School of Electrical Engineering and Telecommunications

Semester 2, 2018
Course Outline

ELEC9712
High Voltage Systems

COURSE STAFF

Course Convener: A/Prof. Toan Phung, Room MSEB547, toan.phung@unsw.edu.au

Lecturer: Dr. Muhammad Tariq Nazir, muhammadtariq.nazir@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. In addition, open consultation is available Mon-Fri 11am-12pm. Students may seek consultation with the course convener at other times by appointment. ALL email enquiries should be made from your student email address with ELEC9712 in the subject line; otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

COURSE SUMMARY

Contact Hours

The course consists of 3 contact hours per week, primarily for lectures but some time is set aside during the semester for tutorials, test and seminars.

	Day	Time	Location
Class time	Friday	6-9 pm	Burrows Theatre K-J14-G5

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 the 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

High voltage engineering and technology form an important area in power engineering. It deals mainly with electrical insulation systems and processes that take place in power system equipment. In-depth knowledge in this area is essential for designers and operators of high voltage equipment and power utility engineers. The course aims to provide students with 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.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1-3	*Coverage of fundamental materials common to the design and operation principles of electrical power equipment***.** Topics include: Fields and materials, power loss generation, electro-dynamic force calculations, thermal behaviour and ratings calculations, electrical contact behaviour.
Week 4-5	*Transmission/Distribution Lines and Cables* 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.
Week 6	***Mid-session test (Friday 31/8/18)***
Week 7-8	*Power transformers* Design principles and operation. Insulation requirements and types. Cyclic rating determination. *Instrument Transformers* - Voltage and Current Design, Accuracy and applications. Modern VTs and CTs. Frequency response
Week 9	*High voltage circuit breaker and surge arrester design* 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.
Teaching Recess (22/9 – 1/10/18)	
Week 10-11	*Modern Condition Monitoring techniques* Generation and measurement of high voltage (AC, DC, impulse). High voltage testing of power system equipment (according to Standards). On-line versus off-line testing techniques. Life assessment of equipment. Reliability.
Week 12	Seminar presentations by students
Week 13	Tutorial - Revision

The above schedule is provisional and may be updated during the semester. You should attend lectures and regularly check the course website for possible updates.

Assessment

Mid-Semester Exam (week 6)	25%
Group Assignment – seminar and report (due end of week 14)	15%
Final Exam (2 hours, during exam period, TBA)	60%

There will be opportunities to earn bonus marks through activities in the class room or through other media. Note that you may have to pass the final exam to pass the course.

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 13 week semester.

Relationship to Other Courses

This is one of the specialization courses for a Master degree in Engineering or Engineering Science (Energy Systems) at UNSW. Some of the topics in this course are covered at an introductory level in ELEC4611 (an undergraduate elective course).

Pre-requisites and Assumed Knowledge

It is assumed that the students have completed all the core courses (or their equivalents) required in the first 3 years of a BEE degree, and in particular the ELEC3105 (Electrical Energy) course. Also, it is recommended that you are familiar with ELEC4611 (Power System Equipment) before this course is attempted. It is further assumed that students have good computer literacy and familiar with Matlab programming.

Learning outcomes

After successful completion of this course, you should be able to:

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

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

This course provides a detailed coverage of the common features of major items of high voltage equipment and components, including materials used and dielectric properties; field analysis and its use in determining the electrical insulation design; thermal ratings of equipment; 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, cables, overhead lines, surge arresters; techniques to generate and measure high voltages; condition monitoring and high-voltage diagnostic testing methods.

TEACHING STRATEGIES

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Guest lectures from professionals and industry experts offering practical experience and knowledge;

Learning in this course

You are expected to attend all lectures, tutorials, and mid-semester exams in order to maximize learning. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW

assumes that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Prior to attending the lectures, students are expected to 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.

The tutorial sessions provide personal assistance to students in solving problems. A total of 4 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.

ASSESSMENT

The assessment scheme in this course reflects the intention to assess your learning progress through the semester.

Mid-Semester Exam

The mid-session examination tests your general understanding of the course material, and is designed to give you feedback on your progress through the analytical components of the course. Questions may be drawn from any course material covered thus far. It will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses.

