Mech. Eng. 756
Introduction to Computational Fluid Dynamics

Graduate Studies
Fall 2023
Course Outline

CALENDAR/COURSE DESCRIPTION

Computational Fluid Dynamics (CFD) is increasingly being used to solve industrial problems involving heat transfer and fluid flow. To use commercial CFD codes intelligently, there must be a fundamental understanding of the equations being solved, the numerical techniques used, the performance of solvers, etc. This course focuses on the fundamentals of the conservation equations and their solution using a finite-volume approach. An understanding of those fundamentals is obtained by developing and experimenting with your own simple code. The assignments begin with simple one-dimensional problems (i.e., 1D conduction) and are eventually extended to model 2D fluid.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): Registration in Graduate Engineering program

Antirequisite(s): -

TIMETABLE

Lectures

Class Number	Day	Start Time		End Time	Room Number
C01 (5597)	Thursday	12:30 PM	to	1:30 PM	JHE 323

Lectures held weekly from September 7th to November 30th, 2023.

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Scott C. Simmons
Office: JHE 326
simmos6@mcmaster.ca

Office Hours:
Thursday – Time TBD
Or virtually/in-person by appointment

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

Avenue to Learn (hereafter: *Avenue*) is used to administer the course. These tools are used to increase efficiency. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, usernames for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor. *Avenue* can be accessed via the following link:

http://avenue.mcmaster.ca/

The course will be delivered in-person. If the course is required to be delivered online, the instructor may modify the course structure and assessment details to more appropriately support an online format. There will be plenty of notice given before any modifications are made. All course information will be communicated through *Avenue* - it is

your responsibility to regularly check the course webpage to stay appraised of course news and any changes in our delivery format.

MATERIALS AND FEES

Textbook:
Patankar, S.V., 'Numerical Heat Transfer and Fluid Flow', Hemisphere, 1980.

- Patankar's book provides a very physical description of finite volume methods. Despite being published in 1980, it is still one of the best books available on CFD and I strongly recommend purchasing it.

Other Helpful Resources (not required):
Versteeg, H. K. and Malalasekera, W., 'An Introduction to Computational Fluid Dynamics', Pearson, 2nd ed., 2007.

- I used this book in my undergraduate and graduate studies, as well as during my research. It is an excellent resource.

White, F, 'Fluid Mechanics', McGraw Hill, 7th ed., 2011

- This textbook is very commonly used in undergraduate studies, and introductory graduate studies. It is an excellent resource on fundamental (and some advanced) fluid mechanics material.

Notes:
Course notes will be posted on Avenue to Learn, you are expected to download the notes packets and supplement with your own notes made in class.

Calculator:
The McMaster Standard Calculator is the only calculator that may be used on the exam.

Drawing Instruments:
Your own ruler, compass, protractor, pencils will be required for assignments and exams.

COURSE TOPICS

Major topics include:

- 1D steady conduction
- Linearization of source terms
- Convergence, accuracy of schemes
- Iterative solvers (emphasis on multigrid)
- 1D transient conduction
- Convection/diffusion of a scalar
- False diffusion
- 1D solution of mass and momentum equations
- Staggered vs. colocated grids
- Segregated methods for simultaneous solution of mass and momentum (pressure-correction techniques)
- 2D solution of mass and momentum on Cartesian grids
- Modelling of turbulent flow (time-permitting)

EMAIL POLICY

Any emails directed to the instructor should include a subject prefix of "ME 756". Your email must be sent from your own McMaster University email account. Do not send any emails through Avenue. Please be brief but descriptive in your email, I will reply within 24 hours (during week days). I do not answer emails in the 24 hours prior to exams.

ASSESSMENT

Component	Weight
Assignments	50%
Final Exam	50%
Total	100%

ASSESSMENT DETAILS

Assignments

Assignments (5 in total, 10% each) are to be submitted INDIVIDUALLY to the "ME 756" drop box online by the time specified. Graded assignments will be returned via the assignment return box. Once assignments have been returned, late submissions will no longer be accepted.

Final Exam

A 2.5-hour final exam will be held in December (date TBD by the registrar). The final exam must be written or else a final grade of 'F' will be awarded with the notation Did Not Write. The standard 'numeric to letter grade' conversion will be used to assign the appropriate letter grade at the end of the course.

MSAF

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work". Should a student need to use the McMaster Student Absence Form (MSAF) for an assignment or in-class activity, the student must inform the instructor ahead of the missed deliverable. Depending on the situation, accommodations will be made to make up the marks.

Re-grading Policy

Re-grading will only be done within two-weeks of the return of the submission. The student must include a written note detailing the reason for the re-grade request.

EQUITY, DIVERSITY, AND INCLUSION

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as the problem occurs.

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics is committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the Equity and Inclusion Office.

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the Student Wellness Centre.

ACADEMIC INTEGRITY

Students are reminded that they should read and comply with the Statement on Academic Ethics and the Senate Resolutions on Academic Dishonesty as found in the Senate Policy Statements distributed at registration and available at the Senate Office. While interaction with your fellow students is expected in learning the course, assignments and projects submitted for academic credit must be your own work.

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g., the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the *Academic Integrity Policy*, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

The following illustrates only three forms of academic dishonesty:
1. plagiarism, e.g., the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

This course may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g., A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

This course uses on-line elements (e.g., e-mail, Avenue to Learn (A2L), etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, usernames for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-

line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

ONLINE PROCTORING

This course may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

CONDUCT EXPECTATIONS (THE "COMMON SENSE" CLAUSE)

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning, and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g., use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

In other words, everyone please be respectful and kind - we are all here to learn.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

1. It is the students' responsibility to regularly check the course webpage (e.g., *Avenue to Learn*) for updates and announcements related to this course.
2. All submissions are due at midnight (specifically, 11:59 PM on the due date)
3. Arrangements be made with the Instructor prior to any missed work/extensions/late submissions. Exceptions may be made regarding unforeseeable situations.
4. Late penalties will be applied at the Instructors discretion.

SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

1. **Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three calendar days:**

- Use the McMaster Student Absence Form (MSAF) on-line self-reporting tool. No further documentation is required.
- Students may submit requests for relief using the MSAF once per term.
- An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
- The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
- The MSAF cannot be used for academic work that has already been completed attempted.
- An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.
- The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.

2. **For medical or personal situations lasting more than three calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:**

   - Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
   - If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by university instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.