Photovoltaic and Renewable Energy Engineering

Course Outline

Term 1 2021

SOLA9001

PHOTOVOLTAICS

Contents

1. Staff contact details

Contact details and consultation times for course convenor
Name: A/Prof Santosh Shrestha
Office location: TETB 243
Tel: (02) 9385 7267
Email: s.shrestha@unsw.edu.au

Consultations: Wednesday 10 am - 11 am, Thursday 4 pm – 5 pm, and drop-in sessions.

Contact details and consultation times for additional lecturers/demonstrators/lab staff
Additional lecturer:
Name: Dr Fiacre Rougieux
Email: fiacre.rougieux@unsw.edu.au

Demonstrators/lab staff:
Name: Lamees Yaqoob Mubarak Al Kiyumi
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Name: Akasha Kaleem
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Please see the course Moodle.

2. Important links

- Moodle
- Health and Safety
- Student Resources
- UNSW Timetable
- UNSW Handbook
- Engineering Student Support Services Centre
- UNSW Photovoltaic and Renewable Energy Engineering

3. Course details

Credit points
This is a 6 unit-of-credit (UoC) course and involves 5 hours per week (h/w) of face-to-face contact.

The normal workload expectations of a student are approximately 25 hours per term for each UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend about 10-15 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Contact hours

	Day	Time	Location
Lectures	Wednesday	9am - 10pm	Online
	Thursday	2pm - 4pm	Online
Tutorial	Wednesday	12pm – 2pm	Online
(Wk 1-4, 8-10)	Thursday	12pm – 2pm	Ainsworth G01 (K-J17-G01)
Lab	Wednesday	12pm – 2pm	Online
(Wk 5, 7)	Thursday	12pm – 2pm	Tyree Energy Tech Studio LG10

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

Summary and aims of the course

This course will focus on factors important to the operation, design and construction of solar cells and PV system design. Students will learn principle of operation of solar cells, loss mechanisms and design features to improve efficiency of solar cells and modules. In addition, students are introduced to application and design of PV systems. System design is focused on stand-alone PV systems but other specific applications such as grid-connected PV systems are also discussed. Importantly, simulation and laboratory exercises are used to reinforce an understanding of modelling and characterisation of solar cells and PV modules.

The aims of the course are to:

- provide students with the fundamental information needed to understand the principles of PV system operation; and
- develop students' ability to undertake simple PV system design.

Student learning outcomes

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

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

Learning Outcome		EA Stage 1 Competencies
1.	Identify and describe the key properties of light-matter interaction that impact the performance of a photovoltaic device.	PE1.1, PE1.3, PE3.2
2.	Calculate the incident solar power on a surface understanding the contributions of orientation, tilt, location, spectral change and weather factors.	PE1.1, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2

3.	Use relevant standards and data sets for calculations of cell, module and system performance.	PE1.1, PE1.3, PE1.5, PE2.1, PE3.2
4.	Analyse and calculate power differences between photovoltaic cells, modules and arrays.	PE1.1, PE1.3, PE2.1, PE2.2, PE3.2
5.	Identify the appropriate system components and arrangements for different PV applications (e.g., grid-connect, stand-alone PV systems).	PE1.3, PE1.5, PE2.1, PE2.3, PE3.2, PE3.3
6.	Design Stand Alone PV systems and analyse system economics.	PE1.3, PE1.5, PE2.1, PE2.2, PE2.3, PE3.2, PE3.3, PE3.6

4. Teaching strategies

The teaching strategy for this course comprises a series of lectures, tutorial sessions, lab work and PV design practice. Lecture will introduce theory, worked examples and case studies. Tutorial problem sets will allow you to practice solving problems related to each topic. During some weeks, tutorials will be used to go through the problem sets for each topic (see the course schedule for details). In other weeks, lab exercises and associated assignments will allow you to develop skills related to the use of software for modeling solar cells, practical skills related to assembling and measuring the performance of photovoltaic systems and skills related to interpreting experimental results. These exercises will enhance your understanding of the operation of photovoltaic cells and systems. The course contains a significant component of self-learning through the experience gained by doing the solar cell/ system simulation using LTSpice and design of PV systems.

Each tutorial activity will be posted on Moodle during the week preceding the activity. It will have a number of learning objectives and students will work through exercises that aim to address these outcomes. Some activities require that students complete calculations, others will involve the use of simulation software and one will involve laboratory measurements.

Students can use their allocated tutorial session to ask any questions they may have about the material taught in lectures. Students are also strongly encouraged to use the Moodle discussion forums to assist their learning. Tutors will monitor the discussions and help answer posted questions.

5. Course schedule

The schedule for lectures and tutorials/labs is given below. The topics and the order are subject to change at any time.

