Course Outline

School of Photovoltaic and Renewable Energy Engineering

Applied Photovoltaics
SOLA2540/ SOLA9001

Session 2, 2014

Table of Contents

1. Staff Contact Details

Course Co-ordinator and Lecturer:
Dr Santosh Shrestha
Room 225, Tyree Energy Technologies Building
Phone: 9385 7267
Email: s.shrestha@unsw.edu.au
Consultation Hours: MON 16:00-17:00 & TUE 16:00-17:00

Demonstrators:
Vincent Allen v.allen@unsw.edu.au
Terry Yang terry.yang@unsw.edu.au
Hongze Xia h.xia@unsw.edu.au

2. Course Description

Units of Credit: 6

Course Context and Description

Photovoltaic devices convert sunlight directly to electricity with no moving parts and 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 in the coming decades, given present global concerns regarding Global Warming due to carbon dioxide emissions from conventional electricity generation from fossil fuels. At present more widespread use of photovoltaics (PV) is constrained by the high initial cost of PV systems. However, this cost continues to fall year by year and the solar resource is one of the few renewable energy sources that is sufficiently available in most parts of the world to meet a significant fraction of electricity demand.

This course covers a wide range of material. 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 system design. As photovoltaic devices are predominantly semiconductor devices, students then learn about the properties of semiconductors and in particular the formation of p-n junctions. The behaviour of solar cells as individual devices, cell properties, efficiency losses (both optical and electrical) and the design of solar cells are then studied. Once individual cells have been studied the course examines PV cell interconnection and the fabrication of PV modules.

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 PV systems. A few specific applications are studied in more detail, including Remote Area Power Supply systems and grid-connected PV systems.

Aim of the course

The aims of this course are to:

- provide engineers with the fundamental information needed to understand the principles of PV system operation; and
- identify appropriate applications and to undertake simple PV system design.

Assumed Knowledge

It is assumed that students enrolled in this course are familiar with calculus and physics at a level of PHYS1131.

Learning Objectives

At the end of this course, students will be able to:

- Calculate the position of the sun and the incident solar irradiation on a plane;
- Explain principles of solar cell operation;
- Describe module loss mechanisms and solar cell design;
- Calculate physical and electrical parameters of solar cells and the impact of loss mechanisms;

- Discuss common applications for photovoltaic systems;
- Design simple PV systems.

Graduate Attributes

This course will assist students in their development of the following UNSW Engineering graduate attributes (www.eng.unsw.edu.au):

- An in-depth engagement with the relevant disciplinary knowledge in its inter-disciplinary context.
- The capacity for analytical and critical thinking and for creative problem solving.
- Information literacy - the skills to appropriately locate, evaluate and use relevant information.
- The skills required for collaborative and multidisciplinary work.
- The skills of effective communication.

Developed Competencies

The Engineers Australia policy on Accreditation of Professional Engineering programs requires that all programs ensure that their engineering graduates develop Stage 1 elements of competency (see www.engineersaustralia.org.au). Listed below are the activities in this course that will help students to achieve at least some of these elements of competency. Note: that not all elements of competency are relevant to each course.

Professional Engineering Stage 1 Elements of Competencies	**Activities used to develop competency**
1. Knowledge and Skill Base	
1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.	Lectures on characteristics of sunlight, p-n junctions, behaviour of solar cells.
1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline.	Lectures on solar cell properties & design, cell interconnection, module fabrication and PV applications.
1.5 Knowledge of contextual factors impacting the engineering discipline.	Materials on greenhouse effect and carbon dioxide emission.
2. Engineering Application Ability	
2.2 Fluent application of engineering techniques, tools and resources.	Lab projects on solar cell modeling and PV systems.
2.3 Application of systematic engineering synthesis and design processes.	Stand Alone PV system design.
3. Professional and Personal Attributes	
3.2 Effective oral and written communication in professional and lay domains.	Lab reports which communicate modelling and design of solar cells and PV systems.
3.3 Creative, innovative and pro-active demeanour.	Lectures on solar cell designs and high efficiency solar cells.
3.6 Effective team membership and team leadership.	Assignments, which require working in a group and effective communication among team members.

