Photovoltaic and Renewable Energy Engineering

Course Outline
Term 1  2021

SOLA2540

APPLIED PHOTOVOLTAICS
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1. Staff contact details

Contact details and consultation times for course convenor
Name: A/Prof Santosh Shrestha
Office location: TEB 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
Email: l.alkiyumi@unsw.edu.au

Name: Akasha Kaleem
Email: a.kaleem@unsw.edu.au

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**

<table>
<thead>
<tr>
<th></th>
<th>Day</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lectures</strong></td>
<td>Wednesday</td>
<td>9am - 10pm</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>Thursday</td>
<td>2pm - 4pm</td>
<td>Online</td>
</tr>
<tr>
<td><strong>Tutorial</strong></td>
<td>Wednesday</td>
<td>12pm – 2pm</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>(Wk 1-4, 8-10)</td>
<td>12pm – 2pm</td>
<td>Ainsworth G01 (K-J17-G01)</td>
</tr>
<tr>
<td><strong>Lab</strong></td>
<td>Wednesday</td>
<td>12pm – 2pm</td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>(Wk 5, 7)</td>
<td>Thursday</td>
<td>Tyree Energy Tech Studio LG10</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>EA Stage 1 Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> Identify and describe the key properties of light-matter interaction that</td>
<td>PE1.1, PE1.3, PE3.2</td>
</tr>
<tr>
<td>impact the performance of a photovoltaic device.</td>
<td></td>
</tr>
<tr>
<td><strong>2.</strong> Calculate the incident solar power on a surface understanding the</td>
<td>PE1.1, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2</td>
</tr>
<tr>
<td>contributions of orientation, tilt, location, spectral change and weather factors.</td>
<td></td>
</tr>
</tbody>
</table>
3. Use relevant standards and data sets for calculations of cell, module and system performance. PE1.1, PE1.3, PE1.5, PE2.1, PE2.3

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.

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture</th>
<th>Tutorial</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PV systems, Stand-Alone PV systems design</td>
<td>Lab 0: Circuit simulation with LT Spice</td>
</tr>
<tr>
<td>2</td>
<td>Energy storage</td>
<td>Tut 1: PV systems &amp; load assessment</td>
</tr>
</tbody>
</table>
### 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

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

1. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
2. Online quizzes where answers are released to students on completion, or
3. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
4. 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](http://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

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/)

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/
PV Watts: https://pvwatts.nrel.gov

UNSW Library website: https://www.library.unsw.edu.au/

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](http://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](http://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
## Program Intended Learning Outcomes

<table>
<thead>
<tr>
<th>PE1: Knowledge and Skill Base</th>
<th>PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing</td>
</tr>
<tr>
<td></td>
<td>PE1.3 In-depth understanding of specialist bodies of knowledge</td>
</tr>
<tr>
<td></td>
<td>PE1.4 Discernment of knowledge development and research directions</td>
</tr>
<tr>
<td></td>
<td>PE1.5 Knowledge of engineering design practice</td>
</tr>
<tr>
<td></td>
<td>PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice</td>
</tr>
<tr>
<td>PE2: Engineering Application Ability</td>
<td>PE2.1 Application of established engineering methods to complex problem solving</td>
</tr>
<tr>
<td></td>
<td>PE2.2 Fluent application of engineering techniques, tools and resources</td>
</tr>
<tr>
<td></td>
<td>PE2.3 Application of systematic engineering synthesis and design processes</td>
</tr>
<tr>
<td></td>
<td>PE2.4 Application of systematic approaches to the conduct and management of engineering projects</td>
</tr>
<tr>
<td>PE3: Professional and Personal Attributes</td>
<td>PE3.1 Ethical conduct and professional accountability</td>
</tr>
<tr>
<td></td>
<td>PE3.2 Effective oral and written communication (professional and lay domains)</td>
</tr>
<tr>
<td></td>
<td>PE3.3 Creative, innovative and pro-active demeanour</td>
</tr>
<tr>
<td></td>
<td>PE3.4 Professional use and management of information</td>
</tr>
<tr>
<td></td>
<td>PE3.5 Orderly management of self, and professional conduct</td>
</tr>
<tr>
<td></td>
<td>PE3.6 Effective team membership and team leadership</td>
</tr>
</tbody>
</table>