Course Details

Course Number and Title: MECH 4822 Numerical Heat Transfer and Fluid Flow

Term: Fall 2019

Number of Credit Hours: 4

Lectures: Room E2-164. MWF: 9h30 to 10h20

Tutorial: Room E2-360 (or other room TBA). M: 11h30 to 13h20

Pre-Requisites: MECH 2150 (or MATH 2120), MATH 3132 (or MATH 3100), MECH 3460 (or MECH 3470), MECH 3492 (or MECH 3490)

Student Contact Time:
Lectures: 3 hrs per week × 13 weeks = 39 hrs
Tutorials: 2 hrs per week × 12 weeks = 24 hrs

Web Page: http://home.cc.umanitoba.ca/~engsjo/teaching/MECH-4822/

Instructor Contact Information

Name: Dr. Scott J. ORMISTON
Office Location: E1-484 EITC
Office Hours or Availability: M: 14h00 to 15h00; T: 14h00 to 15h00; 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)

Teaching Assistant Contact Information

TA for Tutorials: Yasaman TOHIDI (tohidi@myumanitoba.ca)

Textbook, Readings, Materials

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, University of Manitoba Bookstore.

Required textbooks:

Reference Books for Numerical Methods, Numerical Heat Transfer, and Computing Languages

Sources of Help for Linux Questions
2. Unix Reference Notes, Rice University. (Available from the instructor).
3. Course tutorials and reference material from the instructor.

Other course materials: Available on UM Learn.

Course Objectives and General Course Content

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

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 Text book:
- 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 Text book:
Chapter 1: Introduction
All (Sections 1.1 to 1.4).

Chapter 2: Conservation laws of fluid motion and boundary conditions
Sections 2.1 to 2.6; Section 2.8.

Chapter 3: Turbulence and its modelling
Sections 3.1 to 3.7.

Chapter 4: The finite volume method for diffusion problems
All (Sections 4.1 to 4.6).

Chapter 5: The finite volume method for convection-diffusion problems
Sections 5.1 to 5.8.

Chapter 6: Solution algorithms for pressure-velocity coupling
Sections 6.1 to 6.5; Section 6.7; Section 6.9.

Chapter 7: Solutions of discretized equations
Sections 7.1 to 7.6.

Chapter 8: The finite volume method for unsteady flows
Sections 8.1 to 8.4.

Chapter 9: Implementation of boundary conditions
All (Sections 9.1 to 9.8).

Chapter 10: Errors and uncertainty in CFD Modelling
All (Sections 10.1 to 10.8).

Course Evaluation Methods
The final course grade is determined by the student’s performance on the components tabulated below. Methods of Feedback: F - formative (written comments and/or oral discussion), S - summative (number grades). Note that the Voluntary Withdrawal (VW) date is 18 November 2019.

<table>
<thead>
<tr>
<th>Assessment Tool</th>
<th>Due Date:</th>
<th>Value of Final Grade</th>
<th>Feedback Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments (4)</td>
<td>See the table below</td>
<td>30%</td>
<td>F,S</td>
</tr>
<tr>
<td>Term Test</td>
<td>November 20, 2019</td>
<td>10%</td>
<td>F,S</td>
</tr>
<tr>
<td>Project</td>
<td>See the table below</td>
<td>30%</td>
<td>F,S</td>
</tr>
<tr>
<td>Final Exam</td>
<td>TBA (3 hours, in the exam period)</td>
<td>30%</td>
<td>S</td>
</tr>
</tbody>
</table>

Assignment Descriptions, Due Dates and Late Submission Policy

- The plan of the assignments for the course is:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Topic</th>
<th>Out</th>
<th>Due</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grid Generation; Parallel Plate Channel and Cylinder External Flow</td>
<td>11 Sep. 2019</td>
<td>30 Sep. 2019</td>
<td>10%</td>
</tr>
</tbody>
</table>
• Late submissions of assignments will result in a deduction of 25% of the total mark per day.
• Solutions to the assignments will be posted on UM Learn after the submission date of the assignment. Contact the instructor if you want a hard copy of the solutions.
• There will also be self-study assignments that cover material that may be on term tests or the final exam. Those assignments will not be graded and solutions for them will be available on UM Learn.

Project Information
• The design project will be done individually.
• The design project timetable is as follows:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Handed Out</th>
<th>Progress Report Due (Value 10%)</th>
<th>Final Report Due (Value: 20%)</th>
</tr>
</thead>
</table>

Examinations
• The term test and the final examination are open textbook and open supplementary notes. Course notes are not allowed during these examinations and no problem solutions may be written in the textbooks or supplementary notes. Students are encouraged to highlight important relations and to write comments in the margins of the textbook. Additional pages may not be added to the textbooks.
• In order to help students prepare for the term tests and the final examination, some examples from previous years (with solutions) will be made available for review at an appropriate time on UM Learn.
• A student card (or equivalent photo identification) will be required at the term test and the final examination.
• Electronic devices other than dedicated calculators are not permitted during the term test and the final examination. A non-dedicated calculator device serving as a calculator (e.g., a mobile phone running a calculator application) is not allowed.
• There will be no make-up term test. The weight of the final exam will be adjusted to include the weight of any term test that was missed for an accepted reason.
• The solution to the term test will be posted on UM Learn.

