McGill

Course Title: **ECSE 444 - Microprocessors**

Credits: **4**

Hours: **(3-4-5)** Course Prerequisite(s): **ECSE 324** Course Corequisite(s): **N/A**

Course Description: **Design techniques for developing modern microprocessor-based systems, multiple stateof- art instructions set architectures (ISAs) and associated assembly languages, use of tools for compiling, linking, memory overlay; debug techniques for start-stop and realtime debugging, together with debug infrastructure and interfaces: flash patching, variable watching and instruction stream tracing. Use of coprocessors and computer peripherals, such as SPI, I2C, I2S, SAI, USB, wireless standards, timers, DMA units and FLASH accelerators. Interfacing and processing sensor data including multi-sensor integration. Design techniques that promote structured approaches for separation of concerns in computing and communication. Real-time systems and software engineering for tightly integrated hardware.**

Canadian Engineering Accreditation Board (CEAB) Curriculum Content

CEAB curriculum category content	Number of AU's	Description
Math	**0**	Mathematics include appropriate elements of linear algebra, differential and integral calculus, differential equations, probability, statistics, numerical analysis, and discrete mathematics.
Natural science	**0**	Natural science includes elements of physics and chemistry, as well as life sciences and earth sciences. The subjects are intended to impart an understanding of natural phenomena and relationships through the use of analytical and/or experimental techniques.
Complementary studies	**0**	Complementary studies include the following areas of study to complement the technical content of the curriculum: engineering economics and project management; the impact of technology on society; subject matter that deals with the arts, humanities and social sciences; management; oral and written communications; health and safety; professionalism, ethics, equity and law; and sustainable development and environmental stewardship.
Engineering science	**32.5**	Engineering science involves the application of mathematics and natural science to practical problems. They may involve the development of mathematical or numerical techniques, modeling, simulation, and experimental procedures. Such subjects include, among others, applied aspects of strength of materials, fluid mechanics, thermodynamics, electrical and electronic circuits, soil mechanics, automatic control, aerodynamics, transport phenomena, elements of materials science, geoscience, computer science, and environmental science.
Engineering design	**32.5**	Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.

Accreditation units (AU's) are defined on an hourly basis for an activity which is granted academic credit and for which the associated number of hours corresponds to the actual contact time: one hour of lecture (corresponding to 50 minutes of activity) = 1 AU; one hour of laboratory or scheduled tutorial = 0.5 AU. Classes of other than the nominal 50-minute duration are treated proportionally. In assessing the time assigned to determine the AU's of various components of the curriculum, the actual instruction time exclusive of final examinations is used.

Graduate Attributes

This course contributes to the acquisition of graduate attributes as follows:

Graduate attribute	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
Level descriptor	D			A		D	A					

I = Introduced; D = Developed; A = Applied

KB *- Knowledge Base for Engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.*

PA *- Problem Analysis: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.*

IN *- Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.*

DE *- Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.*

ET *- Use of Engineering Tools: An ability to create, select, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.*

IT *- Individual and Team Work: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.*

CS *- Communication Skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.*

PR *- Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.*

IE *- Impact of Engineering on Society and the Environment: An ability to analyse social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.*

EE *- Ethics and Equity: An ability to apply professional ethics, accountability, and equity.*

EP *- Economics and Project Management: An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.*

LL *- Life-Long Learning: An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.*

Policies

Academic Integrity

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures. (see www.mcgill.ca/students/srr/honest/ for more information). (approved by Senate on 29 January 2003)

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.
(approved by Senate on 21 January 2009)

Grading Policy

In the Faculty of Engineering, letter grades are assigned according to the grading scheme adopted by the professor in charge of a particular course. This may not correspond to practices in other Faculty and Schools in the University.

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

Course Learning Outcomes

Microprocessors are the computing workhorses of our connected world. The objective of this course is to provide the necessary understanding and skills for students to design and build microprocessor systems. By the end of the course, students should: (1) understand the organization and design principles of modern microprocessor-based systems; (2) be proficient in assembly and high-level (embedded C language) programming for embedded systems; (3) understand the performance consequences of embedded software design choices, including the effects on energy and storage requirements; (4) know how to interface microprocessors with peripheral devices and networking interfaces, and how to write programs for their efficient use.

Changelog

26 – Aug	Initial draft.

Prerequisites

ECSE 324: Computer Organization

Staff

Instructors

Dr. Donald Davis, email: mcem352@yahoo.ca
Office Hours: 20 minutes before and 20 minutes after the lecture

Rick Fenster, richard.fenster@mcgill.ca
Office Hours: 20 minutes before and 20 minutes after the lecture

Assistants

Guillaume Richard
Shahab Mahmoudi Sadaghiani

Hours and Locations

Lecture	MW	4:05pm to 5:25pm	STBIO S3/3

Tutorial	R	3:35pm to 5:25pm	ENGMD 276
Labs	T	01:35 pm to 03:25 pm	ENGRTR 4160
	R	01:35 pm to 03:25 pm	ENGRTR 4160
	T	03:35 pm to 05:25 pm	ENGRTR 4160
	F	03:35 pm to 05:25 pm	ENGRTR 2110
	T	09:35 am to 11:25 am	ENGRTR 2110
	M	01:35 pm to 3:25 pm	ENGRTR 2110

All course meetings are held in person.

