ENGG*4440 Computational Fluid Dynamics

01

Winter 2024
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 12, 2024

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1 Course Details

1.1 Calendar Description

Computational methods for fluid mechanics form the core of the course. The concepts of modelling are covered including numerical analysis, the governing equations for fluid problems and finite discretization methods. Mathematical models for turbulence are presented and the student is exposed to the use of commercial software for the solution of complex problems in fluid dynamics.

Pre-Requisites:	ENGG*2230, ENGG*3370
Restrictions:	Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Course Description

The goal of this course is to introduce the field of computational solutions to complex fluid flows. Students will be exposed to the nature of complex fluid flows, various numerical methods for solving the non-linear governing equations, and techniques for using commercially available CFD software. There is a focus on building and solving physical models in practical fluid dynamic applications.

1.3 Timetable

Lectures

Monday and Friday, 8:30 AM - 9:50 AM, ROZH 107

Laboratory

Sec 01: Friday 12:30 - 2:20 PM, THRN 1004

Sec 02: Wednesday 9:30 AM - 11:20 AM, THRN 1004

1.4 Final Exam

No final exam for this course.

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Mostafa Elsharqawy Ph.D., P.Eng
Email:	melsharq@uoguelph.ca
Telephone:	+1 519-824-4120 x54013
Office:	RICH 3513
Office Hours:	TBA on CourseLink or by appointment

2.2 Teaching Assistants

Teaching Assistant (GTA):	Salman Soltanian
Email:	ssoltani@uoguelph.ca
Office Hours:	TBA on CourseLink or by appointment

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3 Learning Resources

3.1 Required Resources

Course Website (Website)

Course material, news, announcements, and grades will be regularly posted to the ENGG*4440 CourseLink website. You will be granted access to the website when you register for the course. You are responsible for checking the website regularly.

ANSYS Workbench (Software)

ANSYS Workbench software is available on the school of engineering computer labs. You can also download a student version on your PC using this website https://www.ansys.com/academic/students/ansys-student .

Textbook (Textbook)

H.K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics, 2nd Edition Pearson, 2007.

MATLAB and Excel (Software)

https://remotelab.soe.uoguelph.ca/soe.rca/

We will use MATLAB and Excel to solve finite volume codes. The software are available in

all school of engineering computer labs.

3.2 Recommended Resources

- J.H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, 4th Edition,Springer, 2020
- Suhas Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 1980.
- John Wendt, and John Anderson, Computational Fluid Dynamics: An Introduction. Springer, 2009.
- M.B. Abbott, and D.R. Basco, Computational Fluid Dynamics: An Introduction for Engineers, John Wiley & Sons, Inc., New York, 1990.
- An undergraduate Fluid Mechanics textbook such as F. M. White, Fluid Mechanics, 8th Edition, McGraw Hill, 2016

3.2 Additional Resources

Lecture Information: Lecture notes will be posted on the course website on CourseLink throughout the semester. You will be granted access to the website when you register for the course.

Lab Information: All necessary information for the lab sessions will be posted on CourseLink. Make sure you check the course website for relevant information before each session.

Assignments: Download the assignments according to the schedule given in the CourseLink website and upload a softcopy of your solution to the Dropbox folder.

Miscellaneous Information: Lectures are the main source of material which includes important discussions and worked examples that might not be found elsewhere. Other information related to this course will be posted on CourseLink.

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Comprehend, appreciate, and apply the physics of complex fluid flow
2. Build computational models to analyze complex fluid flow and heat transfer problems.
3. Articulate the major approximations in CFD analysis and control the associated errors, recognizing the limits of the tool and assessing the validity of the conclusion
4. Interpret and communicate computational results in coherent and understandable ways

with both graphs and words

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2
2	Problem Analysis	1, 2
2.1	Formulate a problem statement in engineering and non-engineering terminology	1, 2
2.2	Identify, organize and justify appropriate information, including assumptions	1, 2
2.3	Construct a conceptual framework and select an appropriate solution approach	1, 2
2.4	Execute an engineering solution	1, 2
2.5	Critique and appraise solution approach and results	1, 2
3	Investigation	3, 4
3.4	Assess validity of conclusions within limitations of data and methodologies	3, 4
5	Use of Engineering Tools	2, 3, 4
5.2	Demonstrate proficiency in the application of selected engineering tools	2, 3, 4
7	Communication Skills	4
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	4
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	4
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	4
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	4
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating	4

