UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 2 2019

MECH9720

SOLAR THERMAL ENERGY DESIGN

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: A/Prof Robert A Taylor
Office location: Ainsworth Building (J17), 402C
Tel: (02) 9385 5400
Moodle: I will endeavour to answer questions posted on the MECH 9720 Moodle 'discussion board' within 3 business days (if not already answered by other MECH 9720 students/staff)
Email: unsw.mech.9720@gmail.com (primary contact, course content issues)
Email: Robert.Taylor@unsw.edu.au (special consideration/course coordination issues)

Consultations available upon email request to the email addresses listed above.

Contact details and consultation times for additional lecturers/demonstrators/lab staff

The lead demonstrator, Osama, can be contacted at: unsw.mech.9720@gmail.com. All of the other demonstrators can be contacted via this email address as well if a question regards a specific demonstration or laboratory session (Important note: Please ask general content questions on the online discussion board Moodle, as discussed above). Additional consultations times with demonstrators will be scheduled as needed.

Please see the course Moodle.

2. Important links

- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering

3. 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 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 9 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, doing the online lessons, completing the set assignments, further reading, and revising for any examinations.

Contact hours

	Day	**Time**	**Location**
Lectures	Monday	12noon - 2pm	ChemicalSc M17 (K-F10-M17)
(Web stream)	Any	Any	Moodle
Demonstrations	Tuesday (UG)	As per your enrolment	Ainsworth 101 or 201
(1 h/w)	Wednesday (PG)	As per your enrolment	Ainsworth 101 or 201, or Old Main Building G32
Lab	TBD (sign up for a time slot)	Sunny hours (weather dependent)	Rooftop of Ainsworth (J17), Lvl 6
(1 h/term)	Friday		

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

Solar thermal energy is created when radiation from the sun is converted to heat energy (directly) or into electrical energy (indirectly via heat) for applications in the residential, industrial, 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. Lastly, 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 in the research, development, and installation of these systems, experience which is drawn upon throughout the lectures and tutorials. 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 (MECH3610).

This course should aide 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 pool heating at ~30 ^{o}C to processing minerals (e.g. Aluminium) at >700 ^{o}C.

In summary, this course will provide an engineering basis for a technical analysis of the characteristics of solar radiation and solar collectors. It will provide students with tools for conducting solar thermal collector efficiency evaluations and for the prediction of long-term performance of solar thermal systems. Thus, the course will include energy storage and system modelling via computer simulation of the performance and economic worth of solar thermal systems.

Student learning outcomes

The objectives of the course are 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 collector 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 in the energy systems fields
    - Capable of operating within the agreed Code of Practice

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:

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.	Communicate using the terminology associated with solar thermal energy to deliver a professional, technical report.	PE3.1, PE3.5
4.	Apply the above to assess the techno-economic feasibility of solar thermal systems from an engineering perspective	PE2

4. Teaching strategies

The teaching strategies that will be used include:

- Presentation of the material in lectures and online lessons
- Face-to-face and online discussions about the engineering calculations trade-offs for these technologies
- **25** Interactive lessons in Moodle
- Consideration of how engineering choices play out in real-world business examples to give students a feel for how fluid mechanics and heat transfer are applied
- Hands-on laboratory testing with concentrated and unconcentrated solar thermal collectors
- The use of freeware, in-house, and commercial software to solve solar engineering problems

Suggested approaches to learning in the 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
- Conscientiously working through ALL the online lessons and 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

5. Course schedule

Week	Topic	Location	Suggested Readings
1	Solar Thermal Overview / **3** Moodle Lessons: *Introduction to Solar Energy Systems; Non-Concentrating Solar Thermal Collectors; Concentrating Solar Thermal Collectors*	ChemicalSc M1 / Moodle	Class readings by Moodle week
2	No Face-to-Face Lecture (Queen's Birthday) **2** Moodle Lessons: *The Solar Resource; Black Bodies and Radiation*	ChemicalSc M1 / Moodle	Class readings by Moodle week
3	Solar Resources/Instrumentation / **2** Moodle Lessons: Solar Instruments and Measurements Part 1 & Part 2	ChemicalSc M1 / Moodle	Class readings by Moodle week

