UNSW AUSTRALIA

Course Outline

Semester 2 2015

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

ADVANCED THERMOFLUIDS

MECH3610

Contents

1. Staff Contact Details

Contact details and consultation times for course convenor

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Only use email as a last resort. I would prefer you see me after the lecture if you have a problem.

2. Course details

Credit Points:

This is a 6 unit-of-credit (UoC) course, and involves 6 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

Lectures	**Day**	**Time**	**Location**
	Monday	2pm - 4pm	ChemicalSc M17
	Wednesday	10am – 12noon	Ainsworth Building G03
Demonstrations	Monday	4pm – 5pm	Ainsworth Building 102

Summary of the Course

In recent years, have blended the advanced thermodynamics and heat transfer components of the old MECH3610 Advanced Thermofluids together to create a single new MECH3610 Advanced Thermofluids subject. This will enable us to tackle problems in which both disciplines are required.

Aims of the Course

The aims of the course are to obviously to advance your knowledge of thermodynamics, fluid mechanics and to introduce you to the discipline of heat transfer.

It is generally agreed that our planet is running out of fossil fuels and that the anthropocentric emissions of carbon is causing it to warm. Surely, this is not news to students studying advanced thermofluids! Either of these situations ought to provide enough motivation to students to really try to understand this subject.

I know from my connections overseas that exergy analysis and the idea of entropy generation minimization are becoming very important. I therefore want to place a greater emphasis on these ideas so that we, in this part of the world, can make a contribution.

The student outcomes listed below will give more of an idea of what I am to teach you.

Student learning outcomes

> "Give a man a fish and you feed him for a day. Teach him how to fish and you feed him for a lifetime." **Lao Tzu**

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	Understand conduction, convection and radiation modes of heat transfer, and the development of exergy analysis from the 1st and 2nd laws of thermodynamics.	PE1.1, PE2.1
2	Understand the concept of irreversibility and its relation to inefficiencies.	PE1.1, PE1.3, PE2.1
3	Analyse steady-state and sometimes transient conduction and/or convection heat transfer problems and find solutions.	PE1.1, PE1.3, PE1.4
4	Understand when to use compressible flow analysis.	PE2.1, PE2.2
5	Understand heat exchanger design and analysis, compressible flows, and combustion chemistry	PE1.1, PE1.3, PE1.5, PE2.1
6	Understand the effect of attractive (van der Waals) forces on the behaviour on gases.	PE1.1, PE1.3
7	Develop and understanding of combustion reactions and their energy release. Understand chemical equilibrium and le Chatelier's principle.	PE1.1, PE1.2, PE2.1
8	Understand the idea of radiation as a heat transfer mode.	PE1.1 PE1.3

3. Teaching strategies

General
Lectures are designed to cover the core concepts listed in the course schedule. The material is presented so as to offer an approach to the complex engineering calculations required by industry.

Demonstrations
Demonstartions enable you to test your conceptual framework on problems that are as close to reality as you are liable to get.

4. Course schedule

1.	Exergy analysis of closed and steady-state, steady-flow, open systems.
2.	Introduction to heat transfer (conduction, convection & radiation). 1^{st} law and Fourier's law combined to give the conduction equation. Extention to Cartesian, cylindrical and spherical coordinate systems. Thermal resistance. Convection equation. Composite walls and the overall heat transfer coefficient. Radiation.
3.	Heat transfer applied to the engine cycle engine analysis. Curzon-Ahlborn analysis. Introduction to statistical mechanics, the concept of entropy on the microscopic scale and the partition function.
4.	Gas mixtures and real gas analysis. Van der Waal's and Berthelot's equations. The virial coefficients, Maxwell's relations.
5.	Heat transfer from extended (finned) surfaces. Long fins, finite length fin (with insulated tip), the effect of adding heat transfer through the tip.
6.	More on statistical mechanics. Boltzmann's distribution. The partition functions for translational, rotational and vibrational modes of energy storage for calculation of specific heat capacities.
7.	Forced convection. Laminar boundary layers and heat transfer from a plate in external flow. Turbulent boundary layers. Cylinders in cross flow, etc. Analytical solutions and experimental solutions.
8.	Internal compressible flows. Convergent and convergent-divergent nozzles. Normal and oblique shock analysis.

9.	Free convection. Benard instability. The logistic equation, chaos theory and the idea of sensitive dependence on initial condition, irreversibility. Time dependent conduction.
10.	Heat exchangers. Log-mean temperature difference, the NTU method and second law analysis.
11.	Combustion. 1st law analysis, 2nd law analysis, adiabatic flame temperature and the law of mass action, chemical equilibrium and le Chatelier's principle.
12.	Radiation. Blackbody radiation. Stefan-Boltzmann law. Heat transfer between black surfaces. Real surfaces. Networks.

The schedule could be subject to change at short notice.

5. Assessment

Assessment task	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements
Assignment	TBC	15%	1, 2, 3, 4, 5, 6, 7 and 8.	Understanding of lecture material	To be announced
Laboratory	TBC	10%	3	Understanding of lecture material	Week 11.
Class Test	TBC	15%	1, 2, 3 or 6	Understanding of lecture material	Week 7
Final exam	3 hours	60%	1, 2, 3, 4, 5, 6, 7, and 8	All course content from weeks 2-12	Exam period, date TBC

The assignment will be posted on Moodle.

