



School of Electrical Engineering and Telecommunications

Term 2, 2021

Course Outline

ELEC 3105

Electrical Energy

COURSE STAFF

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Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. You can also post questions in the Moodle discussion forums. **ALL** email enquiries should be made from your student email address with "ELEC3105" in the subject line, otherwise they will not be answered.

Consultation times for the course are:

Keeping Informed: The main announcements regarding the course and its assignments will be made through Moodle <https://moodle.telt.unsw.edu.au/login/index.php>. Announcements may also be made during classes but everything will be formally announced in the relevant sections of Moodle.

Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

COVID-19

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 at:

<https://www.nsw.gov.au/covid-19/what-you-can-and-cant-do-under-rules/self-isolation>

or government authorities. Current alerts and a list of hotspots can be found here:

<https://www.nsw.gov.au/covid-19/latest-news-and-updates>.

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:

<https://nucleus.unsw.edu.au/en/contact-us>

Special Consideration: 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:

<https://student.unsw.edu.au/special-consideration>

through the Special Consideration portal

https://iaro.online.unsw.edu.au/special_consideration/home.login.

Reporting: 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

<https://www.covid-19.unsw.edu.au/covid-19-case-notification>

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:

<https://www.covid-19.unsw.edu.au/safe-return-campus>



CORONAVIRUS
(COVID-19) UPDATE

COURSE INTRODUCTION

Energy plays a critical role in our everyday lives. Electrical energy (or electricity) is both a basic part of nature and one of the most widely used forms of energy. Electricity is a secondary energy source. It is produced through conversion of primary energy sources as coal, hydro, natural gas, nuclear, solar, and wind into electrical energy. Electricity is also a critical energy carrier, facilitating both transfer of energy and conversion to other forms, such as mechanical, chemical, etc.

For long, energy and electricity have been linked to economic growth and increase of energy consumption is linked to increase in GDP. In fact, a 1% increase in electricity consumption leads to approximately 1.5% increase in economic growth. A substantial portion ($\approx 50\%$) of electricity globally is consumed in applications involving electric machines and motors. This increases to over 80% in industrial applications and will further increase primarily driven by electrification of transportation.

However, the landscape is currently changing. As economies move towards greener generation and more efficient electricity consumption, the challenge ahead lies in the decoupling between rates of economic growth and energy demand and fundamentally shifting the way we think about energy.

Our goal in this course is to explore all aspects of electrical energy, from generation to consumption and introduce some of the most common and key components of the electrical network!

Context and Aims

The overarching aim of the course is to allow students to develop an understanding of the fundamental principles and performance of devices / components that are associated with Generation, Transmission, Distribution and Utilisation of Electrical energy and to assist students to gain in-depth knowledge about analysis and design of these circuits and devices.

Specifically, the aims of the course are to:

- Provide an Overview of Energy Systems.
- Introduce three-phase theory with Balanced three-phase AC circuits.
- Analyse Power Transformers in Electrical Systems.
- Provide an overview of Energy Conversion in DC Machines, Induction and Synchronous Machines.

Course Syllabus

Electrical energy supply systems; Transmission and Distribution systems; Energy Conversion; Generation of electrical energy; Utilisation of electrical energy; Thermal energy; Renewable Energy; Wind Energy; Solar Energy; Energy efficiency; Environmental aspects of Energy; Phasors; leading/lagging; Power; Power factor; Active Power; Reactive Power; Transformers; Equivalent circuits; single-phase transformers; Three-phase transformers; Delta connections; Star connections; Harmonics; DC machines; Induction machines; Synchronous machines.

Contact Hours

The course consists of:

1. 4 hours of lectures each week
2. 1-hour exercise solving demonstrations each week.
3. Five two-hour laboratory session throughout the term.

An indicative schedule for the term is given below:

Session	Day	Time	Location
Lecture	Tuesdays	10am - 12pm	Online
	Thursdays	3pm - 5pm	Online
Tutorials	Tuesdays	4pm	CLB 7
	Wednesdays	5pm	CLB 7
	Fridays	6pm	Online
Labs*	Monday	10am - 12pm	EET, Lab 115
	Monday	12pm - 2pm	EET, Lab 115
	Monday	3pm - 5pm	EET, Lab 115
	Monday	5pm - 7pm	Online only**
	Tuesday	2pm - 4pm	EET, Lab 115
	Tuesday	5pm - 7pm	Online only**
	Wednesday	10am - 12pm	EET, Lab 115
	Wednesday	12pm - 2pm	EET, Lab 115
	Wednesday	5pm - 7pm	Online only**
	Thursday	10am - 12pm	EET, Lab 115
	Thursday	1pm - 3pm	EET, Lab 115
	Friday	10am - 12am	EET, Lab 115
	Friday	1pm - 3pm	EET, Lab 115
Office hours	TBA	TBA	MS Teams & Room 325, TETB

* One session depending on your course enrollment. Details on the exact lab schedule will be provided in the second week of the term.

