UNSW AUSTRALIA

Course Outline

Session 1, 2015

Never Stand Still | Faculty of Engineering | School of Mechanical and Manufacturing Engineering

MECH9720

SOLAR THERMAL ENERGY DESIGN

CONTENTS

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COURSE OUTLINE

1. CONTACT DETAILS

Primary contact for course questions

1) Online discussion board (Moodle)
2) Email (all course inquires): unsw.mech.9720@gmail.com

Course Convenor

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2. COURSE DETAILS

Units of credit

This is a 6 unit-of-credit (UoC) course, which includes 3-4 hours per week of face-to-face contact (depending on the laboratory schedule). Some students spend much more, but you should aim to spend not less than 10 h/w on coursework for this 6 UoC course. Time available is based on a total of 40 hours per week spent on 24 units of credit (including both in-class and out-of-class time) for an effective 15 weeks (thirteen weeks of session, plus stuvac, plus one effective exam week). The time

budget above indicates the time expected to be spent on various course activities for an average student aiming for a credit grade. Various factors, such as ability, target grade, etc., will influence the time needed in your case.

Aims of the course

This course focusses on the terminology, principles and methods used in solar thermal engineering. Engineering heat transfer analysis will be used to solve much of the quantitative components of the course (Mech3601). This course aims to train students who intend to take more classes, or pursue a career, in renewable energy and/or the thermal sciences.

The course deliberately stays away from photovoltaics and focuses on the conversion of solar energy into heat. This heat can then be used for a wide variety of applications ranging from domestic solar water heating at 70^{o}C to processing minerals (e.g. Aluminium) at >1000^{o}C.

In this course you will cover the following topics: solar radiation theory and measurements, solar thermal collector systems and materials selection, thermal analysis of solar collectors and systems and system testing.

Lecture periods

This course generally involves a 2 hour lecture and a 1 hour problem solving session, but small group laboratory solar thermal testing (times TBD) will be scheduled for weeks 4-9.

> Lectures: Fridays 12:00-14:00 // Electrical Engineering Building G24 (K-G17-G24)
> Problem solving sessions: Fridays 14:00-15:00 (Starts Week 2) // Multiple rooms (Check Your Enrollment)

Expectations of the students

This course involves 3-4 hours per week of face-to-face contact, and it is expected that you will put in, on average, an additional 6-7 hours per week of your own time (including stuvac and exams). Note that the laboratory sections will be scheduled outside of the designated class time. The 6-7 hours of your own time should be spent in revising the lecture material and further reading, completing the set assignment and problem solving session problems, and revising and learning for the examinations.

Student learning outcomes

The objectives of the course are to:

- Be able to use engineering terminology associated with solar thermal energy systems (information literacy)
- Obtain a basic understanding of how to measure and calculate salient radiation properties and data that will allow you to solve solar thermal energy design problems (independent enquiry)
- Understand how to conduct efficiency tests as per the AS/NZ standard (independent enquiry)
- Learn how to use solar thermal energy systems software tools (digital literacy)
- Apply the above to solar thermal *systems* from an engineering perspective
- Be familiar with the terminology associated with solar thermal energy

If these are realized, with respect to solar thermal technology, you will be:

- capable of independent, self-directed practice
- capable of lifelong learning
- capable of operating within the agreed Code of Practice

Graduate attributes

UNSW's graduate attributes are shown at:
https://my.unsw.edu.au/student/atoz/GraduateAttributes.html

UNSW aspires to develop graduates who are rigorous scholars, capable of leadership and professional practice in a global community. The university has, thus, articulated the following Graduate Attributes as desired learning outcomes for ALL UNSW students.