Assignments

Presentation

All submissions should have a standard School cover sheet.

All submissions are expected to be neat, and clearly set out. Your results are the pinnacle of all your hard work. Presenting them clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Submission

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 https://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.

Examinations

There will be three-hour examination at the end of the session, one covering all of the material covered in the course.

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods, which November for Semester 2.

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

For further information on exams, please see Administrative Matters.

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 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 “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 Administrative Matters, available on the School website and on Moodle, and the information on UNSW’s Special Consideration page.

6. Expected Resources for students

Required textbooks

- Moran, M.J., Shapiro, H.N., Boettner, D.D. & Bailey, M.B. (2011), *Fundamentals of Engineering Thermodynamics*, 7th Edition, John Wiley & Sons.
- Holman, J.P. (2010), *Heat Transfer*, *10th Edition*, McGraw Hill.
- Rogers, G.F.C. and Mayhew, Y.R., *Thermodynamic and Transport Properties of Fluids*, S.I. Units, Basil Blackwell.

Note: It is essential that you get a copy of Rogers & Mayhew as these steam tables are the ones supplied for the final exam. You must know how to read these tables.
Don't say you weren't warned!

Suggested additional readings

- Scruton, R., (2012), *Green philosophy. How to think seriously about the planet.*, Atlantic Books, London.
- Bejan, A., (1993), *Heat Transfer*, John Wiley & Sons.
- Atkins, P., (2014), *Physical Chemistry, A very short introduction*, Oxford University Press.
- von Böckh, P. & Wetzel, T., (2012), *Heat transfer. Basics and practice*., Springer.
- Bejan, A., (1996), *Entropy generation minimization. The method of thermodynamic optimization of finite-size systems and finite-time processes.,* CRC Press.
- Bejan, A., (2006), *Advanced engineering thermodynamics.*, 3rd edition, John Wiley & Sons.
- Çengel, Y.A., *Heat and Mass Transfer, A Practical Approach*, 4th edition in SI Units, McGraw Hill.
- Çengel, Y. A. and Boles, M. A. (2005), *Thermodynamics, an Engineering Approach*, 4th or later editions, McGraw Hill Higher Education.
- Sonntag and van Wylen, G. J. (1991), *Introduction to Thermodynamics Classical and Statistical*, 3rd edition, John Wiley & Sons.
- Widom, B. (2002), *Statistical mechanics, a concise introduction for chemists*, Cambridge University Press.
- Liepmann, H.W. and Roshko, A. (1957), *Elements of gasdynamics*, Dover Publications, Inc., Mineola, New York.
- Wallace, F.J. and Linning, W.A. (1970), *Basic Engineering Thermodynamics*, Pitman Paperback, Bath.
- Atkins, P.W. (2008), *Four Laws that Drive the Universe*, Oxford University Press.
- von Baeyer, H.C. (1999), *Warmth Disperses and Time Passes, the History of Heat*, (previously published as *Maxwell's Demon*), The Modern Library, New York.
- Fermi, E. (1936), *Thermodynamics*, Dover Publications, Inc. New York.
- Lemons, D.S. (2013), *A student's guide to entropy*, Cambridge University Press.

Additional materials provided on Moodle

This course has a Moodle page. Here, you will find demonstration problems, assignments and other notices.

Recommended internet sites

First, a warning. We discovered this year in 1st session that some universities, frustrated by students submitting solutions they find on the internet for assignments, are deliberately placing false solutions on the internet. By searching for solutions, firstly, the student gets misled and secondly, it becomes very easy to identify these students because they all make the same mistakes. Be warned!

Also, there are various sign conventions used in thermodynamics which vary from one part of the world to another. Use of the internet for those not familiar with these conventions may cause a lot of problems. Be warned! Buying the texts recommended for the course is worth it in the long run.

Prior to the start of session, I suggest that you find the paper:

Bejan, A., (1996), "Entropy generation minimization: The new thermodynamics of finite size devices and finite time processes", *J. Appl. Phys.*, **79**, pp 1191-1218.

It is available through the UNSW library. It will be very useful for the first lecture at least. You might also like to search for:

Schneider, E.D. & Kay, J.J., 1995, "Order from disorder: The thermodynamics of complexity in biology", in Michael P. Murphy, Luke A.J. O'Neill (ed), *"What is Life: The Next Fifty Years. Reflections on the Future of Biology",* Cambridge University Press, pp. 161-172.

I will probably suggest other papers during the semester. You also need to be aware of the following site: 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 Course and Teaching Evaluation and Improvement (CATEI) 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 the introduction of a class test in week 7. This will have the effect of letting you know more strongly how you are going before the final exam.

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: https://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:
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, available on the School website.

9. Administrative Matters

You are expected to have read and be familiar with *Administrative Matters*, available on the School website: www.engineering.unsw.edu.au/mechanical-engineering/sites/mech/files/u41/S2-2015-Administrative-Matters_20150721.pdf

This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

Dr John Olsen
20th July, 2015

Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards

	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