Week	Topic	Location	Suggested Readings
4	Diffuse/Tilted Surfaces / **2** Moodle Lessons: *Inclined Surfaces and Diffuse Radiation Models; Applications of Inclined Surfaces*	ChemicalSc M1 / Moodle	Class readings by Moodle week
5	Flat Plate Collectors / **2** Moodle Lessons: *Absorber Plates and Reflection; Collector Efficiency and Operation*	ChemicalSc M1 / Moodle Lessons	Class readings by Moodle week
6	Solar Collector Analysis I / **2** Moodle Lessons: *Solar Collector Heat Losses; Evaluating the Solar Collector Efficiency Factor*	ChemicalSc M1 / Moodle	Class readings by Moodle week
7	Solar Collector Analysis II / **2** Moodle Lessons: *Collector Stagnation Temperature, Part 1 & Part 2*	ChemicalSc M1 / Moodle	Class readings by Moodle week
8	Engineering Trade-Offs / **3** Moodle Lessons: *Flat Plate Solar Collector Optimisation; TRNSYS & Other Solar Modelling Software; Solar Hot Water Systems Part 1*	ChemicalSc M1 / Moodle	Class readings by Moodle week
9	Evacuated Tube Collectors / **2** Moodle Lesson: *Evacuated Tubes; Solar Hot Water Systems Part 2*	ChemicalSc M1 / Moodle	Class readings by Moodle week
10	Concentrated Solar Thermal Systems / **2** Moodle Lessons: *Large Scale Solar Thermal Development, Part 1 and Part 2*	ChemicalSc M1 / Moodle	Class readings by Moodle week
11	Balance of System/System Analysis / **3** Moodle Lessons: *Exam Practice Questions 1-3*	ChemicalSc M1 / Moodle	Class readings by Moodle week

6. Assessment

Assessment overview

Assessment	Group Project? (# Students per group)	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
System Advisor Model (SAM) Technical Report	Yes (3-4)	10-15 pages	25%	1 and 4	All lecture content	Friday, Midnight, Week 10 via Moodle	Wednesday, Midnight, Week 11	Two weeks after submission
Laboratory Report	Yes (up to 12)	15-20 pages	25%	1-4	Laboratory data, lectures 1-6	Friday, Midnight, Week 10 via Moodle	Wednesday, Midnight, Week 11	Two weeks after submission
ONLINE Quizzes (10)	No	Multiple choice / calculated questions (1-5 per week)	10%	1-4	Lecture material from prior week.	Due before lecture time the following week	N/A	Within 3 days of Quiz close
Final exam	No	2 hours	40%	1, 2 and 3	All course content.	Exam period, date TBC	N/A	Upon release of final results

Assignments

Assignments and marking guidelines for them will be all available on Moodle from the beginning of the course. If deemed necessary, email clarifications and hints will be provided through Moodle, so please ensure you check the online discussion boards and 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

All assessments (except the Final Exam) are to be submitted via Moodle. Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 20 percent (20%) of the maximum mark possible for that assessment item, per calendar day.

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:

a. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
b. Online quizzes where answers are released to students on completion, or
c. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
d. 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

This course has a 2-hour, comprehensive Final Exam.

You must be available for all 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

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

- MECH9720 Course Notes* (Available for purchase from the Green Print Centre (Mathews Level 1, adjacent to the Post office)
    - The course notes are needed to solve the demonstration session problems and roughly follow along with the course content.
- Online Lessons in Moodle
- Video recordings of lectures from previous years
- Problem solving videos in Moodle
- Assignment details (templates, examples, rubrics);
- Lecture notes/slides
- Worked and numeric solutions to selected problems
- A discussion board/forum in Moodle

- Links to solar resources and other supplementary information

Suggested reading

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

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

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

Additional materials provided on the Moodle site

The discussion forum in Moodle is intended for you to use with other students enrolled in this course. The course convenor and tutors will regularly read the forum, monitor the language used, and take note of any frequently-asked questions, but may not respond to every question on the forum (particularly if already addressed). If you want help from the course staff on assignments that are more specific, please contact unsw.mech.9720@gmail.com.

Moodle: https://moodle.telt.unsw.edu.au/login/index.php

Recommended internet information

There are many websites giving information in the form of lectures, papers and data on solar technologies…but not all of them are technically and/or economically viable. However, it is worth searching for terms such as “solar thermal”, "solar hot water", "CSP", etc, as you move through the course. YouTube has many entertaining videos related to solar thermal energy, examples of which will be given during lecture.

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 the PG report (additional work for PG students), the addition online quizzes (over a test), resources and feedback (including the adaptive lecture lessons), new laboratory facilities, changes to the assessments, more worked problems during lecture, and additional feedback on progress throughout the course.

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. 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

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
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Lab Access

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