3. Assessment

The assessment of the course consists of mid-term test, three lab reports and a final examination. The mid-term test is used to encourage students to actively engage in the course throughout the semester. The test will be based on the lectures and tutorials from the previous topics, and any additional materials distributed to the class prior to the test. The laboratory projects are designed to give you an opportunity to apply knowledge to practical problems relating to each topic including:

- measurement and analysis of experimental data from PV systems, and
- modelling PV modules using software and interpreting the results.

Assessment weightings and dates of tests and lab assignment due dates are as follows:

Assessment task	Length	Weight	Due date
Mid-term Test	50 min	15%	Wk 8
Lab report 1		10%	Wk 7
Lab report 2		10%	Wk 9
Lab report 3		5%	Wk 11
Assignment		15%	Wk 13
Final exam	3 hrs	45%	TBA

Note:

- Details of test and assignment tasks will be provided via Moodle.
- There will be additional assignment questions for postgraduate students.
- If necessary, assessment marks may be scaled.

Submission of assessment tasks

Both paper and electronic copy of assignments are to be submitted. Please submit the paper copy of your report to the SPREE assignment box on the first floor of Tyree Technology Building (next to the reception desk) and electronic copy via Moodle. Detail instructions including due dates will be provided in the assignment. Please note that penalties (see Section 9) will apply to the late submission.

4. 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	Date	Lecture Topic	Tutorial/Lab
1	28 Jul	Introduction/ Characteristics of Sunlight	
2	4 Aug	Behaviour of Solar Cells	Tutorial 1
3	11 Aug	Cell Properties and Design	Tutorial 2
4	18 Aug	PV Cell Interconnection & Module Fabrication	Lab 1- Modelling Solar Cells
5	25 Aug	PV Cell Interconnection & Module Fabrication	Lab 1- Modelling Solar Cells (contd.)
6	1 Sep	Stand-Alone PV System components	Tutorial 3 (**Lab 1 Due**)
7	8 Sep	Stand-Alone PV Systems Design	Lab 2A- PV Systems
8	15 Sep	Mid-Term test/ Remote Area Power Supply Systems	Lab 2B- PV Systems (Contd.)
9	22 Sep	Grid-Connected PV Systems	Tutorial 4 (**Lab 2 Due**)
Mid Term Break (28 Sep – 6 Oct)			
10	6 Oct	Public holiday	Lab 3- Directly Coupled PV System
11	13 Oct	Advanced PV concepts	Tutorial 5 (**Lab 3 Due**)
12	20 Oct	Review	Review
13	27 Oct		Presentation

5. Delivery of the Course

This course comprises four hours of formal contact per week. The timing and rooms are given below.

	Day	Time	Location
Lectures	Monday	14:00 – 16:00	ChemicalSc M17 (K-F10-M17)
Labs/Tutorials	Tuesday	09:00 - 11:00	Australian School Business 207 (K-E12-207)
	Tuesday	15:00 - 17:00	Australian School Business 118 (K-E12-118)
	Wednesday	09:00 – 11:00	Australian School Business 219 (K-E12-219)
	Wednesday	14:00 – 16:00	Australian School Business 130 (K-E12-130)

Note: Location of the labs will be notified.

Two-hour lecture per week 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.

6. Resources

Recommended Text

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

An interactive website by C.B. Honsberg and S. Bowden covering material similar to this textbook is also available at http://www.pveducation.org/pvcdrom/.

Software

Microcap 11 - http://www.spectrum-soft.com/index.shtm (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/

Moodle will be used to post:

- important announcements
- course materials (lecture slides, tutorial problem sets and worked solutions)
- laboratory assignment briefs & resources
- marks for assessable work

The discussion board in Moodle is your primary mode of communication in relation to the course. It may be used to ask questions or make comments relating to the lectures, problem sets, laboratory assignments or the use of simulation software. Although lecturers and demonstrators will check the discussion board periodically, other students are encouraged to respond to questions. If you do not have your question resolved through the discussion and wish to ask questions of, or obtain feedback from lecturers or tutors, you should bring questions or issues to labs or tutorials. For private or urgent matters only, please use the contact details provided above.

