MECH4620

Computational Fluid Dynamics

Term 3, 2021

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Victoria Timchenko	v.timchenko@unsw.edu.au	Thursday 3 - 4 pm	Room 401C, J17	(02) 9385 4148
Anthony Chun Yin Yuen	c.y.yuen@unsw.edu.au	Wednesday 2 - 3 pm	Room 401E, J17	(02) 9385 4763

Demonstrators

Name	Email	Availability	Location	Phone
Timothy Bo Yuan Chen	timothy.chen@unsw.edu.au	Friday 2 - 3 pm	Room 505, J17	

School Contact Information

Location

UNSW Mechanical and Manufacturing Engineering

Ainsworth building J17, Level 1

Above Coffee on Campus

Hours

9:00–5:00pm, Monday–Friday*

*Closed on public holidays, School scheduled events and University Shutdown

Web

School of Mechanical and Manufacturing Engineering

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

(+61 2) 9385 4097 – School Office**

**Please note that the School Office will not know when/if your course convenor is on campus or available

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

School Office – School general office administration enquiries

- NB: the relevant teams listed above must be contacted for all student enquiries. The School will only be able to refer students on to the relevant team if contacted

Important Links

- Student Wellbeing
- Urgent Mental Health & Support
- Equitable Learning Services
- Faculty Transitional Arrangements for COVID-19
- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Makerspace
- UNSW Timetable
- UNSW Handbook

Course Details

Units of Credit 6

Summary 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.

Course Aims

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 thermosfluid 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 Fluent; and
- Develop an awareness of the power and limitations of CFD.

Course Learning Outcomes

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 Computational Fluid Dynamics (CFD).	PE1.1, PE1.2, PE1.4
2. The ability to develop CFD models for "real world" engineering problems.	PE2.1, PE2.2
3. The technical ability to address complex problems using CFD; specifically with 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 results of the computational analysis.	PE3.1, PE3.2, PE3.3

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.

Additional Course Information

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

Assessment

Assignments

Tutorial-style problems

The short assignments containing 3 sets of tutorial-style problems (T1, T2 and T3) 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.

Individual project

The individual project involves a complete CFD analysis, from the initial concept through to CAD, meshing, pre-processing, solving, validation, verification and post-processing the results. The subject of the CFD investigation will be the selection from of one of the three set problems provided in Moodle.

The list of topics will be announced in Week 2.

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 structured marking criteria. The report will involve you 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. The following tasks are expected from the group assignment report:

(a) creating geometry with appropriate simplification,

(b) generating a mesh with local refinement,

(c) setting up the model, e.g., boundary conditions, models and discretisation scheme, convergence criteria, monitoring points etc,

(d) post-processing data, presenting the results with discussion in the format of contour and plot,

(e) validation and verification of CFD results,

(f) summarising the model and key findings in a 15-pages 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

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.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Tutorial style problems	15%	4 pm Friday, Week 4 (08/10), Week 8 (05/11) and week 10 (19/11) via Moodle	1, 4
2. Individual Project	35%	12/11/2021 04:00 PM	1, 2, 3, 4
3. Final Examination	50%	Exam period, date TBC	1, 2, 4

Assessment 1: Tutorial style problems

Assessment length: 2 - 3 pages
Due date: 4 pm Friday, Week 4 (08/10), Week 8 (05/11) and week 10 (19/11) via Moodle

The short assignments containing 3 sets of tutorial-style problems (T1, T2 and T3) are listed in the Course Schedule. They will involve theoretical work and calculations. Assignments will be available on the Moodle website.

Assessment criteria

Understanding of lecture content

Additional details

Marks returned: 1 week after due date

Assessment 2: Individual Project

Start date: 20/09/2021 02:00 PM
Assessment length: 15 pages
Due date: 12/11/2021 04:00 PM

The individual project focuses on assessing the individual skills in CFD analysis, in particular the capability of using the CFD simulation data to describe the physical behaviours involved in the flow. The subject of the CFD investigation will be the selection from of one of the three set problems provided in Moodle.

The list of topics will be announced in Week 2.

