University of Manitoba

Price Faculty of Engineering
Department of Mechanical Engineering

Course Outline

Instructor
Dr. Scott J. Ormiston
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Office Hours
E1-484:
Fridays: 13h00 to 14h00
or by appointment

Teaching Assistant
Patrick Gareau
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Prerequisites
MATH 3132, MECH 2150, MECH 3460, MECH 3492

Course Information
Log into UM Learn

Contact Hours
4 credit hours
- Lectures:
  3 hours x 12 weeks = 36 hours
- Tutorials
  2 hours x 12 weeks = 24 hours

Important Dates

Term Tests
During tutorial time: **Nov. 22**

Voluntary Withdrawal
Nov. 21

Holidays & Reading Break
- Truth & Reconciliation: Oct. 2
- Thanksgiving: Oct. 9
- Fall Term Break: Nov. 14 to 17
- Remembrance Day: Nov. 13

MECH 4822 Numerical Heat Transfer and Fluid Flow (CRN 18617, A01) **Fall 2023**

Course Objectives
- Introduce some basic concepts, nomenclature, and methods of numerical modelling of heat transfer and fluid flow phenomena.
- Provide experience with numerical solution of heat transfer and fluid flow problems.
- Provide scientific computing experience using a Linux computing environment.
- Provide hands-on experience using commercial grid generation and flow calculation software.

Course Textbook and Learning Resources
Required textbooks:
1. Bergman, T.L., Lavine A.S., Fundamentals of Heat and Mass Transfer, 8th Ed., John Wiley and Sons, 2017.
2. Versteeg, H., Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd edition, Pearson, 2007.

Required supplementary notes:

Ormiston, S.J., MECH 4822 Numerical Heat Transfer and Fluid Flow Supplementary Course Notes, Department of Mechanical & Manufacturing Engineering, University of Manitoba, 2013. Available in pdf or from the University of Manitoba Bookstore (please contact the instructor).

Course Content
Supplementary Notes:
- Overview; Modelling; Computers and Software
- Governing Equations
- Discretisation and Taylor Series; Finite Volume Method
- Detailed Derivation of the Discretisation Equation; One-Dimensional Steady Conduction; Unsteady One-Dimensional Conduction; Source Term Linearisation; Two-Dimensional Conduction
- Convection and Diffusion
- Calculation of the Flow Field; Commercial CFD Computer Codes
- Computational Grids
- General Boundary Conditions
- Two-Dimensional Transport General Discretisation Equation

Bergman and Lavine Textbook:
- Chapter 3: Section 3.5: Conduction with Thermal Energy Generation (to end of 3.5.1); Section 3.6: Heat Transfer from Extended Surfaces

Versteeg and Malalasekera Textbook:

Chapter 1: Introduction (1.1 to 1.4)
Chapter 2: Conservation laws of fluid motion and boundary conditions (2.1 to 2.6; 2.8)
Chapter 3: Turbulence and its modelling (3.1 to 3.7)
Chapter 4: The finite volume method for diffusion problems (4.1 to 4.6).
Chapter 5: The finite volume method for convection-diffusion problems (5.1 to 5.8)
Chapter 6: Solution algorithms for pressure-velocity coupling (6.1 to 6.5; 6.7; 6.9)
Chapter 7: Solutions of discretized equations (7.1 to 7.6)
Chapter 8: The finite volume method for unsteady flows (8.1 to 8.4)
Chapter 9: Implementation of boundary conditions (9.1 to 9.8)
Chapter 10: Errors and uncertainty in CFD Modelling (10.1 to 10.8)

Accreditation Details

Accreditation Units

- Mathematics: 0%
- Natural Science: 0%
- Complementary Studies: 0%
- Engineering Science: 70%
- Engineering Design: 30%

Graduate Attributes

KB: knowledge base
PA: problem analysis
IN: investigation
DE: design
ET: engineering tools
IT: individual and team work
CS: communication skills
PR: professionalism
IE: impact of engineering on society / environment
EE: ethics and equity
EP: economics and project management
LL: life-long learning

Competency Levels

I - Introduced
D - Developed
A - Advanced

Grading Scale

Letter	Mark
A+	≥90
A	80-89.9
B+	75-79.9
B	70-74.9
C+	65-69.9
C	55-64.9
D	45-54.9
F	<45

The historical grade boundaries are shown above. These grade boundaries are subject to modifications at the conclusion of the course and are also subject to departmental review.

