School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC9712

High Voltage Systems

Term 3, 2021

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Toan Phung	toan.phung@unsw.edu.au	12-1pm Mon-Fri	Room 123, Elec. Eng. Building G17	9385-5407

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx 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.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

Course Details

Units of Credit 6

Summary of the Course

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.

Course 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.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Have detailed knowledge of the various types of insulating materials (gaseous, liquids, solids, vacuum, composites) and their applications in high-voltage equipment	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2, PE3.2, PE3.4, PE3.5, PE3.6
2. Apply 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	PE1.1, PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2, PE3.3, PE3.4, PE3.5, PE3.6
3. Explain practical techniques to generate and measure high-voltages (DC, AC, impulse)	PE1.1, PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2, PE3.4, PE3.5, PE3.6
4. Demonstrate advanced knowledge the various types of electrical/physical/chemical diagnostic measurements for insulation assessment; in particular partial discharge detection, measurement, and characterization	PE1.3, PE1.4, PE2.1, PE2.2, PE3.2, PE3.4, PE3.5, PE3.6

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.

UNSW Graduate Capabilities

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

- Developing scholars who have in-depth knowledge and understanding of their discipline through the lectures.
- Developing 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.
- Developing ability to engage in independent and reflective learning (via project assignment).
- Developing effective communication (oral presentation and written report).
- Developing team and collaborative working skills (via group project assignment).

Teaching Strategies

Delivery Mode

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

- Formal 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;

- Blended learning via Moodle;
- 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-term 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 formal 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 term 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.

Additional Course Information

Credits

This is a 6 UoC postgraduate course in the power engineering discipline. The expected workload is 15 hours per week throughout the 10-week term.

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 ELEC3105 (Electrical Energy). 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 such as MATLAB programming.

Assessment

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

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Final Examination	60%	TBA	2, 3, 4
2. Mid-Term Exam	25%	14/10/2021 06:00 PM	1, 2
3. Group Assignment	15%		1, 2, 4

Assessment 1: Final Examination

Due date: TBA

The final exam is a standard 2-hour written examination, covering all remaining topics that were not covered in the mid-term exam. The exam format will be similar to 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 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.

Assessment 2: Mid-Term Exam

Due date: 14/10/2021 06:00 PM

This is a 90-minute written examination. The exam is intended to get early feedback on student performance. It comprises numerical and analytical questions as well as descriptive-type questions, drawn from any course material covered thus far. Assessment is a graded mark according to the correct fraction of answers to the test questions.

Written exam in week 5, covering Topic 1 and part of Topic 2

Assessment 3: Group Assignment (Group)

This is a group project. There are 2 parts.

Part 1 is a literature review or state-of-the-art survey on a topic relevant to this course. A group report is to be submitted at the end of week 6. The assessment criteria aim to evaluate your research and written communication skills. Part 1 counts 5% towards the final course mark.

Part 2 is a computer simulation assignment. An oral presentation and a group report are due in week 10. The assessment criteria aim to evaluate your analytical and oral communication skills. Part 2 counts 10% towards the final course mark.

Late submissions carry a 50% penalty for the first week and will not be accepted beyond that.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

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

View class timetable

Timetable

Date	Type	Content
Week 1: 13 September - 17 September	Lecture	*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 2: 20 September - 24 September	Lecture	*Coverage of fundamental materials common to the design and operation principles of electrical power equipment (cont.)*
Week 3: 27 September - 1 October	Lecture	*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 4: 4 October - 8 October	Lecture	*Transmission/Distribution Lines and Cables (cont.)*
Week 5: 11 October - 15 October	Lecture	*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.
	Assessment	***Mid term exam***
Week 6: 18 October -	Lecture	*Insulating Materials*

22 October		Solid, liquid, and gaseous insulation materials used in high voltage equipment. Physics of electrical breakdowns. *Outdoor insulators*
	Assessment	***Group Assignment Part 1 Report***
Week 7: 25 October - 29 October	Lecture	*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 8: 1 November - 5 November	Lecture	*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 9: 8 November - 12 November	Lecture	*Modern Condition Monitoring techniques (cont.)*
Week 10: 15 November - 19 November	Assessment	***Group Assignment Presentation and Part 2 Report***
Study Week: 20 November - 25 November	Tutorial	*Revision for final exam*

Resources

Prescribed 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.
- 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).

Course Evaluation and Development

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.

Academic Honesty and Plagiarism

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.

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.

Academic Information

COVID19 - Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

Dates to note

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

Student Responsibilities and Conduct

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

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both formal classes and *independent, self-directed study*. In periods where you 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.

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 can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

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

Image Credit

UNSW EET School

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in 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	✓