**ME737**
**Special Topics in Thermo-Fluid Sciences – "Advanced Computational Fluid Dynamics"**
**Winter 2020**

## Purpose of Course:

Computational Fluid Dynamics (CFD) is a powerful tool for the design and analysis of a wide range of products and processes, from aerospace, power generation and chemical processes, to automotive, marine and even health care. Commercial CFD software is as dangerous as it is powerful, unless the user is knowledgeable of the fundamentals of fluid flow, advanced CFD numerics, and the methods employed. Equally important to the theory are the CFD Best Practices required to obtain high quality, error quantified, CFD simulations of value to engineering decision.

ME737 builds on the fundamentals of control volume based CFD methods introduced in ME756. The theory for numerical methods for unstructured multiple element three-dimensional discretisation and linear solution, the state-of-the-art in turbulence modeling approaches, as well as parallel processing, will each be covered. The students will perform practical exploration of the theory covered using a leading commercial CFD software package, experiencing the methods and models first hand. In addition, the practical aspects of CFD will focus on the development of Best Practice procedures designed to control and manage simulation error. Time and interest permitting, advanced modeling topics will be introduced.

## Recommended Textbooks:

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

Versteed, H.K. and Malalasekera, W., 'An Introduction to Computational Fluid Dynamics: The Finite Volume Method', 2nd Edition, Addison Wesley Longman Ltd., Harlow England, 2007.

White, F.M., 2016, Fluid Mechanics, 8th Edition, McGraw-Hill, Toronto.

| **Marking Scheme:** | | |
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| | Class participation: | 5% |
| | Assignments (4): | 45% |
| | Final project: | 50% |

Student engagement in the learning processes will be based on completion of learning activities, on participation in class discussions, and on contributions to maintaining a positive learning environment. There will be four substantial assignments during the first 2/3 of the course, which help prepare the student for the final project. The final project is in lieu of a final exam. In the final project you will analyse a fluid flow design change in a real-world application, and will present your results in a comprehensive professional report.

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

**Course Content:**

- Introduction to advanced CFD
- Review of governing equations
- Review of control volume methodology
- Unstructured meshing systems
- Diffusion and advection numerics for 3-D unstructured meshes
- Mass equation numerics for 3-D unstructured meshes
- Coupled algebraic multigrid linear solution methods
- Advanced meshing systems such as non-conformal interfaces
- Turbulence modeling introduction
- State of the art in RANS, URANS and scale resolving (LES) turbulence models
- Parallel computing by domain decomposition
- Quality control, error analysis and estimation
- Best practice procedures
- Advanced analysis topics such as turbomachinery, free surface flows, multiphase flows, reacting flows, time and interest permitting
- Two in-class hands on workshops in the use of the software (meshing, setup, solve, post process). Additional training in the use of the software occurs on the student's own time, using various online tutorials and resources.

**Additional Course Information:**
While the theory and concepts are generic, the practical aspects of the course are based on ANSYS CFX, written and marketed by ANSYS Inc. Students are required to have a laptop computer running Windows 7 or 10 for use throughout the course, with the latest ANSYS Student (e.g. Version 2019 R2) software installed. The software is free for academic use for one year: https://www.ansys.com/academic/free-student-products

*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.*

**Policy Reminder:**

*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.*

**McMaster University Statement on Academic Dishonesty**

Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and 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.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at http://www.mcmaster.ca/senate/academic/ac_integrity.htm

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. (Insert specific course information, e.g. style guide)
2. Improper collaboration in group work. (Insert specific course information)
3. Copying or using unauthorized aids in tests and examinations.