School of Photovoltaic and Renewable Energy Engineering

SOLA2540 Applied Photovoltaics

Course Outline- Term 3, 2019

Course Staff

Course convener and lecturer: Dr. Fiacre Rougieux (fiacre.rougieux@unsw.edu.au)
Tutors/ demonstrators: Ishpreet Chawla, Geedhika Poduval and Yu Zhang

Consultations: For all enquiries about the course please contact the course convener. You are encouraged to ask the lecturer/ demonstrators in the class and/or post your question on the Moodle Discussion Board. Weekly consultation time(s) will be decided in consultation with students in Week 1.

Keeping Informed: Course material and information about the course will be posted on Moodle. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Details

Credits

This is a 6 UOC course and the expected workload is 10–12 hours per week throughout the 10-week term.

Pre-requisites and Assumed Knowledge

It is assumed that students enrolled in this course are familiar with calculus and physics at a level of PHYS1131. It is also assumed that you can competently use Microsoft Excel (or equivalent software) for data manipulation and graphing.

Following Courses

SOLA2540 is a pre-requisite for SOLA3020 PV Technology and Manufacturing, SOLA307 Solar Cells, SOLA4012 Photovoltaic Systems Design, and SOLA9101 Advanced Photovoltaics.

Relationship to Other Courses

SOLA2540 is a 2nd year course and is a core course for BE (Honours) Photovoltaic and Solar Energy (SOLAAH3707) and BE (Honours) Renewable Energy (SOLABH3707).

Context and Aims

Photovoltaic (PV) devices convert sunlight directly to electricity with low levels of greenhouse gas emissions per kWh of electricity produced. As such they have enormous potential to meet a large fraction of the demand for electricity. This course covers factors important to the design, construction and operation 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 applications and designs of PV systems.

The aims of this course are to:

- Provide students with the fundamental information needed to understand PV system operation; and
- Develop students' ability to undertake PV system designs.

Learning outcomes

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

1. Identify and describe the key properties of light-matter interaction that impact the performance of a photovoltaic device.
2. Calculate the incident solar power on a surface understanding the contributions of orientation, tilt, location, spectral change and weather factors.
3. Use relevant standards and data sets for calculations of cell, module and system performance.
4. Analyse and calculate power differences between photovoltaic cells, modules and arrays.
5. Identify the appropriate system components and arrangements for different PV applications (e.g., grid-connect, stand-alone PV systems).
6. Design Stand Alone PV systems and analyse system economics.

This course is designed to achieve the above learning outcomes which address the specific UNSW and Faculty of Engineering graduate capabilities listed in ***Appendix A***. This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix B***.

Syllabus

This course covers a wide range of materials. The first section of the course deals with the characteristics of sunlight, solar cells and modules, with an emphasis on silicon solar cells. Students first become familiar with the properties of sunlight necessary to enable them to subsequently undertake PV systems design. The course then examines cell and module interconnection and their effect on performance.

The second section of the course covers PV systems, predominantly on developing a technical understanding of PV system components and design. The focus is on stand-alone and grid-connected PV systems.

Indicative Lecture and Tutorial Schedule

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

Week	Summary of Lecture Program	Summary of Tutorial Program
1	Characteristics of Sunlight	Lab 0: Circuit simulation with microcap
2	Characteristics of Sunlight contd. Solar cell operation	Tut 1: Sunlight
3	Solar cell operation PV Cell Interconnection & Module Fabrication	Tut 2: Solar cell operation
4	PV Cell Interconnection & Module Fabrication	Lab 1: Modelling Solar Cells

5	PV system components, Energy Storage	Tut 3: PV Cell Interconnection & Module Fabrication
6	Stand-Alone PV Systems	Lab 2: Mismatch effects, IV measurements and thermal properties of PV modules
7	Stand-Alone PV Systems	Tut 4: PV Systems system components and storage
8	Grid-Connected PV Systems	Lab 2: Mismatch effects, IV measurements and thermal properties of PV modules
9	Grid-Connected PV Systems	Tut 5: Stand-Alone and Grid-Connected PV System
10	Project presentation	Project presentation
11	(Monday) TBA	

Contact Hours

The course consists of lectures and tutorials each week as listed below.

