

COMP ENG 4DM4 Embedded Systems

COURSE OUTLINE

Please refer to course website for updated information.

COURSE DESCRIPTION

Overview of CISC/RISC microprocessors; performance metrics; instruction set design; processor and memory acceleration techniques; pipelining; scheduling; instruction level parallelism; memory hierarchies; multiprocessor structures; storage systems; interconnection networks.

PRE-REQUISITES AND ANTI-REQUISITES

Pre-requisite(s): COMPENG 3DQ5, or permission of the department.

SCHEDULE and MODE OF DELIVERY

Lectures:

- Mondays and Thursdays 12:30PM – 1:20PM **JHE 264**
- Tuesdays 1:30PM – 2:20PM **JHE 264**

Tutorial: Wednesdays 11:30AM – 12:20PM **HSC 1A1**

Lab: Lab starts on September 14th, 2026 in-person in room **ITB 234** as follows

L01 Tuesdays 2:30-5:20pm	Sep 22, Oct 6, Oct 27, Nov 10, Nov 24
L02 Wednesdays 2:30-5:20pm	Sep 16, Sep 30, Oct 21, Nov 4, Nov 18
L03 Wednesdays 2:30-5:20pm	Sep 23, Oct 7, Oct 28, Nov 11, Nov 25
L04 Thursdays 2:30-5:20pm	Sep 17, Oct 1, Oct 22, Nov 5, Nov 19
L05 Thursdays 2:30-5:20pm	Sep 24, Oct 8, Oct 29, Nov 12, Nov 26
L06 Fridays 2:30-5:20pm	Sep 18, Oct 2, Oct 23, Nov 6, Nov 20
L07 Fridays 2:30-5:20pm	Sep 25, Oct 9, Oct 30, Nov 13, Nov 27
L08 Mondays 2:30-5:20pm	Sep 14, Sep 28, Oct 19, Nov 2, Nov 16
L09 Mondays 2:30-5:20pm	Sep 21, Oct 5, Oct 26, Nov 9, Nov 23
L10 Tuesdays 2:30-5:20pm	Sep 15, Sep 29, Oct 20, Nov 3, Nov 17
L11 Tuesdays 6:30-9:30pm	Sep 21, Oct 5, Oct 26, Nov 9, Nov 23

**** All Lab Sessions from Nov 30 – Dec 10 are reserved for Drop-in Project Demo.**

INSTRUCTOR

Dr. Scott Chen
E-mail: chenw184@mcmaster.ca
Office: ITB-A316
Phone: 905-525-9140 ext. 26063
Office Hours: By appointment – see course website for details

TEACHING ASSISTANTS

Names, contact information and office hours are provided on the course website.

COURSE WEBSITE/S

<http://avenue.mcmaster.ca>

COURSE OBJECTIVES

By the end of this course, students should have design exposure and be able to:

- Analyze and assess performance of computing systems
- Hardware Design single cycle, multicycle, and pipelined processors
- Multithread and multicore processors systems
- Caches and Memory Systems

ASSUMED KNOWLEDGE

Good knowledge of digital logic and digital systems design, and a previous exposure to Hardware Descriptive language Verilog / VHDL.

COURSE MATERIALS

Required Texts:

No specific textbook. Lecture notes and lab manuals will be posted on A2L.

Calculator:

Only the McMaster Standard Calculator (Casio fx-991 MS or MS Plus) is permitted in tests and examinations. This is available at the Campus Store.

Reference Texts:

Ref 1- Patterson and Hennessy, "Computer Organization and Design" 6th edition Elsevier/Morgan
Kaufman Ref 2- Hennessy and Patterson, "Computer Architecture: A Quantitative Approach", 5th Edition

Other:

Lecture notes, lab manuals, and online videos

COURSE OVERVIEW

Week	Topic	Readings
1	Introduction to Computer organization and Architecture, CISC & RISC Architectures. Performance, Benchmarks & Amdahl's law	Ref1- Ch 1, Lecture Notes
2,3	Instruction Set Architecture (ISA) Basics, MIPS assembly programming, Hardware/Software interface.	Ref1- Ch 2., Lecture Notes
4	Single Cycle CPU datapath and control path	Ref1- Ch. 4, Lecture Notes
5,6	5-stage pipelined processor, pipeline hazards, data forwarding, branch- stalls, exception	Ref1- Ch. 4, Ch. 6, Lecture Notes
7,8	Memory Hierarchy Design, Cache and VM	Ref1- Ch. 5, Lecture notes
9,10	Parallel Processing, Static and Dynamic scheduling	Ref2- Ch. 3, Lecture notes
11	Multithreading, Multicore and example	Ref2- Ch. 4, Lecture notes
12	Advance Architectural topics	Ref2- Ch. 5, Ch. 6, Lecture notes

A more detailed time line is available on the course website.

