Course Outline

Semester 1, 2015

Never Stand Still | Faculty of Engineering | School of Mechanical and Manufacturing Engineering

MECH9620

COMPUTATIONAL FLUID DYNAMICS

CONTENTS

COURSE OUTLINE

1. STAFF CONTACT DETAILS

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2. COURSE DETAILS

Units of credit

This is a 6 unit-of-credit (UoC) course, and involves 3 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."

For a standard 24 UoC in the session, this means 600 hours, spread over an effective 15 weeks of the session (thirteen weeks plus stuvac plus one effective exam week), or 40 hours per week, for an average student aiming for a credit grade Various factors, such as your own ability, your target grade, etc., will influence the time needed in your case.

Some students spend much more than 40 h/w, but you should aim for not less than 40 h/w on coursework for 24 UoC.

This means that you should aim to spend not less than about 10 h/w on this course, i.e. an additional 7 h/w of your own time. This should be spent in making sure that you understand the lecture material, further reading and research about the course material, practicing the tutorial examples, and completing the major assignment and tutorials.

There is no parallel teaching in this course.

Summary of the course

This course introduces the student to the terminology, principles and methods of CFD – Computational Fluid Dynamics.

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

Aims of the course

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 thermo-fluid research across many disciplines. To develop students' understanding of the conservation laws applied to fluid motion and heat transfer. Familiarise students with basic computational methods including explicit, implicit methods, discretization schemes and stability analysis.
- Familiarise students with the basic steps and terminology associated with CFD.
- To develop practical expertise of solving CFD problems with a commercial CFD code, ANSYS CFX.
- To develop an awareness of the power and of limitations of CFD.

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

Student learning outcomes

- An underlying understanding of the theoretical basis of Computational Fluid Dynamics (CFD).
- The ability to develop CFD models for "real world" engineering problems.
- The technical ability to address complex problems using CFD; specifically with practical skills in using a commercial CFD package, ANSYS CFX.
- The ability to interpret computational results and to write a report conveying the results of the computational analysis.

Graduate attributes

Please refer to UNSW graduate attributes:
https://my.unsw.edu.au/student/atoz/GraduateAttributes.html

UNSW aspires to develop graduates who are rigorous scholars, capable of leadership and professional practice in a global community. The university has, thus, articulated the following Graduate Attributes as desired learning outcomes for ALL UNSW students. UNSW graduates will be:

1. Scholars who are:

a) understanding of their discipline in its interdisciplinary context (*)
b) capable of independent and collaborative enquiry (*)
c) rigorous in their analysis, critique, and reflection (*)

d) able to apply their knowledge and skills to solving problems (*)
e) ethical practitioners (*)
f) capable of effective communication (*)
g) information literate (*)
h) digitally literate (*)

2. Leaders who are:

a) enterprising, innovative and creative (*)
b) capable of initiating as well as embracing change
c) collaborative team workers (*)

3. Professionals who are:

a) capable of independent, self-directed practice (*)
b) capable of lifelong learning (*)
c) capable of operating within an agreed Code of Practice (*)

4. Global Citizens who are:

a) capable of applying their discipline in local, national and international contexts (*)
b) culturally aware and capable of respecting diversity and acting in socially just/responsible ways
c) capable of environmental responsibility

Graduate attributes targeted and developed in this course are marked with an asterisk (*).

Students will be supported in developing the above attributes through:

- the design of academic programs
- course planning and documentation
- assessment strategies
- learning and teaching strategies.

In this course, you will be encouraged to develop Graduate Attributes 1a-h; 2a; 2c; 3a-c and 4a by undertaking the selected activities and knowledge content. These attributes will be assessed within the prescribed assessment task.

3. RATIONALE FOR INCLUSION OF CONTENT AND TEACHING APPROACH

This course is included to give you the skills to conduct CFD analyses of engineering problems and to understand CFD theory and methodology.

The content reflects the experience of the lecturers in both their industrial and research experience with CFD, and practical examples drawn from that experience are used throughout the lectures and laboratory sessions.

Effective learning is supported when you are actively engaged in the learning process and by a climate of enquiry, and these are both an integral part of the lectures and laboratory sessions.

You become more engaged in the learning process if you can see the relevance of your studies to professional, disciplinary and/or personal contexts, and the relevance is shown in the lectures and assignments by way of examples drawn from industry.

Dialogue is encouraged between you, others in the class and the lecturers. Diversity of experiences is acknowledged, as some students in each class have prior CFD experience. Your experiences are drawn on to illustrate various aspects, and this helps to increase motivation and engagement.

It is expected that minor assignments will be marked and handed back in the week following submission. You will have feedback and discussion while fresh in your mind to improve the learning experience. The major assignment may take two weeks to mark.

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.

Tutorials 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. ASSESSMENT

General

You will be assessed by way of 3 sets of tutorial problems, one major assignment and a three-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.