COVID Protocols and Policies

If you experience COVID symptoms, please follow McGill's COVID Reporting Process. Should you test positive, please notify the University, and follow McGill's Health Guidelines for information on when to return to campus. If an instructor is directed to stay at home, the lecture will be moved to Zoom. A link to the meeting will be shared as soon as possible, no later than that morning. If students are directed to stay at home, they are advised to **notify both instructors** for accommodations related to any assessments that may be affected.

Course Materials

Course materials will be made available on myCourses throughout the semester.

Instructor generated course materials (e.g., handouts, notes, summaries, exam questions, etc.) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructors. Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.
In all course-related email correspondence, pleasure ensure the subject line includes the prefix ECSE 444 (This will be automatically inserted if sent from within myCourses.)

Required Text

There is no required text for this course. The supplemental text by Joseph Yiu is the most closely related to the course material and is highly recommended.

Supplemental Texts

Material for this course will be drawn from a wide variety of courses, including, but not limited to, the following texts in order of relevance. The first text is *strongly recommended.*

- Joseph Yiu, *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors,* 3rd edition, Newnes, 2014.
- Daniel W. Lewis, *Fundamentals of Embedded Software with the ARM® Cortex®-M3*, 2nd edition, Pearson 2013.
- David A. Patterson and John L. Hennessy, *Computer Organization and Design,* ARM® Edition*,* Morgan Kaufmann 2017
- Tanenbaum and T. Austin, *Structured Computer Organization*, 6th Edition, Prentice Hall, 2012.

Course Content

The topics covered in the course include but are not limited to:
- Review of computer organization and instruction set architecture
- Introduction of Cortex-M organization and architecture
- ARM C as implemented in assembly
- General purpose digital interfacing and analog interfacing
- Timers, interrupts and exceptions
- Serial communication
- Power management
- Cortex-M OS support and memory protection
- Execution tracing and debugging
- Process scheduling

Evaluation

If you have a disability, please contact the instructors to arrange a time to discuss your situation. It would be helpful, as well, to contact the Office for Students with Disabilities at 514-398-6009 before you do this.

The approximate grading breakdown is:

- Quizzes 20%
- Laboratory Exercises 40%
- Final Project 40%

We reserve the right to change these weights based on class performance.
Note that there is no fixed number to letter conversion for the final grade.

Note: Medical documentation submitted to justify an absence must clearly state your inability to participate in the class at the prescribed time.

Quizzes

There is a total of four quizzes (time for each quiz may vary) throughout the semester. See the course schedule for the dates of these quizzes. All quizzes are on in class during the Wednesday lecture, and cover material through the end of the lecture the previous Monday. While quizzes are not cumulative, strictly speaking, material later in the course builds on that earlier in the course. The purpose of these quizzes is to encourage you to spend time reviewing lecture material, which tends to be more theoretical than the lab and project work. Questions will be restricted to lecture material; answer will generally take the form of short answers and multiple choice. You may reference your course materials as you take the quizzes; you are, however expected to answer questions in your own words.

Laboratory Exercises

There are eight laboratory exercises, all of which are conducted and demoed individually. The purpose of these assignments is to familiarize you with embedded C programming and debugging and working with embedded systems hardware. *All demos will be conducted during scheduled lab times.* All labs require (a) the STM32Cube development toolchain. The software is free, and available for Linux, macOS and Windows. Information can be found here. Development will be performed on the STM B-L4S5I-IOT01A. You may purchase the board from Mouser, DigiKey, Newark or from STMicroelectronics directly.

Project

The four-week final project is to execute a large-scale embedded system project for the Discovery IoT development board. It will be conducted in groups of four. The details of this semester's project will be announced later in the semester. The project consists of four graded deliverables: an initial demo and report, and a final demo and report, worth 16%, 24%, 24% and 36% of the project grade respectively.

Evaluation Policies

Quizzes

All quizzes will be conducted at the last 20 minutes of the selected lecture. If for some reason you are unable to complete a quiz, please contact the instructors as soon as possible.

Demonstrations

All demonstrations will be conducted during scheduled lab times. If you know you are going to miss a demonstration (e.g., for an interview), communicate with the instructor and TAs, in advance and as early as possible to arrange a new time. If you unexpectedly miss a demonstration, due to illness or another unforeseen event, communicate with the instructors, afterward and as soon as possible, with an explanation to arrange a new time. In all other circumstances, you may reschedule a demonstration for 65% of the available marks.

McGill Policy Statements

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L'université McGill attache une haute importance à l'honnêteté académique. Il incombe par conséquent les étudiants de comprendre ce que l'on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduit de l'étudiant et des procédures disciplinaries. Pour de plus amples renseignments, veuillez consulter le site https://www.mcgill.ca/students/srr/honest.

Right to Submit Written Work in English or French

In accordance with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded. In the case of events beyond the control of the university or instructor, the evaluation and content of the course outline may be subject to changes.