Toronto Metropolitan University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Outline (F2022)

COE538: Microprocessor Systems

Instructor(s)	Dr. Lev Kirischian [Coordinator] Office: ENG432 Phone: (416) 979-5000 x 556076 Email: lkirisch@ryerson.ca Office Hours: TBA
Calendar Description	This course introduces students to small microprocessor-based systems, with an emphasis on embedded system hardware and software design. Topics will include microprocessor architecture and structure, with an overview of 8- 16- and 32-bit systems, assembly language programming and the use of high-level languages. Basic input/output including parallel communications with and without handshaking and serial protocols. Hardware and software timing. Using interrupts and exceptions. Overview of single-chip microprocessors and controllers with an emphasis on the Freescale HCS12. The internal structure and design of peripheral devices. Memory system design and analysis. The use and structure of development tools such as (cross) assemblers or compilers, monitor programs, simulators, emulators, etc.
Prerequisites	COE 328 and ELE 404 and MTH 314 and CEN 199
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	1. HCS12/9S12: An Introduction to Software and Hardware Interfacing, Huang, H.-W., Delmar Cengage Learning, 2010. 2. Microprocessor Systems: Selected Course Notes, Lecture slides at D2L.
Reference Text(s):	1. Microcontrollers and Microcomputers: Principles of Software and Hardware Engineering, Cady, F., Oxford University Press, 2010. 2. Introduction to Embedded Systems: Interfacing to the Freescale 9S12, Valvano J., Cengage Learning, 2010. 3. HCS12 Microcontrollers and Embedded Systems, Mazidi, M., Causey, D., and Mazidi, J., Prentice Hall, 2009.
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Use technical knowledge on microprocessor architecture, I/O interface and peripherals, assembly/C language programming and debugging methodology. Use design tools and related resources, microprocessor peripherals, assemblers, compilers, and monitor programs. (**4a**) 2. Learn good practices in structuring a microprocessor control program. Apply the programming principles including top-down programming, bottom-up programming, and functional programming to define an accurate programming problem statement. Recognize that good problem definition assists the program design process. Describe differences between the various approaches to solve a programming problem using assembly/C language. Select one specific approach. When it fails, analyze the cause of failure using

standard programming and debugging methodologies. Based on the analysis, improve the existing approach. Integrate the new suggestions into the existing design plan. Judge the completeness and quality of the generated solutions. (**4b**)
3. Describe the iterative process of programming/debugging assembly/C programs. Use debugging tools to generate information on the current state of a program. Use it to modify/improve the solution as needed. Incorporate and integrate feedback from the instructors and generate new knowledge about the programming problem. (**4c**)
4. A student manages own time and processes effectively to achieve personal and team goals - Assessment of laboratory and project assignments on the correctness and quality of design, decomposing project into key tasks, managing project to meet timeline, code quality, language and technical quality (**6b**)
5. Produce lab and project reports using appropriate format, grammar, and citation styles for technical and non-technical audiences. (**7a**)
6. Illustrate concepts including the structure of assembly/C language programs and obtained experimental results. (**7b**)
7. - Understanding and establishment of project scope - Planing tasks, allocating responsibilities, setting timelines to meet project goals - Identifying assumptions that may affect project success - Communicating key project deliverables in clear, concise manner - Displaying a basic understanding of the issues in managing the implementation of the project - Understanding task inter-relationships and managing project accordingly to time deadlines - Allocating tasks to team members and coordinating dynamically as problems or opportunities emerge (**11b**)

NOTE:*Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*

Course Organization

3.0 hours of lecture per week for 13 weeks
2.0 hours of lab per week for 12 weeks
0.0 hours of tutorial per week for 12 weeks

Teaching Assistants

TBA

Course Evaluation

Labs and Quizzes	25 %
Project	10 %
Midterm Exam	25 %
Final Exam	40 %
TOTAL:	100 %

Note: In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).

Examinations

Midterm exam in Week 7, one hour and fifty minutes, closed book (covers Weeks 1-5).
Final exam, during exam period, three hours, closed-book (covers Weeks 1-12).

Other Evaluation Information

Lab Project
The lab assignments and the project (originally developed by Prof. Peter Hiscocks) involve a robot. The project is to program the eebot mobile robot with a navigation system that can find its way through a maze, reverse, and back its way out again. A possible variation on this is that the robot first learns the maze. Then it is started again at the beginning and should navigate the maze without errors. The project must be demonstrated during the demonstration week. The project

	report must be submitted on or before the end day of the semester. At the time of demonstration, students will also be required to submit the project source code electronically. Lab Management Labs will be graded 8 marks maximum for each lab, to a maximum of 40 marks which will be scaled to 20% of the final mark. And there will be lab quizzes at the end of labs 2, 3, 4 and 5, accounting for a maximum of 5% of the final mark. Credit for labs will be based on the quality of how well the project works (demonstration) and how well the student can answer questions about the lab. If answers to these questions are inadequate, the lab will be marked as 0, although the student will be given an opportunity to rectify his or her preparation. Partial marks may be assigned at the discretion of the instructor. The Lab Project accounts for 10% of the final mark. The project must be demonstrated during the Demonstration Week. The project report must be submitted on or before the end day of the semester. It must include: - A formal description of the work (at least 2 pages, no more than 5 pages) - An appendix containing a hard copy of all source code (.asm file) The proper report description should address the following: - Overall approach and description of performance - Main design decisions - Problems encountered and their solutions - Recommendations: how you would continue the project to make it even better and how you would try to fix any remaining bugs. At the time of demonstration, you will also be required to submit your source code electronically. (You will be told how to do this.) The Project Evaluation will be done according to the following: Evaluation of Lab Project (8%): - 3.5% Basic functionality - 3.5% Code quality - 1.0% Extra functionality Evaluation of Project Report (2%): - 1.0% Report English quality - 1.0% Report technical quality All the labs are done individually. The lab project is done in groups of 3 students. Each student must also keep a complete and continuous record of the year's lab activities. Equipment should not be moved during the lab; if you believe equipment to be defective, report it to the lab instructor who will take care of the problem. Labs are conducted using a Motorola HCS12-based microprocessor board and computer-aided design tools from Freescale, specifically "Special Edition: CodeWarrior for HCS12(X) Microcontrollers (Classic)". To obtain a passing grade in the course, a student must obtain at least 50% in both the lab and theory portions of the course.
Other Information	None.