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 written report is due by 5pm on Friday week 14. 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.

Final Exam

The exam in this course is a standard closed-book 2-hour 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. 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 to the correct fraction of the answers to the exam questions.

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes			
Assessment	**1**	**2**	**3**	**4**
Mid-semester exam	✓	✓	-	-
Assignment	-	✓	-	✓
Final exam	✓	✓	✓	✓

COURSE RESOURCES

Recommended text(s)

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

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:

- E. Kuffel, W.S. Zaengl, and J. Kuffel, ***High Voltage Engineering: Fundamentals***, 2nd edition, Butterworth-Heinemann, 2000.
- N.H. Malik, et al, ***Electrical Insulation in Power Systems****,* Marcel Dekker, 1998.
- P. Gill, ***Electrical Power Equipment Maintenance and Testing***, 2nd edition, CRC Press, 2008.
- H.M. Ryan (ed.), ***High Voltage Engineering and Testing***, 2nd edition, London: Institution of Electrical Engineers, c2001.
- W. Hauschild and E. Lemke, ***High-Voltage Test and Measuring Techniques***, Springer Berlin Heidelberg, 2014.
- F.A.M. Rizk and G.N. Trinh, *High Voltage Engineering*, CRC Press, 2014.
- C.L. Wadhwa, *High Voltage Engineering*, 2nd ed., New Age International, 2007.
- M.S. Nadu and V. Kamaraju, *High Voltage Engineering*, 2nd edition, McGrawHill, 1995.
- M. Abdel-Salam, H. Anis, A. El-Morshedy, R. Radwan, *High-Voltage Engineering – Theory and Practice*, 2nd edition, CRC Press, 2000.
- R.E. James and Q. Su, ***Condition Assessment of High Voltage Insulation in Power System Equipment***, IET, 2008.
- B.M. Weedy, and B. Cory, *Electric Power Systems*, 4th edition, Wiley, 1998.
- W. Tillar Shugg, *Handbook of Electrical and Electronic Insulating Materials*, 2nd edition, New York: IEEE Press, 1995.
- G.J. Anders, *Rating of electric power cables in unfavorable thermal environment*, Hoboken, N.J. ; [Chichester] : Wiley-Interscience, c2005.
- A. Greenwood, *Electrical transients in power systems*, 2nd edition, New York: Wiley Interscience, c1991.
- M.J. Heathcote, *The J & P Transformer Book: A Practical Technology of the Power Transformer*, 13th ed., Elsevier, 2007.
- F.H. Kreuger, *Industrial High Voltage*, vol.1&2, Delft University Press, 1991.

On-line resources

Moodle

The course website is on UNSW Moodle: https://moodle.telt.unsw.edu.au/login/index.php. It contains lecture notes, tutorials, sample exam papers, as well as other relevant information and announcements about this course.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

OTHER MATTERS

Dates to note

Important dates available at: https://student.unsw.edu.au/dates

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 form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/guide), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **10 to 12 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult https://student.unsw.edu.au/special-consideration.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the online student survey myExperience. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

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 and UNSW policies:
https://student.unsw.edu.au/guide
https://www.engineering.unsw.edu.au/electrical-engineering/resources

APPENDICES

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the School in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have in-depth knowledge and understanding of their discipline through the lectures.
- Development of analytical and critical thinking, which is addressed by the tutorial exercises, test, and final examination.
- Developing digital and information literacy and lifelong learning skills - 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).

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes	
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	✓
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	✓
	PE1.3 In-depth understanding of specialist bodies of knowledge	✓
	PE1.4 Discernment of knowledge development and research directions	✓

	PE1.5 Knowledge of engineering design practice	✓
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	✓
	PE2.2 Fluent application of engineering techniques, tools and resources	✓
	PE2.3 Application of systematic engineering synthesis and design processes	
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	
	PE3.2 Effective oral and written communication (professional and lay domains)	✓
	PE3.3 Creative, innovative and pro-active demeanour	
	PE3.4 Professional use and management of information	✓
	PE3.5 Orderly management of self, and professional conduct	✓
	PE3.6 Effective team membership and team leadership	✓