Course outline

Semester 1 2017

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

MECH9720

SOLAR THERMAL ENERGY DESIGN

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Dr Robert A Taylor
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*Consultations available upon email request

2. Course details

Credit Points

This is a 6 unit-of-credit (UoC) course, and involves ***3*** hours per week (h/w) of face-to-face contact.

The UNSW website states “The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week.”

This means that you should aim to spend about 9 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	Tuesday	15:00 - 17:00	CLB 8 (K-E19-105)
(Web)	Any	Any	Moodle
Demonstrations	Tuesday **OR**	17:00 - 18:00	Various locations, check your enrolment
	Wednesday	17:00 - 18:00	Various locations, check your enrolment
Laboratory	After Week 3	1 hour session, times TBD	Lvl 6, J17, R01

Summary of the course

Solar thermal energy is created when radiation from the sun is converted to heat energy (directly) or into electrical energy (indirectly) for applications in residential, industry, and commercial sectors. This course will give you an engineering perspective of how solar thermal technology is designed, constructed, and operated. The first section of the course deals with the characteristics of sunlight, along with some methods of analysis and measurement of solar radiation. The second section of the course covers the working principles of solar thermal technology (low and high tech) and gives you the general tools necessary to analyse heat and mass transfer within these devices. In the final section of the course, we will cover how these technologies can be integrated into systems including control, circulation, and storage.

The content reflects the experience of the lecturer, guests, and demonstrators in the fundamentals and research and design these systems, experience which is presented throughout the lectures and tutorials.

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 instead on the conversion of solar energy into **heat**. This heat can then be used for a wide variety of applications ranging from pool heating at ~30 ^{o}C to processing minerals (e.g. Aluminium) at >700 ^{o}C.

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

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, such as the incident solar irradiation on a plane, that will allow you to solve solar thermal energy design problems (independent enquiry)
- Understand how to conduct solar collectors 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

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

This course is designed to address the below learning outcomes 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.	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	PE1.1
2.	Be able to use engineering terminology associated with solar thermal energy systems	PE1.2, PE1.3
3.	Understand and be able to use the terminology associated with solar thermal energy to create a professional report.	PE3.1, PE3.5
4.	Apply the above to solar thermal systems from an engineering perspective	PE2.1

3. Teaching 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 and heat transfer are 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 tutorials, and asking questions when anything is not understood
- Conscientiously working through ALL the tutorial 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

4. Course schedule

Week	Lecture Content (3pm-5pm, Tuesday, CLB8 and/or via Online Adaptive Tutorials)	Demonstration Content (5pm-6pm, Tues or Wed, Various Locations)
1	Overview of solar thermal technology. Solar collector efficiency, solar thermal power systems.	No demonstration
2	Intro to solar thermal collectors. Solar radiation characteristics, extra-terrestrial radiation, air mass. Spectral distribution of extra-terrestrial and terrestrial radiation.	Calculating transmission of sunlight through glass/plastic covers
3	Solar radiation measurement, data sources. Calculation of global, beam and diffuse radiation on surfaces.	Calculating absorption of sunlight by solar collectors
4	Diffuse radiation models. Calculation of hourly and daily irradiation on inclined surfaces. Clear sky radiation. *Laboratory*	Calculating beam radiation on a surface throughout the year
5	Heat transfer in flat plate solar collectors. Solar collector test methods and standards. Selective surfaces, integrated radiation properties. *Laboratory*	Analysis of tilted, rotated collectors
6	Solar and long wave transmission of collector covers, Thermal analysis of flat plate solar collectors. *Laboratory*	Comparing data to correlations
7	Project/Problem Working Session. *Laboratory*	Incidence angle modifier calculations
	Mid-Semester Break: No lecture, no tutorial, no laboratory	No demonstration
8	Thermal analysis of collectors, solar collector efficiency factor. *Laboratory (if needed)*	Collector efficiency factor calculations
9	Solar collector design sensitivity analysis. Analysis of the long term/system performance. Use of program SAM.	Analysis of the temperature drops inside a solar collector
10	Characteristics of concentrating collectors and evacuated tubes. System sizing and performance.	Calculate the impact of solar collector design changes – part 1.
11	Vast Solar CSP - High temperature solar thermal systems and electricity generation.	Calculate the impact of solar collectors design changes - part 2.