Course Components

Component	Location	Days of the Week	Time
Lectures	E2-164	Monday, Wednesday, Friday	9h30 to 10h20
Tutorials	E2-365; E2-164	Wednesday	14h30 to 16h20

Responsibilities and 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. Students must act in accordance with the *General Academic Regulations and Requirements.* Students are reminded that plagiarism or any other form of cheating in examinations, assignments, 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.

Copyright

All materials provided in this course are copyright. No part of the material protected by copyright law may be stored or redistributed in any manner without the express written permission of the relevant copyright holder.

Student Support and Resources

An extensive range of *resources and support services are available to students*, including: Academic Resources, Counselling, Advocacy and Accessibility.

Technology and other Resource Requirements

Students must be able to access UM Learn and will also require access to software such as Microsoft Office, MATLAB, ThinLinc, etc.

Learning Outcomes

1. Understand the key basic components of numerical modeling (model formation, truncation error, round-off error, grid independence, and time step independence).
2. Ability to derive a finite volume discretisation equation for 1D and 2D steady and unsteady diffusion transport equation (heat conduction).
3. Solve a set of algebraic equations for the solution field by various methods (hand calculation, spreadsheet, and high-level programming language).
4. Understand the derivation and use of an upwind difference advection scheme for a 1D advection-diffusion equation.
5. Learn and use commercial software for grid generation and CFD analysis to solve typical validation problems.
6. Learn to set up, analyze, and report the results of an open-ended application analysis using commercial CFD software.

Expected Competency Levels

Learning Outcome	Attribute											
	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	I											
2	I	D										
3		D			D							
4	I	I										
5	I	D			D							
6	I	A	D	D	A							

Evaluation

Assessment Tool	Value	Attributes Being Assessed	Feedback
Assignments (4)	**30 %**	KB.4: Knowledge base for specialized engineering science PA.2: Develops or implements a strategy PA.3: Analyzes and solves problems ET.1: Uses tools to complete engineering activities	Summative & Formative
Term Test	**10 %**	KB.4: Knowledge base for specialized engineering science PA.2: Develops or implements a strategy PA.3: Analyzes and solves problems	Summative & Formative
Project	**30 %**	PA.2: Develops or implements a strategy PA.3: Analyzes and solves problems PA.4: Evaluates solution IN.1: Gathers information and analyzes data IN.2: Implements appropriate methodology IN.3: Interprets results and reaches appropriate conclusions ET.1: Uses tools to complete engineering activities ET.3: Adapts or creates tools to meet specific analysis or design needs	Summative & Formative
Final Exam	**30 %**	KB.4: Knowledge base for specialized engineering science PA.2: Develops or implements a strategy PA.3: Analyzes and solves problems PA.4: Evaluates solution	Summative

- Submitted work will be graded and normally be returned within 2 weeks of submission
- Please view the schedule on UMLearn for a list of assessment and course component dates

Requirements and Regulations

- Assignments must be submitted prior to the deadline in order to receive marks. Late submissions of assignments will result in a deduction of 25% of the total mark per day.
- There will be no make-up term test.
- The weight of any assignment or test missed for a valid medical or compassionate reason will be transferred to the final exam.
- Students must satisfy each evaluation component in the course to receive a passing final grade.
- It is the responsibility of each student to contact the instructor in a timely manner if they are uncertain about their standing in the course and about the potential for receiving a failing grade.
- Students should also familiarize themselves with the *General Academic Regulations* and *Section 3 of the Price Faculty of Engineering Academic Regulations* regarding incomplete term work, deferred examinations, attendance and withdrawal. Students should also be aware of the *Respectful Work and Learning Environment Policy*, *Communications Policy*, as well as all other *regulations and policies*.
- No programmable devices or systems (such as calculators, iPads, cell phones, wireless communication, or data storage devices) are allowed in examinations unless approved by the course instructor.
- All work is to be completed individually and all submitted work must be the student's own work.
- Deferred exam requests must follow the *deferred exam policy* and are not at the discretion of the instructor.
- The *Temporary Absence Form* must be submitted to the course instructor if you are absent or unable to complete any component of the course for an approved extenuating circumstance.
- Please see the **MECH 4822 Supplementary Information** document for additional information on assignments, tests, expectations, advice on how to succeed in this course, copyright, recording lectures, course technology, class communication, academic integrity, and student accessibility services.