&gt;Design principles and operation. Insulation requirements and types. Cyclic rating determination.</td>
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<td></td>
<td><strong>Instrument Transformers</strong> - Voltage and Current&lt;br&gt;Design, Accuracy and applications. Modern VTs and CTs. Frequency response</td>
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<tr>
<td>9-11</td>
<td><strong>Modern Condition Monitoring techniques</strong>&lt;br&gt;Generation and measurement of high voltage (AC, DC, impulse). High voltage testing of power system equipment (according to Standards). On-line vs off-line testing techniques. Life assessment of equipment. Reliability.</td>
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<tr>
<td>12</td>
<td><strong>Seminar presentations</strong></td>
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8. Resources for Students

Textbooks:
There are no prescribed textbooks for the course. A comprehensive set of lecture notes developed by the convener will be made available for download from the course web site.

Reference books:
The following references will each cover parts of the course only. They are listed in no particular order of importance although the ones in **bold** are perhaps those most relevant:

On-line resources:
The web site for this course is: https://subjects.ee.unsw.edu.au/elec9712/. It contains lecture notes, tutorials, laboratory materials, past exam papers, as well as other relevant information and announcements about this course.

9. Other Matters

Academic Honesty and Plagiarism
Plagiarism is the unacknowledged use of other people’s 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 about plagiarism, please refer to http://www.lc.unsw.edu.au/plagiarism.

All submitted reports and assignments must have an attached cover-sheet that declares that the work detailed in the report/assignment is entirely that of the named student(s) only. The form is available from the EE&T School web site.

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, see http://scoff.ee.unsw.edu.au/