Major Assignment	35%
3 sets of Tutorials	15%
Examination	50%
Total	**100%**

Major assignment

The major assignment involves a complete cycle of a CFD analysis, from the initial concept through to CAD, meshing, pre-processing, solving, and post-processing the results. The subject of your CFD investigation will be of your own choosing – if you are doing a CFD-related thesis you will be allowed to work on something that relates to that project if you wish. Otherwise, choose something you are interested in or you think may relate to the kind of work you'd like to do when you graduate (i.e. HVAC-style problem, flow around an aircraft wing, racing car exhaust, wind study around a building, flow in an artery, etc.).

The report you submit 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: you will write and 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 tutorials and comprise the typical structure of a research report.

Tutorial problems

The short assignments containing sets of tutorial problems (T1, T2, T3) are listed in page 10. They will involve theoretical work and calculations. Assignments will be available on the Moodle website.

Presentation

A standard specification is available from the School office to aid presentation of your assignments (in all courses). All submissions should have a standard School cover sheet. All submissions are expected to be neat and clearly set out. All calculations should be shown as, in the event of incorrect answers, marks are awarded for method and understanding.

The preferred set-out of any numerical calculation is similar to the following:

$P_E = R_T v$	(Equation in symbols)
$= 203.7 \times 20.58$	(Numbers substituted)
$= 4192$ kW	(Answer with units)

Submission

The required submission dates are given on the assignment sheets themselves and also in page 10.

Late submissions attract a penalty of ten percent per *day*, unless prior dispensation has been given; i.e. see the lecturer before the due date to avoid penalty. It is always worth submitting assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Criteria

The following broad criteria will be used to grade assignments, while the major assignment will have more specific criteria incorporated into the report template when issued:

For report-style assignments the following criteria will be used:

- Identification of key facts and the integration of those facts in a logical development.
- Clarity of communication—this includes development of a clear and orderly structure and the highlighting of core arguments.
- Sentences in clear and plain English—this includes correct grammar, spelling and punctuation.
- Correct referencing in accordance with the prescribed citation and style guide.

All other assignments involve numerical calculations, for which the following criteria will be used:

- Accuracy of numerical answers.
- Use of diagrams, where appropriate, to support or illustrate the calculations.
- Use of graphs, were appropriate, to support or illustrate the calculations.
- Use of tables, where appropriate, to support or shorten the calculations.
- Neatness.

Examination

There will be a three-hour examination at the end of the session.

You will need to provide your own calculator, of a make and model approved by UNSW, for the examination. 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 for All Courses*, available from the School website.

6. ACADEMIC HONESTY AND PLAGIARISM

Plagiarism is using the words or ideas of others and presenting them 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 booklet which provides essential information for avoiding plagiarism: https://my.unsw.edu.au/student/academiclife/Plagiarism.pdf

There is a range of resources to support students to avoid 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. Information is available on the dedicated website Plagiarism and Academic Integrity website: http://www.lc.unsw.edu.au/plagiarism/index.html

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 a 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 for All Courses, available on the School website.

7. COURSE SCHEDULE

The lectures and laboratory work in this course are given as follows:

Week	***Lecturer***	***Topic***	***Work during laboratory session***	***DUE (Friday)***
1	VT	Introduction to CFD and ANSYS CFX	Backward facing step exercise Problem setup	-
2	GY	• Defining a CFD problem • Creating and/or Importing Geometry in Design Modeler	Tutorials on creating geometry and meshing	-
3	VT	Kinematic properties of fluids	• Tutorials on creating geometry and meshing • Heat exchanger exercise: Meshes • Discussions about projects	-
4	GY	Conservation Laws and N-S equations	• Tutorial work on conservation laws (T1) • Discussions about projects	Project proposal
5	GY	Similarity, BCs	• Tutorial work on conservation laws (T1) • Backward facing step exercise: Characterization of boundary conditions • Heat exchanger exercise: Characterization of boundary conditions	T1: conservation laws
6	GY	Turbulence: basics and introduction	• Backward facing step exercise: Convergence and Discretization, Turbulence models, T2 work	-
7	GY	Turbulence: applications of models	Major assignment work, T2 work	T2: turbulence
8	VT	Computational methods – discretisation	Major assignment work, T3 work	
9	VT	Solution Procedures	Major assignment work, T3 work	T3: computational methods
10	VT	Post Processing – analysis of results. Validation and Verification	Major assignment work	-

11	GY	Multiphase modelling and combustion	Major assignment work	-
12		No lecture. Major assignment work	Major assignment work	Assignment due
13	VT	Revision		

The schedule shown may be subject to change at short notice.

8. RESOURCES FOR STUDENTS

SUGGESTED TEXTS (either):

1. H.K. Versteeg and W. Malalasekera, An introduction to Computational Fluid Dynamics. The Finite Volume Method, 2nd Edition
2. Jiyuan Tu, Guan Heng Yeoh, and Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Edition 2, 2012.

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.

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

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.

9. COURSE EVALUATION AND DEVELOPMENT

The course has been redesigned in 2015 and will be evaluated at the end of this semester. 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 a reduction in the amount of code-writing required and also the introduction of a major assignment with the topic of the student's choice.

10. ADMINISTRATIVE MATTERS

You are expected to have read and be familiar with Administrative Matters, available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

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