Price Faculty of Engineering
Department of Mechanical Engineering

Course Details

Course Number and Title: **MECG 7810 Computational Thermofluids**

Term: Winter 2024

Number of Credit Hours: 3

Lectures: Room E2-399. T,R: 14h30 to 16h55

Pre-Requisites: None. Having taken MECH 4822 would be a benefit. Experience programming with a high-level language is needed.

Student Contact Time:
Lectures: 3 hrs per week × 13 weeks = 39 hrs

Instructor Contact Information

Name: Dr. Scott J. ORMISTON, P. Eng.

Office Location: E1-484 EITC

Office Hours or Availability: M: 11h30 to 12h30; or by appointment

Email: engsjo@umanitoba.ca

Office Telephone: 204-474-8639

(All email communication must conform to the University of Manitoba electronic communication policy)

Textbook, Readings, Materials

Text book: Maliska, C., *Fundamentals of Computational Fluid Dynamics: The Finite Volume Method*, Springer, 2023.

Other References:

1. Ormiston, S.J., *MECG 7810 Computational Thermofluids Hand-out Notes*.
2. Ormiston, S.J., MECH 4822 *Numerical Heat Transfer and Fluid Flow Supplementary Course Notes* V4.0, Department of Mechanical & Manufacturing Engineering, University of Manitoba, September 2023.
3. Patankar, S.V., *Numerical Heat Transfer and Fluid Flow*, Hemisphere, Washington, 1980.
4. Ferziger, J.H., Peric, M., Street, R.L., *Computational Methods for Fluid Dynamics*, 4th. Edition, Springer Nature Switzerland, 2020.
5. Versteeg, H., Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd edition, Pearson, 2007

Course Web page: http://home.cc.umanitoba.ca/~engsjo/teaching/MECG-7810/

Other course materials will be available on UM Learn.

Course Goals

To provide a graduate student with the background and practical experience required to develop a computer program for the calculation of heat transfer and fluid flow using a Finite Volume Method. Emphasis will be given to physical interpretations in the development of equations and algorithms. Implementation considerations such as code structure and debugging will be part of this course.

Catalogue Description and General Course Content

An introduction to the solution of thermofluids problems. Computational techniques (finite difference, finite element, boundary element). Modelling of turbulent flow. Spectral methods.
Course Outline

- *Introduction*
- *Governing Equations and Mathematical Background*
- *Computational Grid Layout*
- *Heat Conduction*
- *Matrix Equation Solution Methods*
- *Convection Effects*
- *Calculation of the Flow Field*
- *Convection and Flow Calculation*
- *Selected Topics*

Course Evaluation Methods

Methods of Feedback: **F** - *formative* (written comments and/or oral discussion)**, S** - *summative* (number grades)

Assessment Tool	Due Date:	Value of Final Grade	Feedback Methods
Assignments (7)	Three assignments for hand-in. (A3 due 12 February 2024; A5 due 4 March 2024; A7 due 25 March 2024)	40% (A3: 12%; A5: 11%; A7: 17%)	F,S
Paper Review	11 April 2024	5%	F,S
Project	15 April 2024	15%	F,S
Final Exam	April 2024; specific day to be determined	40%	S

Note that the Voluntary Withdrawal (VW) date is 20 March 2024.

Grading Times

After submission of any work, the following timeframes can be used to determine when grades will be returned:

Component	**Grading Timeline**
Assignments	Within 2 weeks of submission

Grading

The grade boundaries shown are the historical boundaries for the course and are subject to slight modifications at the conclusion of the course to compensate for class averages and expectations.

Letter Grade	Percentage Range	Final Grade Point
A+	≥90	4.5
A	80-89.9	4.0
B+	75-79.9	3.5
B	70-74.9	3.0
C+	65-69.9	2.5
C	60-64.9	2.0
D	50-59.9	1.0
F	<50	0

Assignment Due Dates and Late Submission Policy

Late submissions will be assessed a deduction of 25% per calendar day late. A mark of zero will be assessed to submissions more than 4 calendar days late.

Introductory Comments

1. The text book (Maliska) is an excellent new, comprehensive reference Even though some of the algorithms that will be covered in this course have been developed since the book by Patankar was published, it provides a clear explanation of a finite volume method and this course will adopt a similar approach and philosophy. The book by Versteeg and Malalasekera provides an alternative viewpoint on the fundamentals and more up-to-date discussion of some special topics (e.g., multigrid, complex geometries, turbulence modelling). The book by Ferziger et al. is also an excellent reference for more recent information and often has more detail than the Versteeg and Malalasekera book.