Assistance with Academic Skills

SPREE writing and presentation guide (www.pv.unsw.edu.au/documents/WritingGuide2006.pdf) provides for guidance in relation to report writing, presentations, referencing, note taking and time management.

The UNSW Learning Centre website (www.lc.unsw.edu.au) also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- Writing;
- Correct referencing practices;
- Paraphrasing, summarising;
- Note taking;
- Time management;
- Appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance may be available on request from The Learning Centre, if an appointment is made well in advance.

7. Course Evaluation and Development

At the end of the course, you will be asked to complete evaluation forms using the UNSW's Course and Teaching Evaluation and Improvement (CATEI) Process. Your feedback is much appreciated and is taken very seriously. Continual improvements are made to the course based in part on such feedback. For example, since last year Lab 1 project has been extended from one week to two weeks.

8. Plagiarism

Plagiarism is the presentation of the thoughts or work of another as one's own.*

Examples include:

- Direct duplication of the thoughts or work of another, including by copying work, or knowingly permitting it to be copied. This includes copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement
- Paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- Piecing together sections of the work of others into a new whole;
- Presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and,
- Claiming credit for a proportion of work contributed to a group assessment item that is greater than that actually contributed.†

Submitting an assessment item that has already been submitted for academic credit elsewhere may also be considered plagiarism.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism.

Students are reminded of their Rights and Responsibilities in respect of plagiarism, as set out in the University Undergraduate and Postgraduate Handbooks, and are encouraged to seek advice from academic staff whenever necessary to ensure they avoid plagiarism in all its forms.

The Learning Centre website (www.lc.unsw.edu.au/plagiarism) is the central University online resource for staff and student information on plagiarism and academic honesty. The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Students 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 items.

* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle.

† Adapted with kind permission from the University of Melbourne.

9. Other Information

Special Consideration for Illness or Misadventure

If you are unable to submit a piece of assessment on time, or to participate fully in laboratory sessions, due to illness or some other event which was beyond your control, you must follow the UNSW procedures for seeking special consideration. Details of these can be found at https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

Please be aware that requests for special consideration need to be submitted to UNSW Student Central as soon as is practicable after the problem occurs and within three working days of the due date of the relevant assessment task.

Penalties for Late Submission of Work

Where a student submits a piece of assessment late, and a request for special consideration has not been approved, the student will be penalised by a deduction of marks.

Late written work will be penalized by 25% (of the value of the assessment task) for the first day late and an additional 5% per day up to a maximum of 100%. Once solutions are provided for the assessment tasks the maximum penalty will apply. Requests for special consideration should be submitted through UNSW Student Central. An extension of time may only be granted under exceptional circumstances beyond the student's control.

Disability Support

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, with the Equity and Disability Officer in the school office (9385 7993) or with the Equity Officer (Disability) in the Equity and Disability Unit (EADU) 9385 4734. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

Further information is available at http://www.studentequity.unsw.edu.au/.

10. Student Responsibilities and Class Policies

- Attendance and Attention. Responsibility for learning rests primarily with the student. Lecture slide handouts do not necessarily contain sufficient detail to complete the assessment tasks and prepare for the exam, while tutorials and lab classes often cover different material to that covered in lectures. It is therefore recommended that you aim to attend all the lectures, tutorials and labs and take notes where appropriate, avail yourself of the course resources, complete your assessment tasks on time and to the best of your ability, and to be fully aware of the course syllabus and any announcements or changes to the syllabus.
- All assignments and tests are for individual effort and individual assessment except where explicitly specified. You are expected to be aware of, and you will be subject to, the UNSW and School policies that cover plagiarism of written work. Students will be penalised for plagiarism in tests, lab assignments and exams.
- Students are expected not to distract their colleagues during classes.