School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC2911

Power Engineering for Renewable Energy

Term 3, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Branislav Hredzak	b.hredzak@unsw.edu.au	See Moodle	TETB, 324	93854895

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

Contact Hours

The course consists of a total of 4 hrs of lectures weekly, a 1-hr of tutorial (every two weeks), and a 3-hrs laboratory (weeks 7-10). Lectures will begin in week 1. Workshops will start in week 2. Laboratory sessions will start in week 7.

Syllabus

AC calculations: AC circuit calculations – voltage, current, phasors, impedance, sources, loads, RLC passives; single phase power – real and reactive power, power factor; transformers; three-phase circuits – phase and line quantities, power in balanced 3-phase systems.

Power electronics for renewable energy: PV energy conversion systems; principles of power electronic converters - DC/DC, DC/AC; single and 3-phase converters.

Electromechanical machines: principles of energy conversion (mechanical level focus), wind energy conversion systems; EMF and torque calculations; synchronous generator-principles, operation, grid connection.

Transmission and distribution: structure of power systems, introduction to AC transmission and distribution infrastructure, per-unit concepts and calculations, relationship between demand and generation (frequency and load control), relationship between voltage and reactive power.

Context

Renewable energy has become a viable option to fossil-fuel-based electricity generation due to its superior sustainability credentials and cheap cost gained during the previous decade as a result of considerable investment in research, development, and large-scale manufacturing. As a result, renewable energy systems such as solar, wind, and hydro are predicted to become the primary generation sources in the coming decades, meeting the majority of our society's energy needs. These renewable energy sources must be linked into the electrical grid so that the energy can be used safely and efficiently where and when it is most required.

This course will provide the fundamentals of power engineering, with focus on renewable energy This course will teach the principles of power engineering with a focus on renewable energy systems, including renewable power generation, transmission, and distribution. Renewable Energy Engineering covers a wide range of technologies, from those used to collect energy from various renewable sources to those used to convert that energy into electrical energy and then deliver it to customers. As a result, there is a strong connection between this topic and the discipline of Power Engineering. Renewable energy is becoming a more essential and vital part of the networks that supply electricity to households and businesses. This course will provide you with a solid understanding of the technical components of power engineering.

Course Aims

The aims of the course are

- To develop skill and knowledge in calculation and analysis of single-phase and three-phase circuits.
- To introduce the basic principle of operation of transformers.
- To introduce the basic principle of operation of single-phase and three-phase power electronic converters.
- To develop understanding of principles of operation of PV conversion and wind conversion systems.
- To develop understanding of principles of operation of transmission and distribution systems.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Explain the basic operation of single-phase and three-phase AC systems	PE1.1, PE1.2, PE1.3, PE1.5
2. Calculate real and reactive power and power factor in single-phase and three-phase systems	PE1.1, PE1.2, PE1.3, PE1.5
3. Explain the basic operation of transformers	PE1.1, PE1.2, PE1.3, PE1.5
4. Describe operation of power electronic converters, their interface to electrical networks, and perform basic calculations	PE1.1, PE1.3, PE1.5, PE2.1, PE2.2
5. Describe the characteristics and applications of electromechanical machines in renewable energy systems and perform basic calculations	PE1.1, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2, PE3.3, PE3.4
6. Explain principles of operation of PV and wind energy conversion systems.	PE1.1, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2, PE3.3, PE3.4
7. Describe relationship between demand and generation, and voltage and reactive power.	PE1.1, PE1.3, PE1.5, PE2.1, PE2.2

Teaching Strategies

Delivery mode

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

- Online lectures on Microsoft Teams, which provide students with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding. The lectures will be recorded and available on Microsoft Teams for the students to watch them at the time and place of your convenience.
- Online workshops on Microsoft Teams, which allow you to apply concepts introduced in lecture in solving analytical and design-based problems.
- Laboratory sessions, which support the formal lecture material and provide you with LTSpice

circuit simulation, and measurement skills. Students will complete the labs at home. They will be able to simulate and analyze various AC and power electronic circuits which will give them practical understanding of the theoretical concepts covered in the lectures.
- Mid-term exam, which allows students to assess themselves and get feedback to support their self-direct learning and understanding of materials covered in the course

Learning in this course

You are expected to attend all the online lectures and workshops in order to maximize learning. You must prepare well for your laboratory classes and your lab work will be assessed. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending online classes throughout the course.

Lecture classes

The lectures form the core of this subject. Topics presented in lectures will generally be followed by detailed examples to provide students with the real-life applications. Detailed explanations of the topics will be available to students in the form of lecture slides and lecture videos and which will be uploaded on Moodle. The online lectures will be recorded and available to students.

Workshop classes

The tutorial problems provide students with in-depth quantitative understanding of the topics covered in lectures. The problems will be posted on Moodle prior to the tutorial classes. Students are encouraged to attempt them before coming to the tutorial. Discussion forum for the tutorial problems will be made available on Moodle for students to post their solutions and discuss. During the tutorial session, solutions for the problems will be covered focusing on the challenges and issues raised by students in the discussion forum. Since there will not be enough time to cover all problems during the tutorial class, the tutorial will focus on selected problems and high-level discussion.

Laboratory program

The laboratory schedule is deliberately designed to provide exposure to the concepts conveyed in lectures. The laboratories are done by students on their own computers in Weeks 7 to 10 at their own pace. It is anticipated that each lab will take 3 hours to complete. There will be three laboratory experiments in the course, each of which consisting of several parts. One week is reserved for students to install and to get familiar with the simulation software LTspice.

