

**COMP ENG 4DM4  
Computer Architecture**

**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**

Prerequisite(s): Registration in level III or IV in any Computer Engineering or Electrical Engineering Program, COMPENG 3DR4  
Antirequisite(s): COMPSCI 2GA3, SFWRENG 2GA3, 3GA3

**SCHEDULE And MODE OF DELIVERY**

The material for this course will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded), and virtualized laboratories. The platform for each component is noted at the end of each line.

Lecture: Monday, Wednesday 8:30Am – 9:20Am & Friday 10:30Am – 11:20Am – on Zoom  
Tutorial: – Monday 11:30AM - 12:20PM on Zoom / MacVideo  
Lab: Every Other Week L01, L03, L05 on Wednesdays, Thursdays and Fridays 2:30PM - 5:20PM. Using Zoom / WebEx

**INSTRUCTOR**

Dr. Mohamad Abou El Nasr  
Email: [abouem@mcmaster.ca](mailto:abouem@mcmaster.ca)  
Office Hours: Fridays 11:30AM – 1:00PM; and by appointment.

Please note that during the university closures due to Covid-19 in the Fall Term, instructors will not be in their offices. Please see the course website for clarification on their availability.

**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 to:

- Hardware Design single cycle, multicycle and pipelined
- Multithread and multicore processors systems
- Domain Specific Architecture
- Able to Analyze and assess performance of computing systems.

#### ASSUMED KNOWLEDGE

Computer Architecture 4DM4 is an advanced level course suitable for students with previous exposure to introductory courses on computer architecture, digital logic and digital systems design.

#### COURSE MATERIALS

##### Required Text:

[1] Computer Organization and design 5<sup>th</sup> Edition (or recent) by Patterson and Hennessy, Elsevier/Morgan Kaufman ISBN 978-0-12-407726-3

##### Reference Text:

[1] Computer Architecture: A Quantitative Approach”, 5<sup>th</sup> Edition by Hennessy and Patterson

##### Calculator:

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

##### Other:

Class Lecture Notes available at Avenue-to-Learn

## COURSE OVERVIEW

Week	Topic	Readings
1	Intro., Performance, Benchmarks & Amdahl's law.	Text Ch. 1, lecture notes
2	VHDL programming, Instruction Set Architecture (ISA) basics and MIPS Single Cycle CPU -datapath and control path.	Text Ch. 2, lecture notes
3	5-stage pipelined processor, pipeline hazards, data forwarding, branch- stalls, exceptions	Text Ch. 4,6, lecture notes
4	Memory Hierarchy design	Ref. Ch. 2, lecture notes
5	Static scheduling, loop unrolling	lecture notes
6	HW and assignments solutions and Sample problems	In-class exercises
7	Midterm, Midterm-solutions, dynamic scheduling	lecture notes
8	Instruction level parallelism and performance analysis	Ref. Ch.3, lecture notes
9	Dynamic Scheduling: Non-speculative vs Speculative machines, Pentium Processors, ARM processors	lecture notes
10	Thread level parallelism	Ref. Ch. 5, Lecture notes
11	Multithreading, Multicore and examples	lecture notes
12	Domain Specific Architecture	Text Ch. 6, Ref. Ch. 7 lecture notes
13	Course Review	lecture notes

A more detailed time line is available on the course web site. 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

Week	Topic
1	No Labs
2	<b>Lab#1</b> Part A - Introduction to VHDL and FPGAs, PART B - Counter design
3	Practice and work on Lab #1
4	<b>Lab#2</b> Design an ALU for specific calculations (GCD) and Lab#1 demonstration
5	Practice and work on Lab #2
6	<b>Lab #3</b> Design single cycle processor (Part1) Design a 16-bit single cycle MIPS CPU and the Instruction Fetch Unit, the Instruction Decode and the main control unit Testing the design Arithmetical-Logical Instructions.
7	Practice and work on Lab #3
8	<b>Lab#4</b> Design single cycle processor (Part2) design Memory Unit & Write Back Unit & Other necessary connections for branch / jump address computation & Test the Single-Cycle MIPS CPU
9	Practice and work on Lab#4
10	<b>Lab#5</b> pipelined version of the MIPS 16-bit CPU and modified to operate hazards free
11	Practice and work on Lab#5
12	Labs demonstrations
13	Labs demonstrations

### 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.
- The labs for this course will be held virtually via zoom/webex and will be mainly simulation based.
- The labs will be performed in groups of two / three students holding virtual meetings and communicating online as needed.
- Each lab will involve a significant amount of work.
- The lab work will be assessed by TAs via student demonstrations and/or reports. Evaluation and assessments of lab is carried at announced times by the TAs - usually two weeks after the Lab first and initial delivery.
- The TAs and the instructor reserve the right to interview students to assess their understanding of the lab material. Such interviews will be held at random and we reserve the right to adjust the lab mark based on the outcome of the interview.

### ASSESSMENT

Component	Weight
Assignments / HWs	15 %
Labs	20 %
Midterm/s	30 %
Final Exam	35 %
Total	100 %

Late submissions of any required deliverables are subject to 20% penalty per day (less than one day is counted as one day).

No make-up midterm tests will be granted. Weight of a missed midterm test will be transferred to final exam. In case of any unavoidable situation convey it to the instructor via email and make sure you receive the consent of the professor for such a case.

### 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](http://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](mailto: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.

## RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to <http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf>.

## 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)
Capable of selecting appropriate model and methods and identify assumptions constraints	3.2	Labs / exam
Recognizes and follows an engineering design process (This means an iterative activity that might include recognizing the goal, specifying the constraints and desired outcomes, proposing solutions, evaluating alternatives, deciding on a solution, and implementing)	4.1	Assignment/test/exam
Demonstrate ability to respond to technical and non-technical instructions and questions	7.1 (Communications skills)	Lab demonstrations and presentations
Understands the business processes for implementing engineering ideas.	11.3 (Economics project management)	Assignments (Supercomputers / Datacenters)



## 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

Leave equipment in a safe state for the next person - if you're not sure, ask!

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	<a href="mailto:steve@mail.ece.mcmaster.ca">steve@mail.ece.mcmaster.ca</a>
ECE Chair	Tim Davidson- ITB A111	<a href="mailto:davidson@mcmaster.ca">davidson@mcmaster.ca</a>
ECE Administrator	Kerri Hastings- ITB A111	<a href="mailto:hastings@mcmaster.ca">hastings@mcmaster.ca</a>
ECE Course Instructor	Please contact your specific course instructor directly	

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