UNSW Course Outline

ELEC9712 High Voltage Systems - 2024

Published on the 01 Sep 2024

General Course Information

Course Code : ELEC9712
Year : 2024
Term : Term 3
Teaching Period : T3
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Electrical Engineering & Telecommunications
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Large-scale electricity supply networks deliver electricity from the generating sources (e.g., power stations, wind farms, solar farms) to major load centres (e.g., cities, regional areas, heavy industry). This bulk transport of electricity must be carried out at high voltage to reduce power

loss. Thus, high voltage technology is an indispensable specialisation in power engineering. Knowledge in this area is essential for designers and operators of high-voltage equipment and power utility engineers.

This course provides 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 power and instrument transformers, 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 technology is an important specialisation in power engineering that enables the practical implementation of large-scale power grids for the generation, transmission, and distribution of electrical energy. The course aims to provide students with essential knowledge in the technology, condition monitoring, and testing techniques for high-voltage power system equipment and components. Particular emphasis is on current practices by Australian power utilities and industries.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Have detailed knowledge of some major equipment/components in high voltage electricity transmission/distribution networks, their physical design, materials used (particularly insulating materials), and relevant testing Standards.
CLO2 : Apply analysis methods to calculate the electric stress, magnetic field, mechanical force, steady-state and transient thermal ratings, and their application in the design of high-voltage components.
CLO3 : Explain practical techniques to generate and measure high voltages (DC, AC, impulse).
CLO4 : Demonstrate advanced knowledge of the various types of electrical/physical/chemical diagnostic measurements for insulation assessment; in particular partial discharge detection, measurement, and characterisation.

Course Learning Outcomes	Assessment Item
CLO1 : Have detailed knowledge of some major equipment/components in high voltage electricity transmission/distribution networks, their physical design, materials used (particularly insulating materials), and relevant testing Standards.	• Mid-Term Exam • Group Assignment
CLO2 : Apply analysis methods to calculate the electric stress, magnetic field, mechanical force, steady-state and transient thermal ratings, and their application in the design of high-voltage components.	• Final Examination • Mid-Term Exam • Group Assignment
CLO3 : Explain practical techniques to generate and measure high voltages (DC, AC, impulse).	• Final Examination
CLO4 : Demonstrate advanced knowledge of the various types of electrical/physical/chemical diagnostic measurements for insulation assessment; in particular partial discharge detection, measurement, and characterisation.	• Final Examination • Group Assignment

Learning and Teaching Technologies

Moodle - Learning Management System

Other Professional Outcomes

The Course Learning Outcomes (CLOs) contribute to the Engineers Australia Stage

1 Competencies as outlined below

Engineers Australia (EA), Professional Engineer Stage 1 Competencies

PE1: 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: CLO 1, 2, 3

PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline: CLO 1, 2, 3

PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline: CLO 1, 2, 3, 4

PE1.4 Discernment of knowledge development and research directions within the engineering discipline: CLO 1

PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline: CLO 1, 2, 3

PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline: NA

PE2: Engineering Application Ability:

PE2.1 Application of established engineering methods to complex engineering problem solving: CLO 1, 2, 3, 4

PE2.2 Fluent application of engineering techniques, tools and resources: CLO 1, 2, 3, 4

PE2.3 Application of systematic engineering synthesis and design processes: NA

PE2.4 Application of systematic approaches to the conduct and management of engineering projects: NA

PE3: Professional and Personal Attributes:

PE3.1 Ethical conduct and professional accountability: NA

PE3.2 Effective oral and written communication in professional and lay domains: CLO 1, 2, 3, 4

PE3.3 Creative, innovative and pro-active demeanour: CLO 2

PE3.4 Professional use and management of information: CLO 1, 2, 3, 4

PE3.5 Orderly management of self, and professional conduct: CLO 1, 2, 3, 4

PE3.6 Effective team membership and team leadership: CLO 1, 2, 3, 4

This course is also designed to provide the CLOs which arise from targeted graduate capabilities. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (also listed below).

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;
- 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 the 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).

https://www.unsw.edu.au/engineering/student-life/student-resources/program-design

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.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Final Examination Assessment Format: Individual	60%	Due Date: Final Exam Period
Mid-Term Exam Assessment Format: Individual	25%	Due Date: Week 5: 07 October - 13 October
Group Assignment Assessment Format: Group	15%	Start Date: Week 1 Due Date: Week 5: 07 October - 13 October, Week 10: 11 November - 17 November

Assessment Details

Final Examination

Assessment Overview

The final exam is a standard 2-hour written examination to be scheduled during the final exam period. It covers all remaining topics that were not covered in the mid-term exam. Some questions are of a descriptive nature (e.g., explaining some concept) and the rest are problem-solving. 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 your answers to the exam questions.

Course Learning Outcomes

- CLO2 : Apply analysis methods to calculate the electric stress, magnetic field, mechanical

force, steady-state and transient thermal ratings, and their application in the design of high-voltage components.
- CLO3 : Explain practical techniques to generate and measure high voltages (DC, AC, impulse).
- CLO4 : Demonstrate advanced knowledge of the various types of electrical/physical/chemical diagnostic measurements for insulation assessment; in particular partial discharge detection, measurement, and characterisation.