UNSW graduates will be

1. Scholars who are:
   - (a) understanding of their discipline in its interdisciplinary context ✓
   - (b) capable of independent and collaborative enquiry ✓
   - (c) rigorous in their analysis, critique, and reflection
   - (d) able to apply their knowledge and skills to solving problems ✓
   - (e) ethical practitioners
   - (f) capable of effective communication ✓
   - (g) information literate ✓
   - (h) digitally literate ✓

2. Leaders who are:
   - (a) enterprising, innovative and creative

(b) capable of initiating as well as embracing change
(c) collaborative team workers

3. Professionals who are:
   (a) capable of independent, self-directed practice ✓
   (b) capable of lifelong learning ✓
   (c) capable of operating within an agreed Code of Practice ✓

4. Global Citizens who are:
   (a) capable of applying their discipline in local, national and international contexts
   (b) culturally aware and capable of respecting diversity and acting in socially just/responsible ways
   (c) capable of environmental responsibility

✓ = Developed in this course

In this course, you will be encouraged to develop the noted graduate attributes by undertaking the selected activities and knowledge content. These attributes will be assessed within the prescribed assessment tasks, as shown in the assessment table on Page 6.

You will be supported in developing the above attributes through:

i. the design of academic programs;
ii. course planning and documentation;
iii. learning and teaching strategies; and
iv. assessment strategies.

3. RATIONALE FOR INCLUSION OF CONTENT AND TEACHING APPROACH

This course is included to give you an understanding of how solar thermal systems are designed, constructed and operated by showing you some examples of each, and to give you the general tools necessary to analyse their thermal and fluid flow conditions.

The content reflects the experience of the lecturer in research and development of these systems and some of the practical examples drawn from that experience are used throughout the lectures and problem solving sessions.

Effective learning is supported when you are actively engaged in the learning process and by a climate of enquiry, and these are both an integral part of the lectures and problem solving sessions.

You become more engaged in the learning process if you can see the relevance of your studies to professional, disciplinary and/or personal contexts, and the relevance is shown in the lectures and assignments by way of examples drawn from industry.

Dialogue is encouraged between you, others in the class and the lecturer. Diversity of experiences is acknowledged, as some students in each class have prior experience. Your experiences are drawn on to illustrate various aspects, and this helps to increase motivation and engagement.

It is expected that assignments will be marked and handed back within the two weeks following submission. You will have feedback and discussion while fresh in your mind to improve the learning experience.

4. TEACHING AND LEARNING STRATEGIES

The teaching strategies that will be used include:

- Presentation of the material in lectures and discussions so that the students know how to approach complex engineering calculations required in industry.
- To present a wealth of real-world engineering examples to give students a feel for how fluid mechanics is applied in engineering practice
- A research essay into a topic of the students choice
- The use of in-house and commercial software to solve problems

Suggested approaches to learning in the course

Suggested approaches to learning in this course include:

- Careful reading, discussion and understanding of the material presented in lectures.
- Additional reading on and about the material presented in lectures to broaden the knowledge base.
- Paying attention throughout the problem solving sessions, and asking questions when anything is not understood.
- Conscientiously working through ALL the problem solving session problems.
- Learning the lecture material in preparation for examinations.
- Perusal of the past examination paper(s) in this course to ensure that you know how to answer typical questions.

5. ASSESSMENT

Overall rationale for assessment components and their association with course objectives

You are assessed by way of a mid-session test, laboratory work, weekly problem solving session questions and quizzes and an examination which involve both calculations and descriptive material. The postgraduate students will have an additional assignment of a report, written in conference paper format. These assessments test your grasp of the principals involved in the course, your progress in the learning objectives mentioned above, and are typical of the calculations you will be expected to perform as graduate mechanical engineers.

i)	Weekly Problem solving session Questions	0%	Due Weekly
ii)	Online Quizzes	10%	Due Weekly
iii)	Test	20%	Week 6
iv)	'Conference' Paper (PG only)	(10%)	Due Week 10
v)	Individual Lab Report	20%	Due Week 13
vi)	Final Exam UG / (PG)	50% / (40%)	TBD

In order to pass the course, you must achieve an overall mark of at least 50%.

Assignments

Assignments and templates will be all available on Moodle from the beginning of the course. If deemed necessary, email clarifications and hints will be sent through Moodle, so please ensure you check the email designated by Moodle periodically during the session.

