UNSW Course Outline

MECH4620 Computational Fluid Dynamics - 2024

Published on the 04 Apr 2024

General Course Information

Course Code : MECH4620
Year : 2024
Term : Term 1
Teaching Period : T1
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Mechanical and Manufacturing Engineering
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Undergraduate, Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Computational fluid dynamics (CFD) is now progressively becoming more accessible to graduate engineers for research and development as well as design-oriented tasks in industry. Mastery of CFD in handling complex flow and heat industrial problems is becoming ever more important.

Competency in such a skill certainly brings about a steep learning curve for practicing engineers, who constantly face extreme challenges to come up with solutions to fluid flow and heat transfer problems without *a priori* knowledge of the basic concepts and fundamental understanding of fluid mechanics and heat transfer.

Today's engineers are almost certainly geared more towards the use of commercial CFD codes, such as ANSYS-CFX, ANSYS-FLUENT or STAR-CCM+. This course aims to equip students with the terminology, principles and methods of CFD. The dominant feature of the present course is to maintain a balance of practicality in understanding CFD as well as providing the theoretical knowledge about CFD that can be applied in many areas of engineering, including aerodynamics, hydrodynamics, air-conditioning and minerals processing.

Course Aims

This course aims to reinforce students' understanding of core CFD principles, as well as building their capabilities in core engineering practice.

In particular, the course will improve students' ability to: (i) use CFD in the context of a useful design tool for industry and a vital research tool for thermo-fluid research, (ii) familiarize with the basic steps and terminology associated with CFD which includes developing understanding of the conservation laws applied to fluid motion and heat transfer and basic computational methods including explicit, implicit methods, discretization schemes and stability analysis, (iii) develop practical expertise of solving CFD problems with commercial CFD codes and (iv) develop an awareness of the power and limitations of CFD.

The development of proficiency in CFD will complement and strengthen the students' knowledge on how to best tackle real world engineering problems of fluid flow and heat transfer.

Relationship to Other Courses

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

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain the theoretical basis of Computational Fluid Dynamics (CFD).
CLO2 : Develop a CFD model for “real world” engineering problems
CLO3 : Solve complex problems using CFD with the specific focus on developing practical skills in using a commercial CFD package, ANSYS CFX
CLO4 : Interpret computational results and write a report conveying the result of the computational analysis

Course Learning Outcomes	Assessment Item
CLO1 : Explain the theoretical basis of Computational Fluid Dynamics (CFD).	• Group Project • Individual Project • Final Examination • Tutorial style problems
CLO2 : Develop a CFD model for “real world” engineering problems	• Group Project • Individual Project • Final Examination • Tutorial style problems
CLO3 : Solve complex problems using CFD with the specific focus on developing practical skills in using a commercial CFD package, ANSYS CFX	• Group Project • Individual Project • Final Examination • Tutorial style problems
CLO4 : Interpret computational results and write a report conveying the result of the computational analysis	• Group Project • Individual Project • Final Examination • Tutorial style problems

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Other Professional Outcomes

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Group Project Assessment Format: Group Short Extension: Yes (1 day)	25%	Start Date: 22/02/2024 09:00 AM Due Date: 25/03/2024 05:00 PM
Individual Project Assessment Format: Individual Short Extension: Yes (1 day)	25%	Start Date: 26/03/2024 09:00 AM Due Date: 19/04/2024 05:00 PM
Final Examination Assessment Format: Individual	40%	
Tutorial style problems Assessment Format: Individual Short Extension: Yes (1 day)	10%	

Assessment Details

Group Project

<u>Assessment Overview</u>

Assessment length: 15 pages

The group project involves a CFD analysis, from the initial concept through to CAD, meshing, pre-processing, solving, and post-processing the results. 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 criterion. 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 detailed discussion 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. Individual written feedback will be provided online and verbal class-wide feedback during the laboratory sessions.

<u>Course Learning Outcomes</u>

- CLO1 : Explain the theoretical basis of Computational Fluid Dynamics (CFD).
- CLO2 : Develop a CFD model for “real world” engineering problems
- CLO3 : Solve complex problems using CFD with the specific focus on developing practical skills in using a commercial CFD package, ANSYS CFX
- CLO4 : Interpret computational results and write a report conveying the result of the computational analysis

Assessment Length

15 pages

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students can see Turnitin similarity reports.

Individual Project

Assessment Overview

Assessment length: 15 pages

The individual project involves a CFD analysis, focusing primarily on discretization and solution procedure for the problems that have been tackled in the group project. The report to be submitted will be a technical report in the style of a journal article or industrial project report similar to the group project report. The report will briefly contain a short summary of the CFD problem and then with a detailed discussion of your chosen numerical methodologies and assumptions, sensitivity of numerical results based on different discretization schemes, 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. Individual written feedback will be provided online and verbal class-wide feedback during the laboratory sessions.

Course Learning Outcomes

- CLO1 : Explain the theoretical basis of Computational Fluid Dynamics (CFD).
- CLO2 : Develop a CFD model for “real world” engineering problems
- CLO3 : Solve complex problems using CFD with the specific focus on developing practical skills in using a commercial CFD package, ANSYS CFX
- CLO4 : Interpret computational results and write a report conveying the result of the computational analysis

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students can see Turnitin similarity reports.

Final Examination

Assessment Overview

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

This will be an online open-book examination.