Detailed Assessment Description

Invigilated in-person exam, 2 hours to answer 4 questions, each question may have multiple sub-questions, open-book, UNSW-approved calculator, no computer

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

Mid-Term Exam

Assessment Overview

This is a written examination scheduled at mid-term to get feedback on student performance. It comprises numerical and analytical questions as well as descriptive-type questions, drawn from course material covered in the first 4 weeks. Assessment is a graded mark according to the correct fraction of answers to the test questions. Verbal class-wide feedback will be given during lectures and individual feedback will also be provided upon request.

Course Learning Outcomes

- CLO1 : Have detailed knowledge of some major equipment/components in high voltage electricity transmission/distribution networks, their physical design, materials used (particularly insulating materials), and relevant testing Standards.
- CLO2 : Apply analysis methods to calculate the electric stress, magnetic field, mechanical force, steady-state and transient thermal ratings, and their application in the design of high-voltage components.

Detailed Assessment Description

Invigilated in-person exam during week 5, 90 minutes to answer 3 questions, each question may have multiple sub-questions, open-book, UNSW-approved calculator, no computer.

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

Group Assignment

Assessment Overview

This is group work which has 2 parts. Assignment 1 is a literature review or state-of-the-art survey on a technical topic related to high-voltage technology. A group report is to be submitted. The assessment criteria aim to evaluate the rigour of your research and professional writing skills. This assignment counts 5% towards the final course mark. Assignment 2 is an analysis and/or design task involving computer-based simulations. Each group is to make an oral presentation and submit a written report on the technical findings. The assessment criteria aim to evaluate your analytical and oral communication skills. Assignment 2 counts 10% towards the final course mark. Feedback will be given verbally following the presentation and via written comments on the report.

Course Learning Outcomes

- CLO1 : Have detailed knowledge of some major equipment/components in high voltage electricity transmission/distribution networks, their physical design, materials used (particularly insulating materials), and relevant testing Standards.
- CLO2 : Apply analysis methods to calculate the electric stress, magnetic field, mechanical force, steady-state and transient thermal ratings, and their application in the design of high-voltage components.
- CLO4 : Demonstrate advanced knowledge of the various types of electrical/physical/chemical diagnostic measurements for insulation assessment; in particular partial discharge detection, measurement, and characterisation.

Detailed Assessment Description

Assignment Part 1 is due at the end of week 5. Each group is to submit a progress report demonstrating their understanding of the ANSYS software tool and application to perform basic 2D field simulations of some simple geometry high-voltage components.

Assignment Part 2 requires students to demonstrate their proficiency of ANSYS advanced features, e.g., 3D. Each group is to provide a short oral presentation during week 10 and to submit a group report documenting the simulation details and discussion of findings at the end of week 10.

Generative AI Permission Level

Simple Editing Assistance

In completing this assessment, you are permitted to use standard editing and referencing functions in the software you use to complete your assessment. These functions are described below. You must not use any functions that generate or paraphrase passages of text or other media, whether based on your own work or not.
If your Convenor has concerns that your submission contains passages of AI-generated text or media, you may be asked to account for your work. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.
For more information on Generative AI and permitted use please see here.

General Assessment Information

There will be opportunities to earn bonus marks through activities in the classroom or through other media.

Grading Basis

Standard

Requirements to pass course

The final exam mark is at least 35 (out of 100) and the total course mark is at least 50 (out of 100).

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 9 September - 15 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 rating calculations, Electrical contact behaviour.
Week 2 : 16 September - 22 September	Lecture	Coverage of fundamental materials common to the design and operation principles of electrical power equipment (cont.)
Week 3 : 23 September - 29 September	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.
Week 4 : 30 September - 6 October	Lecture	Transmission/Distribution Lines and Cables (cont.)
Week 5 : 7 October - 13 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
	Assessment	Group Assignment Part 1 - submit Progress Report
Week 6 : 14 October - 20 October	Lecture	Insulating Materials Solid, liquid, and gaseous insulation materials used in high-voltage equipment. Physics of electrical breakdowns.
Week 7 : 21 October - 27 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 : 28 October - 3 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 : 4 November - 10 November	Lecture	Modern Condition Monitoring techniques (cont.)
Week 10 : 11 November - 17 November	Assessment	Group Assignment Part 2 - Presentation and submit Final Report

Attendance Requirements

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

General Schedule Information

The schedule shown is provisional and may be updated during the term. Extra sessions (tutorials, revision) may be scheduled. You should attend lectures and regularly check the course website for possible updates.

Course 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 website.

The following references will each cover parts of the course only. They are listed in no particular order of importance although the ones in italic are the 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.

Online 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.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Toan Phung		Room 123, Elec. Eng. Building K-G17	9385-5407	12-1pm Mon-Thu	Yes	Yes

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

II. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Special Consideration

- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students

one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, 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

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)

School-specific Information

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.

Use of AI for assessments

Your work must be your own. If you use AI in the writing of your assessment, you must acknowledge this and your submission must be substantially your own work. More information can be found on this website.

Workplace Health & Safety (WHS)

WHS for students and staff is of utmost priority. Most courses involve laboratory work. You must follow the rules about conduct in the laboratory. About COVID-19, advice can be found on

this website.

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