2. The hand-out notes will serve to present the concepts and some of the important details of the numerical modelling process.

3. It is assumed that students taking this course have a good understanding of the fundamentals of fluid flow and heat transfer. Students should also be proficient in the use of a high level computer programming language such as FORTRAN, C, or MATLAB. The opportunity to learn code development in a Linux environment will be available.

4. An important feature of this course will be the development by each student of a computer code to simulate fluid flow and heat transfer for 2D laminar incompressible flow. This code development will help the student learn to deal carefully and precisely with many details of a numerical model. The program will be developed and applied in stages in a series of assignments. A project will be used to demonstrate the extension of the code to a natural convection flow solution.

Students will be expected to write and debug their own programs and, while students may discuss ideas with each other, they may not share computer code or results with their colleagues.

5. While students may make their own choices about nomenclature, programming language, and code structure, it is **strongly** recommended that they follow the structure and nomenclature that will be suggested in the course. Templates for code segments needed in the assignments will provided in FORTRAN. They are also available in C.

6. It is also **strongly** suggested that a student should take this course *only* if he or she has the need to have experience developing a CFD (Computational Fluid Dynamics) computer code. The code development in the assignments is very time-consuming and requires significant skills in computer programming and debugging. Previous experience has indicated that a person without those skills will be at a considerable disadvantage.

Using Copyrighted Material

Please respect copyright. We will use copyrighted content in this course. I have ensured that the content I use is appropriately acknowledged and is copied in accordance with copyright laws and University guidelines. Copyrighted works, including those created by me, are made available for private study and research and must not be distributed in any format without permission. Do not upload copyrighted works to a learning management system (such as UM Learn), or any website, unless an exception to the *Copyright Act* applies or written permission has been confirmed. For more information, see the University's Copyright Office website at http://umanitoba.ca/copyright/ or contact um_copyright@umanitoba.ca.

Recording Class Lectures

The instructor and the University of Manitoba hold copyright over the course materials, presentations and lectures which form part of this course. No audio or video recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission from Dr. Scott J. Ormiston, P. Eng. Course materials (both paper and digital) are for the participant's private study and research.

Course Technology

It is the general University of Manitoba policy that all technology resources are to be used in a responsible, efficient, ethical and legal manner. The student can use all technology in classroom setting only for educational purposes approved by instructor and/or the University of Manitoba Student Accessibility Services. Student should not participate in personal direct electronic messaging / posting activities (e-mail, texting, video or voice chat, wikis, blogs, social networking (e.g. Facebook) online and offline "gaming" during scheduled class time. If student is on call (emergency) the student should switch his/her cell phone on vibrate mode and leave the classroom before using it.

Class Communication

The University requires all students to activate an official University email account. For full details of the Electronic Communication with Students please visit:

http://umanitoba.ca/admin/governance/governing_documents/community/electronic_communication_with_students_policy.html

Please note that all communication between myself and you as a student must comply with the electronic communication with student policy. You are required to obtain and use your U of M email account for all communication between yourself and the university.

Expectations

Attendance at lectures and laboratories is essential for successful completion of this course. Students must satisfy each evaluation component in the course to receive a final grade. It is the responsibility of each student to contact the instructor in a timely manner if he or she is uncertain about his or her standing in the course and about his or her potential for receiving a failing grade. Students should also familiarize themselves with the General Academic Regulations and Requirements of the University of Manitoba dealing with regards to incomplete term work, deferred examinations, attendance and withdrawal. No programmable devices or systems, such as calculators, PDAs, iPods, iPads, cell phones, wireless communication or data storage devices, are allowed in examinations unless approved by the course instructor. See Respectful Work and Learning Environment Policy.

Academic Integrity:

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the General Academic Regulations and Requirements of the University of Manitoba, students are reminded that plagiarism or any other form of cheating in examinations, assignments, laboratory reports or term tests is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty.

In addition:

(i) Group projects are subject to the rules of academic dishonesty;

(ii) Group members must ensure that a group project adheres to the principles of academic integrity.

(iii) The limits of collaboration on assignments should be defined as explicitly as possible; and

(iv) All work is to be completed independently unless otherwise specified.

Students Accessibility Services

Student Accessibility Services

If you are a student with a disability, please contact SAS for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation.

Student Accessibility Services http://umanitoba.ca/student/saa/accessibility/

520 University Centre

204 474 7423

Student_accessibility@umanitoba.ca