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 you 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.

Assessment criteria

Understanding of CFD modelling and learning how to run CFD simulation using ANSYS software package

Ability to write a report including validation and verification, as well as post-processing of CFD simulation results

Additional details

Marks returned: 2 week after due date

Assessment 3: Final Examination

Assessment length: 2 hours
Due date: Exam period, date TBC

A two-hour examination at the end of the semester.

Assessment criteria

All course content from weeks 1-10

Additional details

This will be an online open-book examination

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 13 September - 17 September	Lecture	Introduction to CFD and some examples of CFD (VT)
	Tut-Lab	(i) Backward facing step exercise (ii) Problem setup
Week 2: 20 September - 24 September	Lecture	Introduction to ANSYS CFX and Fluent (AY)
	Tut-Lab	Lab work on creating geometry and meshing (i) Defining a CFD problem (ii) Creating and/or Importing Geometry in Design Modeler
Week 3: 27 September - 1 October	Lecture	Mass and momentum conservation and Navier-Stokes equations (VT)
	Tut-Lab	(i) Lab work on creating geometry and meshing (ii) Heat exchanger exercise: Meshes (iii) Discussions of Individual project topics
Week 4: 4 October - 8 October	Lecture	Energy conservation and dynamic similarity (VT)
	Tut-Lab	(i) T1 work (ii) Individual project work
	Assessment	**Due: T1: conservation laws (5%)**
Week 5: 11 October - 15 October	Lecture	Initial and boundary conditions: practical guidelines Post-processing – analysis of results. Validation and verification (AY)
	Tut-Lab	(i) Backward facing step exercise: Characterization of boundary conditions

		(ii) Heat exchanger exercise: (iii) Characterisation of boundary conditions (iv) T1 work (v) Individual project work
	Assessment	Feedback: T1: conservation laws
Week 6: 18 October - 22 October	Lecture	Exam Revision (VT/AY)
	Tut-Lab	(i) Individual project work
	Assessment	Feedback: Individual project report
Week 7: 25 October - 29 October	Lecture	Turbulence: basics and introduction (AY)
	Tut-Lab	(i) Backward facing step exercise: Convergence and Discretisation, Turbulence models (ii) T2 work (iii) Individual project work
Week 8: 1 November - 5 November	Lecture	Turbulence: applications of models (AY)
	Tut-Lab	(i) T2 work (ii) Individual project work
	Assessment	**Due: T2: turbulence (5%)**
Week 9: 8 November - 12 November	Lecture	Computational methods - discretisation (VT)
	Tut-Lab	(i) Computational method online tutorial (ii) T3 work (iii) Individual project work
	Assessment	**Due: Individual project report (35%)**
Week 10: 15 November - 19 November	Lecture	Solution procedures (VT)
	Tut-Lab	(i) Revision/consultation (ii) Consultation for exams
	Assessment	**Due: T3: Discretization (5%)**
Study Week: 20 November - 25 November	Lecture	Exam Revision (VT/AY)
	Assessment	Feedback: Individual project report

Resources

Prescribed Resources

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

Recommended Resources

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.

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 the individual project to develop the individual skills in CFD anaylsis, in particular the capability of using the CFD simulation to model practical flow problems. Also, demonstrators are now required to provide more comprehensive feedback on assignment activities during lab sessions and encourage collaborative learning experiences.

Submission of Assessment Tasks

Assessment submission and marking criteria

Should the course have any non-electronic assessment submission, these 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 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.

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.

Late policy

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, for a minimum of zero marks.

The late penalty is applied per calendar day (or part thereof), including weekends and public holidays, that the assessment is overdue.

Work submitted after the 'deadline for absolute fail' is not accepted and a mark of zero will be awarded for that assessment item. For example:

- Your course has an assessment task worth a total of **30 marks (Max Possible Mark)**
- You submit the assessment **2 days after the due date**
- The assessment is marked as usual and achieves a score of **20 marks (Awarded Mark)**
- The late policy is applied using **Late Mark = Awarded Mark - (Days*Penalty per Day)*Max Possible Mark**. Your adjusted final score is **8 marks** (20 - ((2*0.2)*30)).