Course Learning Outcomes

- CLO1 : Explain the theoretical basis of Computational Fluid Dynamics (CFD).

- CLO2 : Develop a CFD model for “real world” engineering problems
- CLO3 : Solve complex problems using CFD with the specific focus on developing practical skills in using a commercial CFD package, ANSYS CFX
- CLO4 : Interpret computational results and write a report conveying the result of the computational analysis

Detailed Assessment Description

Please ignore the above assessment overview, This will be an in-person closed-book examination. Students are allowed to bring a TWO-SIDED ONE PAGE HANDWRITTEN NOTES with them to exam.

Assessment Length

2 hours

Assignment submission Turnitin type

Not Applicable

Tutorial style problems

Assessment Overview

Assessment length: 2-3 pages

The short assignments containing 2 sets of tutorial-style problems (i.e. each contains 5 % of course marks), which will require knowledge of governing equations and turbulence. They will involve theoretical development. Individual written feedback will be provided online and verbal class-wide feedback during the laboratory sessions.

Course Learning Outcomes

- CLO1 : Explain the theoretical basis of Computational Fluid Dynamics (CFD).
- CLO2 : Develop a CFD model for “real world” engineering problems
- CLO3 : Solve complex problems using CFD with the specific focus on developing practical skills in using a commercial CFD package, ANSYS CFX
- CLO4 : Interpret computational results and write a report conveying the result of the computational analysis

Detailed Assessment Description

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. Due date for T1 is 01/03/2024, Friday Week 3. Duedate for T2 is 15/03/2024, Friday Week 5.

General Assessment Information

Assignments

Tutorial-style problems

The short assignments containing 2 sets of tutorial-style problems (T1, T2) and they 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 and individual projects

The group and individual 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.

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:

(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.

Individual project will involve running solutions with diferent discretization schemes and parametric study following with optimization. Details can be seen in assessments section.

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.

Re-weighting is not an option for the school.

Grading Basis

Standard

Requirements to pass course

Attain a mark of 50% and above

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 12 February - 18 February	Lecture	Introduction to CFD and ANSYS software. • Examples of CFD • Defining a CFD problem • Creating and/or Importing Geometry
	Laboratory	• Backward facing step exercise • Problem setup • Lab work on creating geometry and meshing
Week 2 : 19 February - 25 February	Lecture	Mass and momentum conservation and Navier-Stokes equations
	Laboratory	• Lab work on creating geometry and meshing • Heat exchanger exercise: Meshes • Discussions of group project topics
	Assessment	Release: group allocation and project topics
Week 3 : 26 February - 3 March	Lecture	Energy conservation and dynamic similarity
	Laboratory	• Discussions of group project topics, • T1 work
	Assessment	Due: T1 - conservation laws (5%)
Week 4 : 4 March - 10 March	Lecture	Turbulence: basics and introduction
	Laboratory	• Backward facing step exercise: Convergence and Discretisation, Turbulence models • T2 work • Group project work
	Assessment	Feedback: T1- conservation laws
Week 5 : 11 March - 17 March	Lecture	Turbulence: applications of models
	Laboratory	• T2 work • Group project work
	Assessment	Due: T2 - turbulence (5%)
	Activity	
Week 6 : 18 March - 24 March	Reading	
	Group Work	
Week 7 : 25 March - 31 March	Lecture	• Initial and boundary conditions: practical guidelines • Post-processing – analysis of results. Validation and verification.
	Laboratory	• Backward facing step exercise: Characterization of boundary conditions • Heat exchanger exercise: Characterisation of boundary conditions • Individual project work
	Assessment	Feedback: T2- turbulence Due: Group project report (25%)
Week 8 : 1 April - 7 April	Lecture	Computational methods – discretisation
	Laboratory	• Computational method online tutorial • Individual project work
	Assessment	
Week 9 : 8 April - 14 April	Lecture	Guest Lecture
	Laboratory	Individual Project work
Week 10 : 15 April - 21 April	Lecture	Solution Procedures
	Laboratory	Individual Project work
	Assessment	Due: Individual project report (25%)

Attendance Requirements

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

General Schedule Information

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.

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.

Course 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.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Victoria Timchenko		Room 401C, J17	(2) 9385 4188	Thursday 3 - 4 pm	No	No
Demonstrator	Ivan Miguel De Cachinho Cordeiro		Room 401		Friday 2 - 3 pm	No	No
Convenor	Guan Yeoh		Room 401B, J17	+61414960019	Tuesday 2 - 3 pm	No	Yes

Other Useful Information

Academic Information

I. 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, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, 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.

II. 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
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

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.

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 or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) 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. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be 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 will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;

- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, 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

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)

School-specific Information

Short Extensions

Short extensions are not currently applicable to Mechanical and Manufacturing Engineering Courses.

Review of Results

The purpose of a review of results is if there was a marking error. Review of results is for when you have cause to believe that there is a marking error. Review of Results cannot be used to get feedback. If you would like feedback for assessments prior to the final exam, you are welcome to contact the course convenor directly. No feedback will be provided on final exams.

Use of AI

The use of AI is prohibited unless explicitly permitted by the course convenor. Please respect this and be aware that penalties will apply when unauthorised use is detected, such as through Turnitin. If the use of generative AI, such as ChatGPT, is allowed in a specific assessment, they must be properly credited, and your submissions must be substantially your own work.

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