UNSW SYDNEY
Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

T1 2020

MECH4620

COMPUTATIONAL FLUID DYNAMICS

Contents

1. Staff contact details

Contact details and consultation times for course convenors

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

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For more information, please see the course Moodle.

2. Important links

- Moodle
- Lab Access
- Health and Safety
- 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 3.5 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.

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	Wednesday	11:00pm – 12:30pm	Webster Theatre A
(Web stream)	Any	Any	Moodle
Lab	Wednesday	13:00pm – 15:00pm	Ainsworth 203
	Wednesday	13:00am – 15:00pm	Ainsworth 204
	Wednesday	15:00am – 17:00pm	Ainsworth 204

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

This course will focus on the terminology, principles and methods of CFD – Computational Fluid Dynamics

CFD can be applied in many areas of engineering, including aerodynamics, hydrodynamics, air-conditioning and minerals processing, and you will find relevance towards many other courses you are currently taking.

The aims of the course are to:

- Place CFD in the context of a useful design tool for industry and a vital research tool for thermos-fluid research across many disciplines;
- Familiarize students with the basic steps and terminology associated with CFD. This includes developing students' understanding of the conservation laws applied to fluid motion and heat transfer and basic computational methods including explicit, implicit methods, discretisation schemes and stability analysis;
- Develop practical expertise in solving CFD problems with a commercial CFD code, ANSYS CFX; and

- Develop an awareness of the power and limitations of CFD.

This course builds on knowledge gained in other courses such as Fluid Mechanics, Thermodynamics, and Numerical Methods.

Student learning outcomes

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.	An underlying understanding of the theoretical basis of CFD	PE1.1, PE1.2, PE1.4
2.	The ability to develop a CFD model for “real world” engineering problems	PE2.1, PE2.2
3.	The technical ability to address complex problems using CFD with the specific focus on developing practical skills in using a commercial CFD package, ANSYS CFX	PE1.3, PE1.5
4.	The ability to interpret computational results and to write a report conveying the result of the computational analysis	PE3.1, PE3.2, PE3.3

4. Teaching strategies

Lectures in the course are designed to cover the terminology and core concepts and theories in CFD. They do not simply reiterate the texts, but build on the lecture topics using examples taken directly from industry to show how the theory is applied in practice and the details of when, where and how it should be applied. The WEB stream version of the course will also be available. This provides students with the opportunity to learn the lecture content online interactively in their own time.

Lab sessions are designed to provide you with feedback and discussion on the assignments, and to investigate problem areas in greater depth to ensure that you understand the application and can avoid making the same mistake again.

5. Course schedule

Week	Lecturer	Topic	Work during laboratory session	Assignment Activity
1	GY	Introduction to CFD and some examples of CFD	• Backward facing step exercise • Problem setup	
2	GY	• Introduction to ANSYS CFX and Fluent • Defining a CFD problem • Creating and/or Importing Geometry in Design Modeler	• Lab work on creating geometry and meshing	Release: group allocation
3	VT	Mass and momentum conservation and Navier-Stokes equations	• Lab work on creating geometry and meshing • Heat exchanger exercise: Meshes • Discussions of group project topics	Release: group project topics
4	VT	Kinematic properties of fluids, dynamic similarity and energy conservation	• Discussions of group project topics • T1 work	
5	GY	Initial and boundary conditions; Post-processing –. Validation and verification	• Backward facing step exercise: Characterization of boundary conditions • Heat exchanger exercise: • Characterisation of boundary conditions	**Due: T1: conservation laws (5%)**
6	GY	Turbulence: basics and introduction	• Backward facing step exercise: Convergence and Discretisation, Turbulence models • T2 work	Feedback: T1: conservation laws
7	GY	Turbulence: applications of models	• Group project • CFD case study tutorials	**Due: T2: turbulence (5%)** **Due: Group project report (20%)**
8	VT	Computational methods – discretisation	• Computational method online tutorial • Sample CFD laboratory test practices	Feedback: T2: turbulence
9	VT	Solution Procedures	• Preparation for lab practice test	Feedback: Group project report **Lab practice test (20%)**
10	GY, VT	Revisions		

6. Assessment

Assessment overview

You will be assessed by way of 2 sets of tutorial-style problems, one group project and one individual project and a two-hour examination at the end of the session. Details of each assessment component, the marks assigned to it, the criteria by which marks will be assigned, and the dates of submission are given below.