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:

1. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
2. Online quizzes where answers are released to students on completion, or
3. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
4. Pass/Fail assessment tasks.

Examinations

You must be available for all quizzes, tests and examinations. For courses that have final examinations, these 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.

Special Consideration

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.

UNSW now has a Fit to Sit / Submit rule, which means that if you attempt 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.

Please note that students will **not** be required to provide **any** documentary evidence to support absences from any classes missed **because of COVID-19 public health measures such as isolation**. UNSW will **not** be insisting on medical certificates from anyone deemed to be a positive case, or when they have recovered. Such certificates are difficult to obtain and put an unnecessary strain on students and medical staff.

Applications for special consideration **will** be required for assessment and participation absences – but no documentary evidence **for COVID-19 illness or isolation** will be required.

Special Consideration Outcomes

Assessments have default Special Consideration outcomes. The default outcome for the assessment will be advised when you apply for Special Consideration. Below is the list of possible outcomes:

Outcome	Explanation	Example
Time extension	Student provided more time to submit the assessment	e.g. 1 more week of time granted to submit a report
Supplementary assessment	Student provided an alternate assessment at a later date/time	e.g. a supplementary exam is scheduled during the supplementary exam period of the term
Substitute item	The mark for the missed assessment is substituted with the mark of another assessment	e.g. mark for Quiz 1 applied also applied as mark for Quiz 2, meaning if a student achieved a mark of 20/30 for Quiz 1 and was granted Special Consideration for Quiz 2, a mark of 20/30 would be applied for Quiz 2, etc
Exemption	All course marks are recalculated excluding this assessment and its weighting	e.g. The course has an assessment structure of: - Assignments 30%, - Lab report 30%, - Final Exam 40%. If the Lab report is missed and student is granted Special Consideration, then the assessment structure may be reweighted as follows: - Assignments 50% - Final Exam 50% as though the Lab report did not exist
Non-standard	Course Coordinator is contacted for the outcome when special consideration is granted as the outcome differs on a case-by-case basis	e.g. typical for group assessments where time extension supplementary assessment could be granted to the group member, time extension could be granted to the whole group, etc. Clarify with your Course Convenor for

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

Academic Information

Credit points

Course credit is calculated in Units-Of-Credit (UOC). The normal workload expectation for one UOC is approximately 25 hours per term. This includes class contact hours, private study, other learning activities, preparation and time spent on all assessable work.

Most coursework courses at UNSW are 6 UOC and involve an estimated 150 hours to complete, for both regular and intensive terms. Each course includes a prescribed number of hours per week (h/w) of scheduled face-to-face and/or online contact. Any additional time beyond the prescribed contact hours should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

On-campus class attendance

****T3-2021 UPDATE****
Classes will be entirely ONLINE until at least Week 6, after which we will receive further advice from UNSW about the return of face-to-face classes. Students who are enrolled in face-to-face classes will have access to the course's online content but NO classes will be changed to reflect online delivery until Week 6 due to uncertainty regarding delivery mode for the rest of the term. Please go to your course's Moodle modules and MS Teams sites for further information about accessing course resources and content.

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Public distancing conditions must be followed for all face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. No over-enrolment is allowed in face-to-face classes. Students enrolled in online classes can swap their enrolment from online to a **limited** number of on-campus classes by Sunday, Week 1. Please refer to your course's Microsoft Teams and Moodle sites for more information about class attendance for in-person and online class sections/activities.

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate.** We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed. Further information is available on any course Moodle or Teams site.

In certain classroom and laboratory situations where physical distancing cannot be maintained or there is a high risk that it cannot be maintained, face masks will be considered **mandatory PPE** for students and staff.

For more information, please refer to the
FAQs: https://www.covid-19.unsw.edu.au/safe-return-campus-faqs

Guidelines

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
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism

Image Credit

Photo by Stephen Blake March 2017, Willis Annexe (J18) Thermofluids lab

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	✓
PE3.2 Effective oral and written communication in 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	