University of Manitoba
Price Faculty of Engineering
Department of Electrical and Computer Engineering

Course Outline

Instructor

- Prof. Peng Hu, P.Eng.
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Office Hours
- By appointment.

Teaching Assistant
- Nasrin Abharian
  abharian@myumanitoba.ca

Contact Hours
- 4 credit hours
- Lectures:
  3 hours x 13 weeks = 39 hours
- Laboratories:
  3 hours x 5 weeks = 15 hours

Prerequisites:
- ECE 3610 Microprocessor Systems

Traditional Territories Acknowledgement

The University of Manitoba campuses and research spaces are located on original lands of Anishinaabeg, Ininiwak, Anisininewuk, Dakota Oyate, Dene and Inuit, and on the National Homeland of the Red River Métis.

We respect the Treaties that were made on these territories, we acknowledge the harms and mistakes of the past, and we dedicate ourselves to move forward in partnership with Indigenous communities in a spirit of Reconciliation and collaboration.

ECE 4560 – Modern Computing Systems

Fall 2025

Course Objectives

This course introduces advanced topics in computer architecture and organization. Topics include instruction set architecture, performance measures, pipeline processor design, data and instruction cache, data dependencies, branch prediction and penalties, and multiprocessor system design. As well, this course is concerned with an engineering approach to selecting and interconnecting hardware components to create computers that meet functional, performance and cost goals. The course covers improvements and refinements to the basic computer designs as taught in undergraduate courses, and is intended to be a successor of same. Therefore, it is crucial that students have a good grasp of basic computer architecture as taught at ECE 3610 or in similar classes elsewhere.

Course Content

The following topics will be covered:

- Instruction Set Architecture
  - Components, Instruction Lengths and Formats, Very Long Instruction Word, ARM, MIPS
- Performance – Meaning and Metrics
  - Computer Metrics – efficiency, throughput, latency, etc.
  - Moore's Law, Amdahl's Law
  - MIPS, MFLOPS, SPEC, and benchmarks
- Processor Control
  - Hardwired vs. Microprogram
  - Pipelining
    - Data and Branch Hazards, Stalls, and Branch Penalty
    - Static and Dynamic Branch Prediction and Speculative Execution
- Cache Memory Systems
  - (Fully Associative, Direct Mapped, Set-Associative, and Pseudo-Associative) Cache Structure
  - Performance
  - Considerations of Cache Design
- Input/Output
  - Advanced Interrupt Strategies
  - Computer Bus
    - History, review, and evolutionary perspectives of computer buses: VME, NuBus, PCI, PCIe, Firewire, USB
    - Bus Arbitration
- Parallel Processing and Multicore
  - Superscalar, multithreading, parallel processing, multi-core CPUs
  - In-order and out-of-order instruction execution
  - Multiple-instruction instruction word
  - Superscalar pipelining
  - Compiler and hardware instruction level parallelism
  - Cache Coherency
  - Multiprocessor Topologies
    - Partial and Fully Connected (Crossbar, Butterfly, Cluster, Multiprocessor Interconnection Networks)

Important Dates

- **Term Test**
  November 5th, 2025
  6:00PM – 8:00PM
- **Voluntary Withdrawal Deadline**
  November 18th, 2025
- **National Day for Truth and Reconciliation**
  September 30th, 2025
  No classes or examinations
- **Thanksgiving Day**
  October 13th, 2025
  No classes or examinations
- **Remembrance Day**
  November 11th, 2025
  No classes or examinations
- **Fall Term Break**
  November 10th –14th, 2025
  No classes or examinations

Accreditation Details

Accreditation Units

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

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)

Textbook

Computer Organization and Architecture – Themes and Variations, A. Clements, Cengage Learning, 2014. ISBN-13: 978-1-111-98704-6.

Other Resources

Computer Architecture: A Quantitative Approach, J. Hennessy and D. Patterson, Morgan Kaufmann Publishers, 2003.

Learning Outcomes

1. Identify advanced topics in computer architecture and organization.
2. Demonstrate the ability to create new macroinstructions by designing new and reusing existing microinstructions.
3. Demonstrate the ability to analyze a given pipelined system and identify potential hazards.
4. Demonstrate the ability to analyze a given parallel processing and multicore system, and performance metrics in the design of an embedded system..

Expected Competency Levels

Outcome	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	2	2		2	2		2					2
2	2	2	3	3	3		3					
3	2	3	3	3	3		3					
4	2	3	3	3	3		3					

Evaluation

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

Component	Value (%)	Method of Feedback	Learning Outcomes Evaluated
Projects	30	F, S	1, 2, 3, 4
Term Test	20	F, S	1, 2, 3, 4
Final Examination	50	S	1, 2, 3, 4

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

CEAB Graduate Attributes Assessed

PA.2 – Develops and/or implements a strategy to analyze complex engineering problems.

CS.1 – Designs and produces effective written an graphical engineering documents for specific audiences (e.g. research reports, engineering reports, design documents.)

Student Absences

Attendance in lectures, tutorials, and laboratories is mandatory. For short-term absences due to illness or other extenuating circumstances of 120 hours (5 days) or less, students are required to complete a *Self-Declaration Form for Brief or Temporary Absence* available on the University website.🔗 This form must be submitted to the course instructor within 48 hours of the absence. (No additional documentation is required.)
Note that students are responsible to complete any missed work and must consult with the instructor to make appropriate arrangements.
For absences longer than 120 hours, students must contact the instructor and ECE Undergraduate Advisor, Tammy Holowachuk (Tammy.Holowachuk@umanitoba.ca) for further instructions.

Grading Scale

Letter	Mark
A+	95–100
A	85–94
B+	80–84
B	70–79
C+	65–69
C	55–64
D	45–54
F	< 45

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.

Deferred Final Examinations

Students who miss the regular scheduled writing of a final examination, for valid medical or compassionate reasons, may be given the opportunity to write a deferred examination, subject to approval by the Associate Dean (Undergraduate). All requests for a deferred examination must be made within 48 hours of the missed examination, and must follow the procedure described on the Faculty website, without exception. Course instructors do not have the discretion to grant deferred final examinations. (https://umanitoba.ca/engineering/student-experience#engineering-student-policies)

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). This includes the unauthorized use of AI when preparing course deliverables. A student found guilty of contributing to cheating by another student is also subject to serious academic penalty. Integrity also applies to respecting copyrighted course content, which should not be distributed without the creator's permission. Uploading content for the purpose of transcription or other AI-enabled features is commonly a violation of the copyright holder's rights.

Copyright Notice

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.

🔗 *Supplemental Resources*

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.