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Grading Timeline</th>
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<tbody>
<tr>
<td>Term Test</td>
<td>Within 2 weeks of submission</td>
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<tr>
<td>Assignments</td>
<td>Within 2 weeks of submission</td>
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<tr>
<td>Project Progress Report</td>
<td>Within 2 weeks of submission</td>
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</tbody>
</table>
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 and are subject to departmental review.

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Percentage Range</th>
<th>Final Grade Point</th>
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<tbody>
<tr>
<td>A+</td>
<td>≥90</td>
<td>4.5</td>
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<tr>
<td>A</td>
<td>80 to 89.9</td>
<td>4.0</td>
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<tr>
<td>B+</td>
<td>75 to 79.9</td>
<td>3.5</td>
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<tr>
<td>B</td>
<td>70 to 74.9</td>
<td>3.0</td>
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<tr>
<td>C+</td>
<td>65 to 69.9</td>
<td>2.5</td>
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<tr>
<td>C</td>
<td>55 to 64.9</td>
<td>2.0</td>
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<tr>
<td>D</td>
<td>45 to 54.9</td>
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<td>F</td>
<td>&lt;45</td>
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How to Succeed in this Course
- Attend all lectures and tutorials.
- Take notes during lectures and participate in class discussions.
- Bring your textbook and handouts to the lectures and tutorials.
- Keep up to date with the course material. After each lecture: review your lecture notes, read the related material from the textbooks as appropriate, and review related example problems in the textbook and from the lecture.
- Submit all assignments.
- Consult with the instructor and the teaching assistant regarding any difficulties in understanding the course material.
- Do not leave solving problems to the last minute. Give yourself time to work through the problems and to understand the concepts and methods.
- Prepare for the term test and the final examination by working through example term tests and final examinations without referring to the solutions.

Intended 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. 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 (ANSYS Mesher or ICEM CFD) and CFD analysis (ANSYS CFX) to solve typical validation problems.

6. Learn to set up, analyze, and report the results of an open-ended application analysis using ANSYS CFX.

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>KB</th>
<th>PA</th>
<th>IN</th>
<th>DE</th>
<th>ET</th>
<th>IT</th>
<th>CS</th>
<th>PR</th>
<th>IE</th>
<th>EE</th>
<th>EP</th>
<th>LL</th>
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**Attributes:**

- **KB**: A knowledge base for engineering science
- **PA**: Problem analysis
- **IN**: Investigation
- **DE**: Design
- **ET**: Use of engineering tools
- **IT**: Individual and team work

**Levels:**

- **I**: Introduced
- **D**: Developed
- **A**: Applied

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**MECH 4822 Assessments, Attributes, and Indicators**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Attributes Covered</th>
<th>Indicators being assessed (explicit or implicit)</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments (4)</td>
<td>30%</td>
<td>1 Knowledge Base</td>
<td>KB.4: Knowledge base for specialized engineering science</td>
<td>S,F</td>
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<td></td>
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<td>2 Problem Analysis</td>
<td>PA.2: Develops or implements a strategy</td>
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<td>PA.3: Analyzes and solves problems</td>
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<td>5 Engineering Tools</td>
<td>ET.1: Uses tools to complete engineering activities</td>
<td></td>
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<tr>
<td>Term Test</td>
<td>10%</td>
<td>1 Knowledge Base</td>
<td>KB.4: Knowledge base for specialized engineering science</td>
<td>S,F</td>
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<td>PA.3: Analyzes and solves problems</td>
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<tr>
<td>Project</td>
<td>30%</td>
<td>2 Problem Analysis</td>
<td>PA.2: Develops or implements a strategy</td>
<td>S,F</td>
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<td></td>
<td>PA.3: Analyzes and solves problems</td>
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<tr>
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<td>3 Investigation</td>
<td>IN.1: Gathers information and analyzes data</td>
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<td>IN.2: Implements appropriate methodology</td>
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<td></td>
<td></td>
<td>IN.3: Interprets results and reaches appropriate conclusions</td>
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<tr>
<td></td>
<td></td>
<td>5 Engineering Tools</td>
<td>ET.1: Uses tools to complete engineering activities</td>
<td>S,F</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>ET.3: Adapts or creates tools to meet specific analysis or design needs</td>
<td></td>
</tr>
<tr>
<td>Final Exam</td>
<td>30%</td>
<td>1 Knowledge Base</td>
<td>KB.4: Knowledge base for specialized engineering science</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Problem Analysis</td>
<td>PA.2: Develops or implements a strategy</td>
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<td>PA.3: Analyzes and solves problems</td>
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<td>PA.4: Evaluates solution</td>
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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 the instructor. Course materials (both paper and digital) are for the participants’ 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 a student is on call (emergency) the student should switch his/her cell phone on vibrate mode and leave the classroom before using it. (©S Kondrashov. Used with permission)

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/media/Electronic_Communication_with_Students_Policy_-_2014_06_05.pdf

Please note that all communication between the instructor and you as a student must comply with the electronic communication with student policy http://umanitoba.ca/admin/governance/governing_documents/community/electronic_communication_with_students_policy.html. 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 electronic devices, such as programmable calculators, PDAs, iPods, iPads, cell phones, wireless
communication or data storage devices, are allowed in lectures, tutorials, or 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, Section 8.1, 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.

**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/](http://umanitoba.ca/student/saa/accessibility/)*

520 University Centre
204 474 7423

*Student_accessibility@umanitoba.ca*