At certain points in the course, it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

LABORATORY OVERVIEW

Labs are NOT held during the first week of term.

Lab	Topic
1	Introduction, environment, github classroom, MacSim simulator, Pintool, Performance Measurements
2	- In-order vs Out-of-Order Processors - Pipelining
3	Caches
4	DRAMs

LABORATORY OPERATION

- Each student in the course is required to pass the lab safety quiz prior to attempting any of the laboratories. The video and quiz will be on Avenue to Learn.
- Access to all labs is restricted in the interest of security and safety. Although we will not access the labs on campus for this term, information on accessing and using the lab can be found on the webpage: <https://www.eng.mcmaster.ca/ece/labs-and-health-safety#Labs-Access-and-Use>
- Lab Experiments: Every student conducts the lab experiment individually at home.
- Lab Requirements: Students need to submit their experiment results on Avenue to Learn on the due date described in the lab manual. No late submission will be accepted.

ASSESSMENT

Component	Weight
Labs (4)	25 %
	(Lab1: 4%, Lab2: 7%, Lab3: 7%, Lab4: 7%)
Project	25%
Midterm	15%
Final Exam (1)	35 %
Total	100 %

Grading and Evaluation Policies

- There are four (4) labs, one (1) project, one (1) midterm, and one (1) final exam to be evaluated in this course.
- Use of books, notes, other copied materials, computers or cell phones are not allowed during exams.
- Having a passing grade in the final exam (at least 50% of the total final grade) is a must to pass the course

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty. Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour 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. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at <https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/>

The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the

electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online. It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make

arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations.

Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

ACCREDITATION LEARNING OUTCOMES

Note: The *Learning Outcomes* defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: <http://www.engineerscanada.ca>.

Outcomes	Indicators	Measurement Method(s)
Identifies and states reasonable assumptions and suitable engineering fundamentals, before proposing a solution path to a problem.	2.1	Students are asked to state assumptions, which are deemed necessary towards their solution of any design or analysis problem they were provided with in the midterm or final exams
Selects appropriately from relevant knowledge base to plan appropriate data collection methods and analysis strategies.	3.1	Students will be assessed during the demo of labs and projects on their ability to connect practice to fundamental engineering concepts

Synthesizes the results of an investigation to reach valid conclusions.	3.2	Students during labs are asked to collect data and use it to reach a conclusion that they state in their lab reports
Defines the problem by identifying relevant context, constraints, and prior approaches before exploring potential design solutions.	4.1	Throughout labs, students are assessed in their knowledge of using state-of-the-art architectural solutions, their limitations and potential benefits
Explores a breadth of potential solutions, considering their benefits and trade-offs as they relate to the project requirements.	4.2	In the projects, the students explore several solutions (architectures and designs) on their own and choose the one that best fits their project needs. They are asked to list their design choices and associated trade-offs in the project report

www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory and online <https://hr.mcmaster.ca/app/uploads/2019/07/2019-McMaster-Lab-Manual.pdf>

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following whether conducting lab work at school or at home:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.
9. Personal ergonomics should be practiced when conducting lab work. <https://bit.ly/3fOE71E>
10. Current University health and safety issues, and protocol should be known. <https://hr.mcmaster.ca/resources/covid19/workplace-health-and-safety-guidance-during-covid-19/>

Location of Safety Equipment

Fire Extinguisher

On walls in halls outside of labs

First Aid Kit

ITB A111, or dial “88” after 4:30 p.m.

Telephone

On the wall of every lab near the door

Fire Alarm Pulls

Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.

Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.

University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.

See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs

Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.

ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (On Campus Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In power labs, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol For Safe Laboratory Practice

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	