	Day	**Time**	**Location**
Lecture	Monday	11:00 - 13:00	Mathews 103^
	Wednesday	13:00 - 14:00	Mathews 103
Tutorial	Thursday	10:00 - 12:00	Law G17*
	Thursday	12:00 - 14:00	Gold G03*
	Friday	13:00 - 15:00	SEB B25*

^ Monday Wk 4 is a public holiday. Substitute class will be held on Tuesday 13:00-14:00 in Wk 11.
*In Wk 4, 6 and 8 tutorial classes will be held in Tyree Energy Technology LG09.

Assessment

Assessment	**Percentage of total Mark**	**Date Due**
Topic quizzes, mid-term test	25%	Wk 2-10
Lab reports	10%	Wk 7, 9
PV system design	25%	Wk 10,11
Final Exam	40%	TBA

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

Topic quizzes

Regular online quizzes are designed to help with continues learning and learning enhancement.

Lab reports

In some weeks (see the schedule) you will work on different lab projects. The laboratory projects 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. The reports must be submitted on-line via Moodle by the due date. Late reports will attract a penalty of 10% per day (including weekends). Reports submitted after results have been released will incur the maximum penalty.

Mid-term test

Mid-term test is designed to test analytical and critical thinking and general understanding of the course material. The tests will be based on the lectures and tutorials from the previous topics, and any additional materials distributed to the class prior to the tests.

PV design assignment

The PV design assignment will give you opportunities to apply knowledge to address practical problems and present it to stakeholders. Your group presentation on the allocated PV design project will be assessed according to structure, content and presentation quality. Late reports will attract a penalty of 10% per da*y* (including weekends). Reports submitted after results have been released will incur the maximum penalty.

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.

Relationship of Assessment Methods to Learning Outcomes

	Learning Outcomes					
Assessment	**1**	**2**	**3**	**4**	**5**	**6**
Topic quizzes	✓	✓	✓	✓	✓	
Lab reports	✓	✓	✓	✓	✓	
Mid-term test	✓	✓	✓	✓		
PV design assignment	✓	✓	✓	✓	✓	✓
Final Exam	✓	✓	✓	✓	✓	✓

Teaching Strategies

Delivery Mode

The teaching strategy for this course comprises a series of lectures and tutorial sessions. Lecture will introduce theory, worked examples and case studies. Tutorial problem sets will allow you to practice solving problems related to each topic and develop skills needed for the tests, lab assignments and the final exam. 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 Microcap and design of PV systems.

Learning in this course

You are expected to attend all lectures and tutorials in order to maximise learning. You will need to complete some pre-work for each of your tutorial classes. In addition to the lecture notes, you will be expected to read relevant papers and texts as required. Group learning is encouraged. UNSW assumes that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Course Resources

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

Microcap: Circuit simulator. Evaluation Version can be downloaded from http://www.spectrum-soft.com/demoform.shtm.

Retscreen: Energy Project Analysis Software http://www.retscreen.net/ang/home.php

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/.

Moodle: As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Announcements concerning course information will be given in the lectures and/or on Moodle. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

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 ten to twelve hours per week studying a 6 UOC course, 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.

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.

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.

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 should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be lodged online through myUNSW within 3 working days of the assessment, not to course or school staff. For more detail, consult 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 RESOC 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. For example, PV design project assignment has been introduced. In addition, lab projects have been re-reviewed to remove non-essential components and consultation hours have been extended.

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.

Appendix A: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly address following UNSW graduate capabilities:

a) Scholars capable of independent and collaborative enquiry, rigorous in their analysis, critique and reflection, and able to innovate by applying their knowledge and skills to the solution of novel as well as routine problems;
b) Entrepreneurial leaders capable of initiating and embracing innovation and change, as well as engaging and enabling others to contribute to change;
c) Professionals capable of ethical, self- directed practice and independent lifelong learning;
d) Global citizens who are culturally adept and capable of respecting diversity and acting in a socially just and responsible way.

Appendix B: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes		Relevant LO
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	✓	LO1, LO2, LO3, LO4
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing		
	PE1.3 In-depth understanding of specialist bodies of knowledge	✓	LO1 - LO6
	PE1.4 Discernment of knowledge development and research directions		
	PE1.5 Knowledge of engineering design practice	✓	LO2, LO3, LO5, LO6
	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	✓	LO2 - LO6
	PE2.2 Fluent application of engineering techniques, tools and resources	✓	LO2, LO4, LO6
	PE2.3 Application of systematic engineering synthesis and design processes	✓	LO5, LO6
	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)	✓	LO1 - LO6
	PE3.3 Creative, innovative and pro-active demeanour	✓	LO6
	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	✓	LO6