Presentation

A standard specification is available from the School office to aid presentation of your assignments (in all courses). All submissions should have a standard School cover sheet. All submissions are expected to be neat and clearly set out. All calculations should be shown as, in the event of incorrect answers, marks are awarded for method and understanding.

The preferred set-out of any numerical calculation is similar to the following:

$\Delta = \rho\nabla$	(Equation in symbols)
$= 1.025 \times 200$	(Numbers substituted)
$= 205$ t	(Answer with units)

Submission

Although there is no official mark for problem solving session questions, student wanting feedback on their solutions can turn them in at the start of the problem solving session session in the week following when they were assigned. Late submissions will not receive feedback.

Online quizzes are due and set to 'close' electronically at the beginning of lecture each week. No late quizzes are allowed. In special consideration cases a 'make-up' quiz might be issued.

For all other assignments, late submission of assignments attracts a penalty of ten percent per *day*, unless prior dispensation has been given; i.e. see me before the due date to avoid penalty. It is always worth submitting assignments – in the event of difficulty making a final grade (either to pass or higher), the penalties for late submission may be removed.

Criteria

The following criteria will be used to grade assignments:

For reports:

- Identification of key facts and the integration of those facts in a logical development.
- Clarity of communication—this includes development of a clear and orderly structure and the highlighting of core arguments.
- Sentences in clear and plain English—this includes correct grammar, spelling and punctuation.
- Correct referencing in accordance with the prescribed citation and style guide.

For numerical calculations:

- Accuracy of numerical answers.
- All working shown (see *Presentation* above).
- Use of diagrams, where appropriate, to support or illustrate the calculations.
- Use of graphs, were appropriate, to support or illustrate the calculations.
- Use of tables, where appropriate, to support or shorten the calculations.
- Neatness.

*Detailed marking rubrics will be made available on select assignments.

Final exam notes

There will one three-hour examination at the end of the semester, covering all material covered during the whole semester. Please check my.unsw.edu.au for your Final Exam Timetable.

Calculators

You will need to provide your own calculator, of a make and model approved by UNSW, for the examination. The list of approved calculators is shown at: https://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 "UNSW Approved" label for it from the School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an "UNSW Approved" sticker will not be allowed into the examination room.

Special Consideration and Supplementary Assessment

For details of applying for special consideration and conditions for the award of supplementary assessment, see *Administrative Matters*, available from the School website.

6. Academic Honesty and Plagiarism

Plagiarism is using the words or ideas of others and presenting them 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 booklet which provides essential information for avoiding plagiarism: https://my.unsw.edu.au/student/academiclife/Plagiarism.pdf

There is a range of resources to support students to avoid 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. Information is available on the dedicated website Plagiarism and Academic Integrity website: http://www.lc.unsw.edu.au/plagiarism/index.html

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. This course is for third year, fourth year, and postgraduate students, so it is taken very seriously and instances WILL be investigated. Each MECH9720 course in recent years has had infractions -- do NOT let it be you. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in a honours thesis) even suspension from the university. The Student Misconduct Procedures are available here:
http://www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is presented in a School handout, *Administrative Matters for All Courses*, available on the School website.

7. COURSE SCHEDULE

Week	Activities
1 6/March	Intro to solar thermal collectors. Solar radiation characteristics, extra-terrestrial radiation, air mass. Spectral distribution of extra-terrestrial and terrestrial radiation.
2 13/March	Overview of solar thermal technology. Solar collector efficiency, solar thermal power systems. *Problem solving session.*
3 20/March	Solar radiation measurement, data sources. Calculation of global, beam and diffuse radiation on surfaces. *Problem solving session.*
4 27/March	Diffuse radiation models. Calculation of hourly and daily irradiation on inclined surfaces. Clear sky radiation. *Problem solving session.*
5 3/April	No Lecture, A NSW Public Holiday