** Online labs are available only for those outside of Australia. No substitutions will be allowed.

Indicative Lecture - Laboratory Schedule

Period	Summary of Lecture Program
Week 1	<p>Topic 1: Introduction to Energy Systems</p> <ol style="list-style-type: none"> 1. Overview of power generation 2. Energy resources: fossil and renewable 3. Emphasis on photovoltaic and wind energy conversion
Week 2	<p>Topic 2: Balanced Three-phase AC circuits</p> <ol style="list-style-type: none"> 1. Introduction to three-phase AC systems, 2. Wye-Delta connections, 3. Phase and Line quantities, 4. Balanced three-phase circuits, 5. Wye-Delta transformation, 6. Power in a balanced three-phase system
Week 3	<p>Topic 3: Transformers</p> <ol style="list-style-type: none"> 1. Ideal transformer, 2. Impedance transformation, 3. Practical or non-ideal transformer, 4. Equivalent circuit and parameters
Week 4	<p>Topic 3: Transformers</p> <ol style="list-style-type: none"> 1. Per Unit (PU) calculations 2. Auto-transformers and instrument transformers 3. Three-phase transformers
Week 5	<p>Topic 4: Electrical Energy Conversion and DC Machines</p> <ol style="list-style-type: none"> 1. Principles of energy conversion- energy and co-energy 2. Force and torque calculations in the electromechanical systems 3. Introduction to DC machines and construction features, 4. Brush-commutation and armature reaction, torque and EMF calculation 5. Type of DC machines and equivalent circuits, equations 6. Torque –speed characteristics of DC motors 7. Concept of self- excitation in DC generators
Weeks 6	FLEXIBILITY WEEK

Period	Summary of Lecture Program
Week 7	<p>Topic 5: The Induction Machine</p> <ol style="list-style-type: none"> 1. Working principle – rotating magnetic field, 2. Synchronous speed and slip, 3. Induced voltages in stator and rotor 4. Equivalent circuit and parameter measurements
Week 8	<p>Topic 5: The Induction Machine</p> <ol style="list-style-type: none"> 1. Motoring and generating operations 2. Stator current and Power factor 3. Torque-speed characteristics 4. Single-phase induction motors
Week 9	<p>Topic 6: The Synchronous Machine</p> <ol style="list-style-type: none"> 1. Working principle 2. Induced voltage and synchronous speed, 3. Generation and motoring operations, 4. Equivalent circuit and parameters, 5. Phasor diagrams of various operation and their applications
Week 10	<p>Topic 6: The Synchronous Machine</p> <ol style="list-style-type: none"> 1. The physical meaning of the load angle, 2. Power and torque calculations, 3. Salient pole type SM.

TEACHING STRATEGIES

Delivery

The teaching in this course aims at establishing a good fundamental understanding of all topics:

1. 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; *Active learning is encouraged strongly.*
2. Exercise solving demonstrations, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of the material;
3. Laboratory sessions, which support the formal lecture material and provide you with practical hand-on experience, measurement and debugging skills;
4. Short periodic quizzes provide feedback on the progress in learning.

Learning in this course

You are expected to complete suggested tasks of all lectures, tutorials, labs, and quizzes in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed by oral exam. In addition to the lecture notes/video/screencast, you should read relevant sections of the recommended textbooks. 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 classes throughout the course.

Tutorials

You should attempt all tutorial sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasised, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Solutions of the tutorials will be released in Moodle progressively. Tutors may discuss the more complex questions in the tutorial class. Solutions discussed in the tutorial classes may not be available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

Laboratories

The laboratory program is an integral part of learning in this course. The aim of the laboratory component is to ground the analytical subject material in a practical problem, meaning that the skills and knowledge you learn throughout the course will be applied in real engineering work.

You are required to complete all relevant laboratory tasks. Laboratory oral exam will be a part of your assessment.

