

**COMP ENG 2DX4**  
Microprocessor Systems Project  
Embedded Intelligence -- “Observe, Reason, and Act”

**COURSE OUTLINE**

Please refer to course website for updated information.

**COURSE DESCRIPTION**

Microprocessor systems, introduction to the design process, project development by small teams of students, oral presentations and engineering report writing.

**PRE-REQUISITES AND ANTI-REQUISITES**

Pre-requisite(s): ElecEng 2CI5, CompEng 2SH4

Anti-requisite(s): CompEng 2DP4

**SCHEDULE AND MODE OF DELIVERY**

**Lectures:** We 11:30AM - 12:20PM, Fr 1:30PM - 2:20PM

**Tutorials (Studio):** Fr 10:30AM - 11:20AM

**Labs (L01-L10):** see Laboratory Overview section.

**INSTRUCTORS**

**Dr. Doyle**



doylet@mcmaster.ca

**Dr. Haddara**



yaser@mcmaster.ca

**Dr. Shirani**



shirani@mcmaster.ca

Individual office hours will be posted on course website.

**TEACHING ASSISTANTS**

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

### COURSE WEBSITE

The Course website will be Avenue to Learn ( <http://avenue.mcmaster.ca/> ). The student is required to **check the system daily** for assignment release/submission, course related material, and posted announcements.

### EMAIL POLICY

When sending an email to your professors or your TA(s) it is important we can quickly identify it and that it has the necessary information to help you. First, ensure your email subject starts with "COE2DX4:", and include in the body of the message: i) your name, ii) student number, and iii) lab section. Please include prior correspondence and endeavour to keep your email concise. We can only respond to emails sent from your @mcmaster.ca account.

### COURSE OBJECTIVES

The primary objective of this course is to become proficient with the fundamentals of microprocessor systems and their relation to embedded system design. The course is project based and structured around the embedded themes of how devices observe, reason, and act within the world around them.

By the end of this course, students should be able to:

- Discuss the details of microprocessors, microprocessor systems, and microcontrollers
- Program the microprocessor at the assembly level
- Analyze and synthesize the hardware and software organization of a microprocessor system
- Analyze and synthesize microprocessor system memory (structure, timing, interfacing, decoding, maps)
- Discuss, manipulate, and control microprocessor system Input / Output
- Discuss, manipulate, and control microprocessor system Interrupts
- Discuss, manipulate, and control microprocessor system Peripherals
- Discuss and implement introductory concepts in Digital Signal Processing related to Analog-to-Digital, Digital-to-Analog, Sampling, Simple Data Processing, Fixed/Floating-Point Considerations and Standards
- Discuss embedded programming concepts such as control structures, abstract data types, procedural programming, event-based programming, modularity, and unit testing
- Discuss the impact of microprocessor system design on society
- Design, implement, and discuss a microprocessor system from a given problem specification

### ASSUMED KNOWLEDGE

Successful completion of ElecEng 2CI5 and CompEng 2SH4. Students are expected to be proficient in these courses and basic electronics.

## COURSE MATERIALS

### Required:

1. Textbook: Valvano, “Embedded Systems: Introduction to ARM Cortex-M Microcontrollers”, 5<sup>th</sup> edition, 6<sup>th</sup> printing, January 2019. Please note the edition, printing, and date! (A Kindle digital version may be available via Amazon – confirm version before purchase)
2. Hardware: A course hardware kit will be required. Information about the kit and purchase procedure will be available on Avenue.
3. Software: A free Integrated Development Environment (IDE) will be used for this course. Refer to the course website for information on obtaining the software.

### Optional:

4. Textbook: Valvano, “Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers”, 5<sup>th</sup> edition, 6<sup>th</sup> printing, December 2017. Please note the edition, printing, and date! (A Kindle digital version may be available via Amazon – confirm version before purchase)

**Calculator:** None required. **Not permitted on exams.**

## COURSE OVERVIEW

Lectures are complemented by the lab and design studio. Labs and design studios will be carried out using the course hardware kit at home. To take full advantage of the lecture time, the student must keep up with assigned readings and do the assigned problems. Lectures are intended to introduce theory and concepts that will be reinforced through experiential studio and integrative labs. This course has a major project that serves as the method of course knowledge synthesis. Lecture time will not be used to teach the software applications or to review hardware bit-level configuration.

The following is anticipated to be the weekly topic in lecture:

Week	Topic
0	Embedded Systems & Architecture
1	Signals Around Us (Digital vs. Analog)
2	Transduction & Analog Data Acquisition
3	Timing, I/O, & Structured Program Organization
4	Peripheral Interfacing
5	Transfer Function & Calibration
6	System Integration & Abstract Data Types
7	Event Based Programming with Interrupts
8	Communication Protocols (Wired)
9	Data Visualization
A	Distributed and Intelligent Embedded System
B	Course Overview

Refer to course website for assigned reading and questions (CompEng 2DX4 Schedule). Subjects may be reorganized/modified if deemed necessary by the instructor(s). Any reorganization/modification will be communicated to the class.

## LABORATORY OVERVIEW

The laboratory manual is available on the course website for download. Always check to ensure you have the most recent version while working on your lab because updates occur based on student questions and input.

Labs will typically have the following components: 1) pre-lab assignment/design, 2) during lab time build-test-evaluate\*, and 3) a formal report. In general, attending a lab unprepared will result in an incomplete result. Attendance is mandatory.

