School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC4611

Power System Equipment

Term 1, 2023

Course Overview

Staff Contact Details

Convenors

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

Demonstrators

Name	Email	Availability	Location	Phone
Hua Chai	hua.chai@unsw.edu.au			

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

Overview of electricity supply network infrastructure; Electrical insulation in power system equipment and components: materials and dielectric properties, electric stress calculation, field grading; Overcurrent: electrodynamic forces, offset current transient, short-circuit thermal effects, protection (fuses, circuit breakers); Overvoltage: steady-state and transient, recovery voltage, surge propagation, protection (arresters), insulation coordination; Equipment rating: thermal equivalent circuit, steady-state temperature rise; High-voltage testing: power frequency overvoltage, lightning and switching impulse; Diagnostic methods for insulation assessment: insulation resistance, dielectric dissipation factor, partial discharge, dissolved gas-in-oil analysis.

Course Aims

The course aims to provide the student with essential knowledge in high-voltage power system components and equipment: their functions and physical design; electrical, mechanical and thermal factors affecting their operation; and diagnostic techniques to monitor their condition.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Explain the functions of various types of equipment and major components used in electrical power systems	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2, PE3.5, PE3.6, PE3.2, PE3.4
2. Explain the different effects (thermal, mechanical, electrical) caused by short-circuit faults and over-voltage transients	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2, PE3.2, PE3.4, PE3.5, PE3.6
3. Calculate the steady-state thermal ratings of power cables and overhead lines	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2, PE3.2, PE1.5, PE3.4, PE3.5, PE3.6
4. Calculate the electric stress and explain the dielectric design of high-voltage components	PE1.1, PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2, PE3.4, PE3.5, PE3.6
5. Apply appropriate electrical/physical/chemical measurement methods for insulation assessment	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 a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and oral assessments during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.
- Developing digital and information literacy and lifelong learning skills through written report work.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities (laboratory work), and tutorials

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;
- Laboratory sessions, which support the formal lecture material and also provide you with practical construction, measurement, and debugging skills.

Learning in this course

You are expected to attend all lectures, tutorials, labs, and mid-term exams in order to maximize

learning. You must prepare well for your laboratory classes and your lab work will be assessed. 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.

Lectures: Students are expected to prepare themselves for the lectures. 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.

Tutorial classes: The tutorial sessions provide personal assistance to students in solving problems. A total of 5 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 an 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 an interactive discussion on any questions, issues or topics relevant to the course.

Laboratory work: The laboratory work provides the student with exposure to practical high-voltage testing, measurement and reporting. Students will work in groups of three. There will be five three-hour experiments in total. The experiments will contain material that may not be covered in lectures until after the experiment is done. This requires that the laboratory sheets must be read thoroughly before the laboratory session. Students must come prepared for the laboratory sessions; the laboratory sessions are short, so this is only possible way to complete the given tasks. Laboratory attendance WILL be kept, and you MUST attend all labs. If, for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a lab, you will need to apply for a catch-up lab during another lab time, as agreed by the laboratory coordinator.

Home work: The class lectures can only cover the course material to a certain depth; students must down-load the lecture notes (from the course web site) 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 homework is preparation for laboratory, tutorials, and writing laboratory reports.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Laboratory Report	5%	27/4/23 11:55pm	1, 2, 4, 5
2. Final Examination	60%	TBA	1, 2, 3, 5
3. Mid-Term Exam	25%	15/3/23	1, 2, 4
4. Laboratory Practical Experiments	10%	At end of each lab session	1, 2, 4, 5

Assessment 1: Laboratory Report

Due date: 27/4/23 11:55pm

A group report on an experiment is to be submitted. Late submissions carry a 5% penalty per day, capped at 5 days, and will not be accepted beyond that. Delays on medical grounds are accepted. The reports must be submitted online via the course Moodle as one pdf file including a cover page declaring that the work detailed in the report is entirely that of the named student(s) only. Marks are awarded based on a sound explanation of the experiment concept and theoretical analysis, correct measurement results and their interpretation.

Assessment 2: Final Examination

Start date: TBA
Due date: TBA

The exam in this course is a 2-hour written examination, covering all aspects of the course that have been presented in the lectures, laboratory experiments, and tutorials. University-approved calculators are allowed. The exam format will be similar to the previous years' examinations. 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.

Assessment 3: Mid-Term Exam

Start date: 15/3/23
Due date: 15/3/23

This is a 90-minute written examination, held in week 5. The test 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 up to the end of week 3. Assessment is a graded mark according to the correct fraction of answers to the test questions.

Assessment 4: Laboratory Practical Experiments

Start date: At start of each lab session
Due date: At end of each lab session

Laboratories are primarily about learning, and the laboratory assessment is designed mainly to check your knowledge as you progress through each experiment. You are required to maintain a lab book for recording your observations and experimental results. A lab book is an A4 size notebook containing a mix of plain pages and graph sheets. A suite of video recordings explaining laboratory experiments available on Moodle to help students prepare before they attend laboratory classes.