The laboratory syllabus covers 5 experiments:

1. Experiment 1: Balanced Three-Phase Circuits.
2. Experiment 2: The Power Transformer.
3. Experiment 3: The DC Motor.
4. Experiment 4: The Three-Phase Induction Motor.
5. Experiment 5: The Synchronous Machine.

The laboratory timetable and schedule produced by the timetabling division will be followed strictly for lab assessment.

COURSE DETAILS

Credits

ELEC3105 is 6 UOC course. The expected average workload, including Lab attendance, open labs, and self-study is approximately **16-18 hours per week** during the normal term.

Relationship to Other Courses

Pre-requisites and Assumed Knowledge

The course is a third-year core elective for students following a BE and BE/ME(Electrical) in the School of Electrical Engineering and Telecommunications at UNSW, Australia.

The prerequisites for this course are ELEC2134, Circuits and Signals, ELEC3115, Electromagnetic Engineering. It is essential that students are familiar with basic circuit theory and electromagnetics.

Students must revise the following materials from the prerequisite courses: **From ELEC 2134 (Circuits and Signals)**: Fundamentals of AC Sinusoids – frequency; time period; phase angle; Concept of leading and lagging; phasor representation and phasor diagrams; complex number algebra; impedance and admittance; equivalent impedance of series and parallel combinations; AC circuit analysis and theorems – current/voltage divisions; Thevenin's theorem; superposition theorem; maximum power transfer theorem.

From ELEC3105(Electromagnetics) Magnetic field, magnetic flux density, flux intensity, permeability, reluctance Faraday's law, Ampere's law, hysteresis loop, Eddy current, BH graph.

Learning outcomes

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

LO-1: Be able to analyse single and three phase AC circuits

LO-2: Be able to know the working principle, and to analyse steady state performances of some important power engineering devices such as transformer, DC machine, Induction machine and Synchronous machine.

LO-3: Be capable of selecting and designing these devices for real-life applications by applying underlying theories and concepts, recognise and evaluate the practical limitations and aspects of these devices.

LO-4: Gain experience in the performance and operation of power engineering devices and circuits through laboratory experiments and simulation.

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

- The capacity for analytical and critical thinking and for creative problem solving.
- The ability to engage in independent and reflective learning.
- Information Literacy – the skills to locate evaluate and use relevant information.
- The capacity for enterprise, initiative and creativity.
- The skills of effective communication.

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**.

Laboratories

Students are required to attend the laboratories as outlined in the Contact hours.

COURSE RESOURCES

On-line resources

Moodle

As a part of the teaching component, Moodle will also be used. Lab assessment marks will also be available via Moodle <https://moodle.telt.unsw.edu.au/login/index.php>. As the course progresses, students' marks from assessments such as labs and the quizzes are available for personal viewing on this website.

Textbooks

Relevant Textbooks

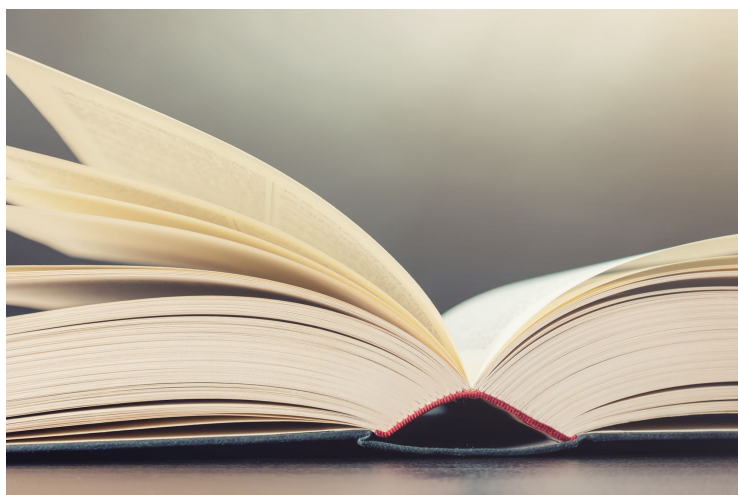
1. Electrical Machinery Fundamentals (prescribed) Author: Stephen J. Chapman (fifth edition) Publisher: McGraw Hill
2. Principles of Electric Machines and Power Electronics (2nd ed, prescribed) Author: P. C. Sen Publisher: John Wiley and Sons
3. Electromechanics and Electrical Machinery, Authors: J. F. Lindsay and M. H. Rashid Publisher: Prentice-Hall
4. Electric Machines and Power Systems Author: V. D. Toro Publisher: Prentice-Hall

For Further Reading:

The following books may be consulted for further reading by those who really want to explore further.