Assessment task	**Group Project?** (# Students per group)	**Length**	**Weight**	**Learning outcomes assessed**	**Assessment criteria**	**Due date, time, and submission requirements**	**Deadline for absolute fail**	**Marks returned**
Tutorial style problems (T1 & T2)	No	2-3 pages	10% (2x 5% each)	1 and 4	Understanding of lecture material	4 pm Friday, Week 5 (20/03), Week 7 (03/04) via Moodle	Same as assignment deadline	1 week after the due date
Group Project	Yes(5)	15 pages	20%	2, 3 and 4	See below	4 pm Friday, Week 7 (03/04) via Moodle	4 pm Monday, Week 5 (16/03)	1 week after the due date
Lab practice test	No	2 pages	20%	2, 3 and 4	See below	In-class test, Week 9 (15/04)	N/A	1 week after the due date
Final exam	No	2 hours	50%	1	All course content from weeks 1-10	Exam period, date TBC	N/A	TBC

Assignments

Tutorial-style problems

The short assignments containing 2 sets of tutorial-style problems (T1 and T2) are listed in the Course Schedule. They will involve theoretical work and calculations related to the Course materials. Assignments will be available on the Moodle website.

Group project

The group project involves a complete CFD analysis, from the initial concept through to CAD, meshing, pre-processing, solving, and post-processing the results. The project description will be available on Moodle.

In Week 2, students need to complete a Moodle questionnaire for group allocation purposes. The groups and allocated project topics will be announced in Week 3.

The report to be submitted will be a technical report in the style of a journal article or industrial project report for a client familiar with CFD – a template will be provided to you which will also contain a structured marking criteria. The report will involve writing an abstract/executive summary, and you will be required to conduct a short review of some similar CFD you are able to find in relevant journal papers. Following this, you will write a discussion of your chosen numerical method and assumptions, and then sections relating to mesh convergence, turbulence modelling, and presentation of key results – these reflect the topics which will be covered in depth in the lectures and labs and comprise the typical structure of a research report.

Lab practice test

The lab practice test is to assess the hands-on skills of conducting engineering scaled simulation practice using ANSYS package. In particular, this test focuses on evaluating the students' capability of generating the CFD model and using the simulation data to describe the physical behaviours involved in the flow.

The 2-hour in-class test is scheduled in Week 9, at the designated computer lab, i.e., Ainsworth 203 or 204. During the session, students are expected to use the modelling technique learned from this course to solve a real engineering problem. This consists of

- creating geometry via importing an external CAD file,
- generating a mesh with local refinement,
- setting up the model, e.g., boundary conditions, models and discretisation scheme, convergence criteria, monitoring points etc,
- post-processing data and presenting the results in the format of contour and plot,
- composing a discussion based on the simulation results
- summarising the model and key findings in a 2-page report

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

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

There will be a two-hour examination at the end of the Term.

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

Recommended textbooks

1. J.Y. Tu, G.H. Yeoh, and C. Liu, Computational Fluid Dynamics: A Practical Approach, 3rd Edition, 2018, **or**
2. H.K. Versteeg and W. Malalasekera, An introduction to Computational Fluid Dynamics. The Finite Volume Method, 2nd Edition

Other references

1. J.D. Anderson, Computational Fluid Dynamics.
2. P.J. Roache, Fundamentals of Computational Fluid Dynamics.
3. P.J. Roache, Verification and Validation in Computational Science and Engineering.
4. J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer.
5. S.V. Patankar, Numerical Heat Transfer and Fluid Flow.
6. D.C. Wilcox, Turbulence modelling for CFD.

All of the above textbooks can be found in the UNSW Library: https://www.library.unsw.edu.au/

Recommended Internet sites

www.ansys.com
www.cfd-online.com

Additional materials provided in UNSW Moodle

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);
- tutorial-style problems;
- discussion forum;
- links to any useful material discussed in class.

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

The discussion forum is intended for you to use with other enrolled students. The course convenor and/or demonstrators will occasionally look at the forum, monitor any inappropriate content, and take note of any frequently-asked questions, but will only respond to questions on the forum at their discretion. If you want help from the convenor, then direct contact is preferred.

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 the introduction of a group project to encourage collaborative learning experiences. Also, demonstrators are now required to provide more comprehensive feedback on assignment activities during lab sessions.

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 School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

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