10/April	Mid-Semester Break: No lecture, *no problem solving session, no laboratory*
6 17/April	Heat transfer in flat plate solar collectors. Solar collector test methods and standards. Selective surfaces, integrated radiation properties. *Problem solving session, laboratory*
7 24/April	**Test *(laboratory held, but no problem solving session)***
8 1/May	Test review. Solar and long wave transmission of collector covers, Thermal analysis of flat plate solar collectors. *Problem solving session, laboratory*
9 8/May	Thermal analysis of collectors, solar collector efficiency factor. *Problem solving session, (laboratory if needed)*
10 15/May	Solar collector design sensitivity analysis. Analysis of the long term/system performance. Use of program SCAED. *Problem solving session.*
11 22/May	Characteristics of concentrating collectors and evacuated tubes. System sizing and performance. *Problem solving session.*
12 29/May	Vast Solar CSP - High temperature solar thermal systems and electricity generation. *Problem solving session.*
13 5/June	*[Make-up Lecture for NSW Holiday]* Effect of collector loop heat exchanger pipe losses. Storage, thermal stratification. CSP systems analysis. *Problem solving session.*
Stuvac	Review and revision. Day(s)/time(s) determined by student poll.

**The schedule shown may be subject to change at short notice*

+ Check my.unsw.edu.au for Final Exam Timetable

8. RESOURCES FOR STUDENTS

MECH9720 Class notes (cheaper than a textbook!)

Available for purchase from the Green Print Centre (Mathews Level 1, adjacent to the Post office)

Suggested Readings:

Duffie J.A. & Beckman, W.A. **Solar Engineering of Thermal Processes**, Wiley 2006

Cengal, Y.A. and Ghajar, A.J., **Heat and Mass Transfer**, McGraw Hill, 2011

Gordon J. **Solar Energy: The State-of-the-Art**. Routledge, 2001

Academic Journals: Solar Energy, J. Solar Energy Engineering, Applied Solar Energy, Renewable Energy, Renewable and Sustainable Energy Reviews.

Additional materials provided on the Moodle Site

This course has a website on UNSW Moodle which includes:

- copies of assignments (as they are issued, in case you missed the hand-out in class);
- lecture notes
- solutions to selected problems
- a discussion forum
- links to solar resources and other supplementary information

The discussion forum is intended for you to use with other students enrolled in this course. The course convenor and demonstrators will occasionally look at the forum, monitor the language used and take note of any frequently-asked questions, but may not respond to every question on the forum. If you want help from the convenor then direct contact through unsw.mech.9720@gmail.com or an office visit is preferred.

Recommended Internet sites

There are many websites giving lectures, papers and data on solar technology. Try searching for “solar thermal”, "solar hot water", "CSP", etc. YouTube has many entertaining (and sometimes very informative) videos related to solar thermal energy. Some examples will be given during lecture.

Other Resources

If you wish to explore any of the lecture topics in more depth, then other resources are available and assistance may be obtained from the UNSW Library.

9. COURSE EVALUATION AND DEVELOPMENT

Feedback on the course is gathered periodically using various means, including the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the final problem solving session 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, revised problem solving session and lecture notes will be included for students. In addition, a demonstrator will be available to support and construct liaise between course convenor and student for continual and further improvement.

10. ADMINISTRATIVE MATTERS

You are expected to have read and be familiar with *Administrative Matters*, available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

As a lab course, information on relevant Occupational Health and Safety policies and expectations: www.ohs.unsw.edu.au

General Laboratory Safety

All staff and students must observe all safety requirements in the laboratory. You must come to the laboratory dressed for work, NO LOOSE OR BAGGY CLOTHING, NO SANDALS, and NO BARE FEET. Before beginning any experiment you will be required to do the 'Solar Lab' safety induction which requires you to inspect all equipment and the surroundings on the solar lab for potential hazards. While using laboratory equipment keep alert for any developing hazard, other students working, any unusual noise, vibration, unusual data trends, etc.

Dr. Robert A. Taylor
January 2015