1. Alternating Current Machines by M. G. Say
2. Electric Machines and Drives by G. R. Slemon
3. Analysis of Electric Machinery by Paul Krause

You may also refer to online academic skills resources page for general guidance on study skills: <http://www.lc.unsw.edu.au/olib.html>



ASSESSMENT

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the lab checkpoints, online quizzes, assignment and the mid-semester exam.

Brief Assessment Description

1. Laboratory Practical Experiments:	15%
2. On-line Quizzes:	12%
3. Assignment:	13%
4. Final Exam (2 hours):	60%

You are expected to attend all labs and also make use of the open-lab hours of the course in order to maximize learning. It is important to prepare in advance of attending the laboratories each week; this includes preparing your own simulations and results. In addition to the lecture notes, you should read relevant sections of the recommended textbooks, articles and other provided material. Reading additional texts would further enhance your learning experience. *Group learning is strongly encouraged.*

Laboratory Assessment

Laboratories are primarily about learning, and the laboratory assessment is designed mainly to check your knowledge as you progress through each stage of the laboratory tasks. You are required to maintain a lab book for recording your observations. A lab book is an A4 size notebook containing a mix of plain pages and graph sheets. You must have your own lab book to record your test results. You will be recording your observations/readings in your lab book. Your notes, experimental results, graphs produced using measured data recorded in the lab book and your verbal explanation of the results will be examined by the demonstrators. Assessment marks will be awarded according to your preparation i.e. 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 measurements, graphs produced from the set of measured data, and your understanding of the topic covered by the lab.

Mid-Term Exam

No mid-term exam but each topic end quiz will contribute a total of 2% towards your final mark.

Assignment

The assignment allows self-directed study leading to the solution of partly structured problems. Marks will be assigned according to how completely and accurately the problems have been addressed, how well the relevant information is communicated, application of critical thinking while identifying assumptions, conclusions and implications and overall understanding of the course material demonstrated by the assignment report.

Online feedback quizzes

At the end of each topic, an online review quiz will be released, which students can complete on their own time, consulting lecture notes and books if necessary. These quizzes will give you feedback on how you are doing in the topics. Only the first attempt of the quizzes will be graded.

Final Exam

The exam in this course is a standard two-hour written examination, comprising compulsory questions. The examination tests analytical and critical thinking and general understanding of the course material. Questions may be drawn from any aspect of the course (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses.

Submission of Assessment Tasks

Assessment tasks will be submitted via the Moodle page of the course. Each Report must follow the style of the template provided and explained at the first week of classes.

Any submissions might be checked for originality and plagiarism with Turnitin (<https://student.unsw.edu.au/how-use-turnitin-within-moodle>). Assessments deemed to have an unacceptable level of similarity will not be marked.

Relationship of Assessment Methods to Learning Outcomes

	Learning Outcomes			
	LO1	LO2	LO3	LO4
Laboratory Assessments	✓	✓	✓	✓
Online Quizzes	✓	✓	✓	
Assignment	✓	✓	✓	✓
Final exam	✓	✓	✓	

ASSESSMENT



OTHER MATTERS

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a 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 16 to 18 hours per week studying a 6 UoC course over the term, from Week 1 until the final assessment, including both face-to-face 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.

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.

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>.

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 Course and Teaching Evaluation and Improvement Process. 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, enrollment, rights, and general expectations of students, please refer to the School and UNSW policies:

<https://www.engineering.unsw.edu.au/electrical-engineering/resources/undergraduate-resources/policies-and-procedures>

<https://student.unsw.edu.au/guide>

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 <select those which apply (maybe 3-5) and adapt to suit course>:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and 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 interactive checkpoint assessments and lab exams 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 assignment work.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.
- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities.

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	1-4
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	1-4
	PE1.3 In-depth understanding of specialist bodies of knowledge	1-4
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	1, 3
	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	1-4
	PE2.2 Fluent application of engineering techniques, tools and resources	1-4
	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	1-4
	PE3.2 Effective oral and written communication (professional and lay domains)	3
	PE3.3 Creative, innovative and pro-active demeanour	1-4
	PE3.4 Professional use and management of information	4
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	