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in other courses, all students enrolled in this course must take the labs.

Additional Course Information

Credits

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week term.

Relationship to Other Courses

This is a 2nd year course in the School of Electrical Engineering and Telecommunications.

Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC1111, Electrical Circuit Fundamentals. You are strongly advised to revise the circuit analysis techniques in ELEC1111 in your own time to get yourself ready for this course.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. AC theory laboratories	10%	Week 8	1, 2, 3
2. Power electronics laboratories	20%	Week 10	4
3. Mid-term exam	20%	Week 7	1, 2, 3, 4
4. Final exam	50%	TBA	1, 2, 3, 4, 5, 6, 7

Assessment 1: AC theory laboratories

Start date: Week 7
Due date: Week 8

You will be required to write up in your laboratory book a detailed account of your experiments. You will have to submit a report where you compare the results from your analytical solutions and the LTspice simulation, and answer given questions.

Students will be marked individually.

Assessment 2: Power electronics laboratories

Start date: Week 9
Due date: Week 10

You will be required to write up in your laboratory book a detailed account of your experiments. You will have to submit a report with answers to given questions.

Students will be marked individually.

Assessment 3: Mid-term exam

Assessment length: 1 hr + 30 mins (uploading submission)
Due date: Week 7

The mid-term exam in this course is a 1-hour written examination. Questions will be drawn from the topics of the course presented in weeks 1 to 5, unless specifically indicated otherwise by the lecturer. It will contribute 20% to the overall mark. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion.

Assessment 4: Final exam

Assessment length: 2 hrs + 30 mins (uploading submission for online final exam)
Due date: TBA

The final examination in this course is a standard 2-hour written examination, comprising of four or five compulsory questions. It is worth 50% of the overall mark. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. 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.

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: 12 September - 16 September	Lecture	AC circuit calculations – voltage, current, phasors, impedance, sources, loads, RLC passives
Week 2: 19 September - 23 September	Lecture	Single-phase power– real and reactive power, power factor. Transformers
	Workshop	Single-phase AC circuits (Tutorial 1)
Week 3: 26 September - 30 September	Lecture	Three-phase circuits – phase & line quantities, power in balanced 3-phase systems.
Week 4: 3 October - 7 October	Lecture	PV energy conversion systems. Principles of power electronic converters.
	Workshop	Three-phase AC circuits and transformers (Tutorial 2)
Week 5: 10 October - 14 October	Lecture	Single and three-phase power electronic converters.
Week 6: 17 October - 21 October	Blended	Flexibility week.
Week 7: 24 October - 28 October	Lecture	Principles of energy conversion, wind energy conversion systems. EMF and torque calculations.
	Assessment	Mid-term exam
	Laboratory	Introduction of LTspice (Lab 1)
Week 8: 31 October - 4 November	Lecture	AC machines.
	Workshop	Power electronic converters and PV systems (Tutorial 3)
	Laboratory	AC calculations (Lab 1)
Week 9: 7 November - 11 November	Lecture	Structure of power systems. Introduction to AC transmission and distribution infrastructure.
	Laboratory	DC-DC Step-Down (Buck) Converter (Lab 2)

Week 10: 14 November - 18 November	Lecture	Relationship between demand and generation (frequency and load control). Relationship between voltage and reactive power.
	Workshop	Electromechanical machines, transmission, and distribution (Tutorial 4)
	Laboratory	DC-DC Step-up (Boost) Converter (Lab 3)

Resources

Prescribed Resources

On-line resources

Moodle

The course web page is hosted on the UNSW's Moodle server, which can be accessed at: https://moodle.telt.unsw.edu.au/login/index.php. All lectures, tutorial, labs, video and any other resources will be available on this page, as well as access to the student marks, discussion forums and official course announcements. It is a requirement of the course that students check this page for new announcements on a daily basis.

Microsoft (MS) Teams

The course has MS Teams for lecture, tutorial, and laboratory. The classes are **CLS-ELEC2133_T2_2022_Lecture, CLS-ELEC2133_T2_2022_Tutorial** and **CLS-ELEC2133_T2_2022_Lab** respectively. All lectures and tutorials videos are recorded and made available on MS Teams for students to watch them at any time and place of their convenience. The classes on MS Teams will also be used to make announcements and students are required to check messages on daily basis.

Recommended Resources

Recommended books:

- C. K. Alexander and M. N. O. Sadiku, Fundamentals of Electric Circuits, 6th ed., New York, NY, USA: McGraw-Hill, 2017.
- Ned Mohan, Tore M. Undeland, William P. Robbins, 'Power Electronics: Converters, Applications, and De-sign', Wiley, 3rd Edition, 2002.
- Turan Gönen, 'Electric Power Distribution Engineering', 3rd Edition, CRC Press, 2014.
- William H. Kersting, 'Distribution System Modelling and Analysis', 4th Edition, CRC Press, 2017.
- Electric Drives by Ion Boldea and S. A. Nasar, CRC Press, 3rd edition, 2017.

Course Evaluation and Development

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process.

Laboratory Workshop Information

Tutorial classes

Complete worked out solutions in the forms of text will be uploaded on Moodle after the tutorial so that students can go through them at their time of convenience. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation.

Laboratory program

Regular laboratory sessions will run from **week 7 to week 10** every week.

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course must take the labs.

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

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

Synergies in Sound 2016

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	