Week	Topic
0	--
1	--
2	Simple digital i/o
3	Parallel digital inputs
4	Acquiring analog input (digitization)
5	Duty Cycle and Pulse Timing
6	Peripheral Interface
7	Integration Lab 1
8	Mid-Project Milestone Demonstration
9	Interrupts
A	Sensor Data
B	Visualization of Acquired Data
C	Project Submission

\*Note that lab exercises are to be treated like homework exercises and substantially started prior to coming to the lab. The required Hardware Kit will allow students to perform the labs off campus at home. Lab time should be for final debugging, evaluation, data collection, and report completion.

\*\*Not assessed as a lab.

**Notice – All Project Demonstrations and Interviews will be scheduled in week B Monday-Friday. A schedule will be posted with time and location.**

## LABORATORY OPERATION

- The student has chosen or been assigned specific laboratory section. The day and time of these sections are listed in the McMaster Undergraduate Master Timetable. Attendance of the assigned laboratory time slot is compulsory. The student must attend the assigned section. Attendance will be taken. Labs are due before the end of the session.

- At the beginning of every term, every Undergraduate student using an ECE Lab is required to complete the ECE Lab Safety Quiz (one completed quiz covers every course that term). The quiz and other information are provided on the Avenue page.
- Each lab will involve a significant amount of pre-lab work. One pre-lab report per person.

Penalties for late submission, tardiness, or absence without a valid reason are typically a 0 on the assigned work.

A laboratory exercise deemed to be partially or fully copied will be considered an academic offence and be subject to the terms laid out under the McMaster Academic Integrity Policy.

All work is required to be done individually and, unless explicitly stated, no collaborative work is permitted.

Please be aware of the following penalties for lab work:

1. Failure to properly upload and submit your lab evaluation assignment will result in being assigned a 0 for that evaluation. **This means ALL files necessary to evaluate your work.**
2. Failure to submit a lab evaluation assignment by the specified time up to two minutes late will result in a 20% penalty. If more than two minutes then a 100% penalty is applied.

**For example, failure to submit your lab report, code, or designs, etc. after completing a lab exercise will result in a grade of 0 for the entire lab (not just a 0 for the marks associated with missing piece(s)).**

In terms of submission time, the Avenue to Learn clock will be the official time. Should Avenue be unavailable, the TA will specify the reference clock for submission deadlines.

The TAs and the instructor reserve the right to interview students to assess their understanding of the lab material (including pre-lab). Such interviews will be held at random and we reserve the right to adjust the lab mark based on the outcome of the interview.

<b>ASSESSMENT</b>
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Component	Total Weight
Lab Evaluation	20%
Midterm Exam(s)	30%
Studio Attendance	5%
Individual Project	30%
Final Exam	15%
<b>Total</b>	<b>100%</b>

The final exam must be written else a final grade of F will be awarded with the notation DNW (Did Not Write). Statistical adjustments (such as bell curving) will not normally be used.

In a case where the component weight cannot be fulfilled as a result of unforeseen and/or uncontrollable circumstance(s) in the course operation or execution, the grades assigned to that component may be pro-rated.

**Midterm exams are scheduled for Feb 12, 2021 and March 12, 2021 during Friday studio time slot 10:30 AM.** These dates/times are subject to change and student must confirm on the course web site. The instructor(s) reserves the right to choose the format (i.e. written or oral) of any deferred midterm or exam in this course.

Final exam details are set by the Registrar. The instructor(s) reserves the right to choose the format (i.e. written or oral) of any deferred midterm or exam in this course.

Unless otherwise stated, all assessments are closed-book.

Please note that announcements concerning any type of graded material may be in any format (e.g., announcements may be made only in class). Students are responsible for completing the graded material regardless of whether they received the announcement or not. This means that if you skip a class and an announcement for a quiz, lab, test, project, etc. is made in that class, then you are still responsible for that material.

#### **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.

#### 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 Methods(s)
Demonstrates and ability to identify reasonable assumptions when designing a data acquisition system that could or should be made before a solution path is proposed.	2.1	Documented final project assumptions for the data acquisition requirements
Can estimate the digital mapping of an analog signal based upon the combination of applying Shannon's Sampling Theorem and the quantization effect from Analog-to-Digital Conversion (Successive Approximation Method).	3.3	As part of a lab, compare and contrast different data acquisition systems.
Using specialized software and hardware to demonstrate designing, building and troubleshooting microprocessor systems.	5.2	As a component of a lab, evaluation of ability to use design and synthesis tools for implementation of microprocessor system.
Demonstrates an ability to respond to technical and non-technical instructions and questions	7.1	Evaluation of performance during project interview(s)



Presents instructions and information clearly and concisely as appropriate to the audience	7.2	Evaluation of student explanation of project and/or lab milestone deliverable(s)
Constructs effective oral or written arguments as appropriate to the circumstances	7.3	Evaluation of rationale to support design decision related to project and/or lab milestone deliverable(s).
Critically evaluates and applies knowledge, methods and skills procured through self directed and self identified sources, including those that lie outside the nominal course curriculum.	12.1	Evaluation of project final report presented at a data-sheet. Student will need to critically evaluate datasheet contents and formats for their own submission.

[www.eng.mcmaster.ca/ece](http://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

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	