Assessment of the laboratory work will be on the basis of (i) an oral examination conducted by the demonstrators during each laboratory session, and (ii) a detailed written report to be submitted at the end of the term on one of the experiments.

Students are required to attend all the scheduled laboratory sessions. After completing each experiment, your work will be assessed by the laboratory demonstrator. Assessment marks will be awarded according to your preparation (readiness for the lab in terms of pre-reading), how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the information you write during your lab work, and your understanding of the topic covered by the lab.

Attendance Requirements

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

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 13 February - 17 February	Lecture	Topic 1: Overview - Equipment and components used in electrical power systems Topic 2: Insulation of HV equipment - electric stress calculation, field grading
Week 2: 20 February - 24 February	Lecture	Topic 2 (cont.)
	Tutorial	Tutorial 1
Week 3: 27 February - 3 March	Lecture	Topic 3: Overcurrents - electrodynamic forces, thermal effects, protection.
Week 4: 6 March - 10 March	Lecture	Topic 4: Overvoltages – steady-state/transient, recovery voltage, current chopping.
	Tutorial	Tutorial 2
	Laboratory	First lab session
Week 5: 13 March - 17 March	Lecture	Topic 4 (cont.): surge propagation on transmission lines or cables, overvoltage protection, insulation coordination.
	Laboratory	Second lab session
Week 6: 20 March - 24 March	Homework	Flexibility week
Week 7: 27 March - 31 March	Lecture	Topic 5: Equipment rating: thermal equivalent circuit, steady-state temperature rise.
	Tutorial	Tutorial 3
	Laboratory	Third lab session
Week 8: 3 April - 7 April	Lecture	Topic 5 (cont.):
	Laboratory	Fourth lab session
Week 9: 10 April - 14 April	Lecture	Topic 6: High-voltage testing techniques and insulation assessment.

	Tutorial	Tutorial 4
	Laboratory	Fifth lab session
Week 10: 17 April - 21 April	Lecture	Topic 6 (cont.), revision
	Tutorial	Tutorial 5

Resources

Prescribed Resources

Moodle

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

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).

Recommended Resources

Textbooks

Prescribed textbook: there are no prescribed textbooks for the course. A 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:

- E. Kuffel, W.S. Zaengl, and J. Kuffel, *High Voltage Engineering: Fundamentals*, 2nd ed., Butterworth-Heinemann, 2000.
- P. Gill, Electrical *Power Equipment Maintenance and Testing*, 2nd ed., CRC Press, 2008.
- H.M. Ryan (ed.), *High Voltage Engineering and Testing*, 2nd ed., London : Institution of Electrical Engineers, c2001.
- R.E. James and Q. Su, *Condition Assessment of High Voltage Insulation in Power System Equipment*, IET, 2008.
- 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.
- T.J. Gallagher and A.J. Pearmain, *High Voltage: Measurement, Testing, and Design*, Chichester [Sussex] ; New York : Wiley, c1983.
- N.H. Malik, et al, *Electrical Insulation in Power Systems,* Marcel Dekker, 1998.
- M.S. Naidu and V Kamaraju, *High Voltage Engineering*, 2nd ed., McGraw-Hill, 1996.
- C.R. Bayliss and B.J. Hardy, *Transmission and Distribution Electrical Engineering*, 4th ed, Elsevier, 2012.
- J.D. Glover, T.J. Overbye and M.S. Sarma, *Power System Analysis and Design*, 6th ed., Cengage Learning, 2016.
- B.M. Weedy, and B. Cory, *Electric Power Systems*, 4th ed., Wiley, 1998.
- N. Mohan, *First Course on Power Systems*, Minneapolis, 2006.
- T.R. Bosela, *Electrical Power System Technology*, Prentice-Hall, 1997.
- J. Eaton, and E. Cohen, *Electric Power Transmission Systems,* 2nd ed., Prentice-Hall.

- M.E. El-Hawary, *Electrical Power System Design and Analysis*, Prentice-Hall, 1983.
- T. Gonen, *Electric Power Distribution System Engineering*, McGraw-Hill, 1986.
- P. Hasse, *Overvoltage Protection in Low Voltage Systems*, Peter Peregrinus, 1992.
- F. Kussy, and J. Warren, *Design Fundamentals for Low Voltage Distribution and Control*, Marcel Dekker, 1987.
- J.C. Whitaker, *AC Power Systems Handbook*, CRC Press, 1991.

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. **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.unsw.edu.au/engineering/our-schools/electrical-engineering-telecommunications/student-life/resources

Disclaimer

This Course Outline sets out 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 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 (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

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	✓