Week	Lecture	Tutorial
1	PV systems, Stand-Alone PV systems design	Lab 0: Circuit simulation with LT Spice
2	Energy storage	Tut 1: PV systems & load assessment

3	Solar cells and modules	Lab 1: Modelling of Solar Cells
4	Solar cells and modules	Tut 2: Solar cells and modules
5	Solar resource assessment	Lab 2: Mismatch, IV and Thermal properties of PV modules
6	Q&A	
7	Solar resource assessment	Lab 2: Mismatch, IV and Thermal properties of PV modules
8	Charge controller and inverter sizing	Tut 3: Resource assessment
9	Installation, design and costing	Tut 4: PV systems and components
10	Other applications for PV (Grid-Connected PV Systems)	PV system design project presentation

6. Assessment

Assessment overview

Assessment	Group Project? (# Students per group)	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Quizzes	No	10 – 15 questions	25%	1 - 5	To be advised (TBA)	Friday Week 2, 4, 6, 8, 10 Submission via Moodle	N/A	Upon completion
Lab reports	No	10 – 15 pages	10%	1 - 4	See lab assignment brief	Lab 0: Monday Wk 2 Lab 1: Monday Wk 7 Lab 2: Friday Wk Submission via Moodle	One week after due date	Two weeks after submission
Stand Alone PV system design	Yes	5000 words	30%	1 - 6	See PV system design assignment brief	Preliminary report: Monday Wk 8 Report: Friday Wk 10 Submission via Moodle	One week after due date	Two weeks after submission
Final exam	No	2 hours	35%	1 - 6	All course content from Weeks 0-10	Exam period, date TBC	N/A	Upon release of final results

This course will include the following hurdle requirements that are closely linked to a set of learning outcomes which demonstrate that you have acquired the required skills and competencies within this discipline:

- Students must demonstrate they can design a stand-alone PV system for optimum performance and conformance to relevant Australian Standards. A minimum mark of 60% must be obtained in the Stand-Alone PV system design assignment in order to pass this subject. Failure to achieve this minimum mark will result in an unsatisfactory fail (UF) grade, regardless of the performance in the rest of the course.

The assessment scheme in this course reflects the intention to assess your learning progress through the term.

Quizzes: Regular online quizzes are designed to help with continues learning and learning enhancement. You will have to complete five quizzes (weeks 2, 4, 6, 8 and 10).

Lab reports: In some weeks (see the schedule) you will work on lab projects which are designed to give you an opportunity to apply knowledge to practical problems relating to solar cells and systems. You will need to write a report for each lab answering specific questions.

Stand Alone PV system design: The PV design assignment will give you opportunities to apply knowledge to address practical problems and present it to stakeholders. You will need to present your work to your peers and academics. You will also need to write a report.

Final Exam: The exam in this course is a standard closed-book 2 hour written examination. 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, unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses.

The assessment tasks, except for quizzes and final exam, will be provided via Moodle at least a week in advance.

Presentation

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Submission

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 30 percent (30%) mark reduction on the first day and an additional 10% per day thereafter, consistent with other SPREE courses.

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.

Work submitted after the 'deadline for absolute fail' is not 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 are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

a. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
b. Online quizzes where answers are released to students on completion, or
c. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
d. Pass/Fail assessment tasks.

Marking

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Examinations

You must be available for all quizzes, tests and examinations.

Final examinations for each course are held during the University examination periods: February for Summer Term, May for T1, August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates.

For further information on exams, please see the Exams webpage.

Calculators

You will need to provide your own calculator of a make and model approved by UNSW for the examinations. The list of approved calculators is available at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an "Approved" sticker for it from the Engineering Student Supper Services Centre prior to the examination. Calculators not bearing an "Approved" sticker will not be allowed into the examination room.

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 submitting an assessment or sitting an exam.

Please note that UNSW now has a Fit to Sit / Submit rule, which means that if you sit an exam or submit a piece of assessment, 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.

7. Expected resources for students

Reference Books
Wenham, S., Green, M., Watt, M. & Corkish, R. (2009) Applied Photovoltaics - 2nd Edition, 2009 Revision, Sydney, Australia, UNSW Centre for Photovoltaic Engineering.

Software
LTSpice: *https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html* (can be also accessed from UNSW myAccess - *https://www.myaccess.unsw.edu.au/)*

PVSYST: Software for photovoltaic Systems *http://www.pvsyst.com/*

On-line Resources

PV Education: PV Education is an online, interactive website by C.B. Honsberg and S. Bowden covering material similar to this textbook is also available at *http://www.pveducation.org/pvcdrom/*

PVWatts: *https://pvwatts.nrel.gov*

UNSW Library website: https://www.library.unsw.edu.au/
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

8. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal discussion in the final class for the course, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

In this course, recent improvements resulting from student feedback include removal of non-critical questions from lab assignments, and increasing the weigh for the PV stand-alone PV system design assignment.

9. Academic honesty and plagiarism

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.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

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) even suspension from the university. The Student Misconduct Procedures are available here:
www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

10. 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

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	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
	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
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (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