#	Outcome	Learning Outcome
	meaningful questions	

5 Teaching and Learning Activities

5.1 Lecture

Week 1

Topics: Introduction to CFD and course outline
The CFD Process

References: Chapter 1

Week 2

Topics: Finite Volume Method (FVM)

Steady Diffusion Problems

References: Chapter 4

Week 3

Topics: Governing Equations in CFD

References: Chapter 2

Week 4

Topics: The Finite Volume Method (Convection)

Laminar Flow in Pipe

References: Chapter 5

Week 5

Topics: Convection-Diffusion Upwind Scheme
Boundary Layer Theory

Steady Convection-Diffusion cont.

References: Chapter 5

Week 6

Topics: Pressure-Velocity Coupling
FVM for Unsteady Diffusion

References: Chapters 6 & 8

Week 7

Topics: FVM for Unsteady Diffusion cont
Modeling Turbulent Flow

References: Chapters 8 & 3

Week 8

Topics: Modeling Turbulent Flow & Review
Midterm and lab exams

References: Chapter 3

Week 9

Topics: Modeling Turbulent Flow cont.
Turbulent Flow in Pipe

References: Chapter 3

Week 10

Topics: Geometry and Mesh in ANSYS
Boundary Conditions & Physics

References: ANSYS Manual

Week 11

Topics: Properties and Misc. Models

References: ANSYS Manual

Week 12

Topics: Project Presentation

5.2 Lab

Week 1

Topics: No Lab during this week

Week 2

Topics: Lab 1 Introduction to ANSYS Workbench

Week 3

Topics: Lab 2 Steady Diffusion Problems

Week 4

Topics: Lab 3 Laminar Flow in Pipe

Week 5

Topics: Lab 4 Flow over Flat Plate

Week 6

Topics: Lab 5 2D Steady Convection

Week 7

Topics: Lab 6 Unsteady Diffusion

Week 8

Topics: Lab 7: Lab Test

Week 9

Topics: Lab 8 Flow Over Cylinder

Week 10

Topics: Lab 9 Turbulent Flow in Pipe

Week 11

Topics: Lab 10 Flow and Heat in a Mixing Elbow

Week 12

Topics: Lab 11 Project Help

5.3 Other Important Dates

Monday, January 8, 2024: First day of classes

Monday, February 19, 2024 – Friday, February 23 , 2024: Winter Break

5.4 Disclaimer

The instructor reserves the right to change any or all of the above in the event of appropriate circumstances, subject to the University of Guelph Academic Regulations.

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Assignments	25
Midterm	30
Lab Test	15
Project	30
Total	100

6.2 Assessment Details

Assignments (25%)
Learning Outcome: 1, 2
To be submitted electronically through CourseLink Dropbox.

Assignment 1 – Due 26 January (5%)

Assignment 2 – Due 9 February (5%)

Assignment 3 – Due 1 March (5%)

Assignment 4 – Due 15 March (5%)

Assignment 5 – Due 29 March (5%)

Midterm (30%)
Date: Fri, Mar 8, 8:30 AM - 9:50 AM
Learning Outcome: 1, 2
30% weight on March 8, Friday, in class time (8:30 am – 9:50 am)

Lab Test (15%)
Date: Week 8, Lab
15% in Week #8 during scheduled lab time

Project (30%)
Date: Fri, Apr 7
Learning Outcome: 2, 3, 4
Due Friday, April 7th 2023 – to be submitted electronically on CourseLink.

6.3 Important Notes

While you are encouraged to discuss with other classmates about the labs, there is zero tolerance for plagiarism or copying. Cases of academic misconduct will be reported.

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:

http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:

http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Late Assignments: Late submissions of assignments or project report will not be accepted. *10% mark deduction will be applied for every one hour late submission after the first hour.*

Passing Grades: The passing grade is 50%.

Questions Concerning Grades: If you have questions about the grade of your test/assignment received, please ask your TA within *one week* of the grade being released.

7.2 Relationships with other Courses & Labs

Previous Courses:

ENGG*2230: An introduction to many aspects of fluid properties, fluid motion, and engineering applications that involve fluid mechanics.

ENGG*3370: Relevant application of fluid mechanics.

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory

supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

9.9 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).