12	Effect of collector loop heat exchanger pipe losses. Storage, thermal stratification. CSP systems analysis.	Systems analysis
13	No lecture	*Assessment Discussions/ Exam preparation*
Stuvac	Review and revision. Day(s)/time(s) determined by student poll.	

5. Assessment

Assessment overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Online Quizzes	1-5 questions per week	10%	1-4	Weekly Lecture/ Demonstration Topic	Weekly, via Moodle	Upon Quiz close	After the Quiz closes
PG 'Conference' Paper [X]	8 pgs. (w/ template)	10% = PG	2 and 3	See marking rubric.	Due Week 10, via Turnitin on Moodle	Week 12	Week 12
Solar Thermal Reports (2)[Y] = SAM Design Report, Lab Report	10 multiple choice	40% = 20%+20%	1-4	See marking rubric.	Due by Week 12, via Turnitin on Moodle (2)	Stuvac	Stuvac
Final exam	2 hours	50% = UG 40% = PG	1-4	All course content from weeks 2-12 inclusive.	Exam period, date TBC	N/A	Upon release of final results

X - Topics for the PG paper must be selected by week 6 – a sign-up sheet can be found on Moodle

Y - Assessment description for the Solar Thermal Report(s) can be found on Moodle.

You are assessed by way of a mid-session test, laboratory work, weekly tutorial 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)	Online Quizzes	10%	Due Weekly
ii)	'Conference' Paper (PG only)	(10%)	Due Week 10
iii)	Solar Thermal Reports (2)	40%	Due by Week 12
iv)	Final Exam UG / (PG)	50% / (40%)	TBD

Important points on these assessments:

- Deadline for absolute fail
  - Online quizzes (i) close just before the next week's lecture time, late submissions are not accepted.
  - For assignments (ii)-(iii) a 5% per day penalty will be deducted, which calculates out to 10 days until > 50% is not possible.
- Assessments (i)-(iii) should be marked and returned within 2 weeks of the due date.
- 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

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

Although there is no official mark for tutorial questions, student wanting feedback on their solutions can turn them in at the start of the tutorial 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.

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Where an assessment task is worth less than 20% of the total course mark and you have a compelling reason for being unable to submit your work on time, you must seek approval for an extension from the course convenor ***before the due date***. Special consideration for assessment tasks of 20% or greater must be processed through student.unsw.edu.au/special-consideration.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Where there is no special consideration granted, the 'deadline for absolute fail' in the table above indicates the time after which a submitted assignment will not be marked, and will achieve a score of zero for the purpose of determining overall grade in the course.

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

This course has one 2-hour final exam. You must be available for it. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2.

Provisional Examination timetables are generally published on myUNSW in May for Semester 1 and September for Semester 2

For further information on exams, please see the Exams section on the intranet.

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 shown 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 School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an "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 the School intranet, and the information on UNSW's Special Consideration page.

6. Expected resources for students

MECH9720 Course Notes*

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

*Needed to solve tutorial problems and follow along with lecture.

Suggested Readings:

Duffie J.A. & Beckman, W.A. **Solar Engineering of Thermal Processes**, Wiley 2013 [4th edition available from https://library.unsw.edu.au in the Wiley eBooks Collection]

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

Standard I. 9806-1 (1994). Test Methods for Solar Collectors, Part.1.

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 tutors 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: http://info.library.unsw.edu.au/web/services/services.html

7. 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 online quizzes and resources (including the adaptive lecture notes new in S1 2017!), new laboratory facilities, changes to the assessments, more worked problems during lecture, and additional feedback on progress throughout the course.

8. 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: 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

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

9. Administrative matters

All students are expected to read and be familiar with School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support Services

Dr Robert A Taylor
1 February, 2017

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