ECE 4530 – Parallel Processing

IMPORTANT NOTICE – Mandatory Requirement to Report

This course will be conducted using remote instruction. Students who are accessing the course from outside of Canada or the USA must notify the instructor and indicate in which country they are located. Access to software may be restricted from some countries and failure to comply with these restrictions may result in criminal prosecution.

Course Objectives

The objectives of this course are to introduce students to High-Performance Computing (HPC) and to give students the ability to understand, analyze, design and implement parallel software solutions. Students will develop skills in writing message-passing parallel codes for accelerating computational problems. Core concepts such as parallel efficiency and load balancing will be covered. The course features detailed analysis of effective techniques for parallel processing of inherently parallel problems and provides a foundation for critically analyzing current and future HPC solutions. Additionally, General Purpose Graphics Processing Units (GPGPUs) will be introduced as parallel co-processors.

Course Content

The following topics will be covered:

- Basic parallel computer architectures
- Parallel computing using the Message-Passing Interface (MPI)
- Evaluating parallel programs
- Partitioning strategies
- Load balancing
- Algorithms and applications
- Co-processor acceleration using GPGPUs.

Laboratories

There will be five labs covering the following topics:

1. Point-to-point and collective communication using MPI
2. Embarrassingly parallel computations
3. Divide-and-conquer computations
4. Synchronous computations
5. Shared memory computing using OpenMP

Textbook


[Not required.]

Learning Outcomes

1. A working knowledge of the Message-Passing Interface (MPI) and its use in parallel software solutions.
2. The ability to analyze a problem and to design and implement parallel strategies for its solution with an emphasis on the trade-offs between time and memory efficiency.
3. Experience with various types of parallelization patterns/algorithms (divide-and-conquer, pipeline, load-balancing) and their application to real-world large-scale engineering computations and software.
4. Familiarity with different parallel hardware architectures (distributed/cluster computing, shared memory systems, and heterogeneous parallel systems) and their influence on parallel software design decisions.
5. The ability to apply parallel programming concepts and skills to emerging and future high-performance computing systems.
Evaluation

The final course grade is determined by the student’s performance on assignments, in laboratories, and on examinations. Students must complete all laboratories and receive a passing grade on the final examination in order to be eligible to receive a passing grade.

*Method of Feedback: F - Formative (written comments and/or oral discussion), S - summative (numerical grade)

CEAB Graduate Attributes Assessed

KB.4 – Recalls and defines, and/or comprehends and applies, first principles and concepts in specialized engineering science.

PA.3 – Analyzes and solves complex engineering problems.

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 on Academic Integrity, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalty.

Requirements and Regulations

- 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 University’s General Academic Regulations, as well as Section 3 of the Faculty of Engineering Academic Regulations dealing with 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.
- Students should be aware that they have access to an extensive range of resources and support organizations. These include Academic Resources, Counselling, Advocacy and Accessibility Offices as well as documentation of key University policies e.g. Academic Integrity, Respectful Behaviour, Examinations and related matters.

Accreditation Details

Accreditation Units
- Mathematics: 0%
- Natural Science: 0%
- Complementary Studies: 0%
- Engineering Science: 65%
- Engineering Design: 35%

Graduate Attributes

KB: A knowledge base for engineering
PA: Problem analysis
IN: Investigation
DE: Design
ET: Use of 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

1 - Knowledge (Able to recall information)
2 - Comprehension (Ability to rephrase information)
3 - Application (Ability to apply knowledge in a new situation)
4 - Analysis (Able to break problem into its components and establish relationships.)
5 - Synthesis (Able to combine separate elements into a whole)
6 - Evaluation (Able to judge the worth of something)

Grading Scale

<table>
<thead>
<tr>
<th>Letter</th>
<th>Mark</th>
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<tbody>
<tr>
<td>A+</td>
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<td>F</td>
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Note: These boundaries represent a guide for the instructor and class alike. Provided that no individual student is disadvantaged, the instructor may vary any of these boundaries to ensure consistency of grading from year-to-year.

Expected Competency Levels

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<thead>
<tr>
<th>Component</th>
<th>Value (%)</th>
<th>Method of Feedback</th>
<th>Learning Outcomes Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments</td>
<td>15</td>
<td>F, S</td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Laboratories</td>
<td>25</td>
<td>F, S</td>
<td>1, 2, 3, 5</td>
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<tr>
<td>Term Test</td>
<td>20</td>
<td>F, S</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Final Examination</td>
<td>40</td>
<td>S</td>
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Retention of Student Work

Students are advised that copies of their work submitted in completing course requirements (i.e. assignments, laboratory reports, project reports, test papers, examination papers, etc.) may be retained by the instructor and/or the department for the purpose of student assessment and grading, and to support the ongoing accreditation of each Engineering program. This material shall be handled in accordance with the University’s Intellectual Property Policy and the protection of privacy provisions of The Freedom of Information and Protection of Privacy Act (Manitoba). Students who do not wish to have their work retained must inform the Head of Department, in writing, at their earliest opportunity.