Course Content

Week	Hours	Chapters / Section	Topic, description

1	3	1, 2	Introduction to COE 538 - Scope and objectives, management Introduction to the HCS12 Microcontroller Chapter 1: - 1.3 Computer Hardware Organization - 1.5 Memory system Operation - 1.6 Program Execution - 1.8 The HCS12 CPU Registers - 1.9 HCS12 Addressing Modes - 1.11 A Sample of HCS12 Instructions HCS12 Assembly Programming Chapter 2: - 2.2 Assembly Language Program Structure - 2.3 Assembly Directives
2	3	2, 3, 4	HCS12 Assembly Programming Chapter 2: - 2.5 Writing Programs to Do Arithmetic - 2.6 Program Loops - 2.7 Shift and Rotate Instructions - 2.8 Boolean Logic Instructions - 2.9 Bit Test and Manipulate Instruction - 2.10 Program Execution Time HW/SW Development Tools Chapter 3: - 3.2 Development Tools for the HCS12 - 3.8 Using CodeWarrior Advanced Assembly Programming Chapter 4: - 4.10 Intro to Parallel I/O Port & Devices - 4.11 Simple I/O Devices
3	3	4, 7	Advanced Assembly Programming Chapter 4 - 4.3 Stack - 4.4 What Is a Subroutine? - 4.5 Issues related to Subroutine Calls - 4.6 The Stack Frame - 4.9 Subroutines for Creating Time Delay Advanced Parallel I/O Chapter 7: - 7.5 The HCS12 Parallel Ports - 7.7 Liquid Crystal Displays (LCDs) - 7.8 The HD4478U LCD Controller - 7.9 Interfacing Parallel Ports to a Keypad
4	3	6, 12	Interrupts Chapter 6 - 6.2 Fundamental Concepts of Interrupts Analog-to-Digital Converter Chapter 12

			- 12.2 Basics of A/D Conversion - 12.3 The HCS12 A/D converter - 12.4 The Functioning of the ATD Module - 12.5 Procedure for Performing A/D Conversion
5	3	6, 8	Interrupts, Clock Generation and Operation Modes Chapter 6 - 6.3 Resets - 6.4 HCS12 Exceptions - 6.6 Clock and Reset Generation Block - 6.7 Real-Time Interrupt - 6.11 HCS12 Operation Modes Timer Functions Chapter 8 - 8.3 Standard Timer Module - 8.4 Timer Counter Register
6	3	8	Timer Functions Chapter 8 - 8.5 Input-Capture Function - 8.6 Output-Compare Function - 8.7 Pulse Accumulator - 8.8 Modulus down Counter
7	2	1-4, 6, 7, 12	Midterm Covers all material up to week 5 (excluding chapter 8)
8	3	5	C Language Programming Chapter 5 - 5.3 Types Operators and Expressions - 5.4 Control Flow - 5.5 Input and Output - 5.6 Functions and Program Structure - 5.7 Pointers Arrays Structures and Unions - 5.8 Writing C Programs to Perform Simple I/O - 5.11 Using the CodeWarrior to Develop C Programming
9	3	9	Serial Communication Interface Chapter 9 - 9.3 The RS-232 Standard - 9.4 The HCS12 SCI - 9.5 SCI Baud Rate Generation - 9.6 The SCI Operation - 9.9 Interfacing SCI with TIA-232
10	3	10	The SPI Function Chapter 10 - 10.2 Introduction to the SPI Function

			- 10.3 Registers Related to the SPI Subsystem - 10.4 SPI Operation - 10.5 SPI circuit connection - 10.6 Configuration / Data Transfer in SPI - 10.8 The 74HC595 Shift Register
11	3	11	Inter-Integrated Circuit (I2C) Interface Chapter 11 - 11.2 The I2C Protocol - 11.3 An Overview of the HCS12 I2C Module - 11.4 Registers for I2C Operation - 11.5 Programming the I2C Module
12	3	14	Internal Memory Configuration and External Expansion Chapter 14 - 14.3 Internal Resource Remapping - 14.4 Expanded Memory Mapping - 14.7 HCS12 External Memory Interface - 14.9 Memory Devices - 14.10 Example of External Memory Expansion for the HCS12
13	3	1-12, 14	Review and Catch Up
Exam Period	3	1-12, 14	Final Exam - Covers material up to end of week 12

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2	ENG411	Lab 1: Using the CodeWarrior IDE and Introduction to Assembly Language Programming
3-4	ENG411	Lab 2: Programming the I/O Devices
5-6	ENG411	Lab 3: Battery and Bumper Displays
7	ENG411	Lab 4: Motor Control & Using the Hardware Timer

8-9	ENG411	Lab 5: Robot Roaming Program
10-12	ENG411	Project: Robot Guidance Challenge

Policies & Important Information:

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

1. In accordance with the Policy on TMU Student E-mail Accounts (Policy 157), Toronto Metropolitan University (TMU) **requires** that any electronic communication by students to TMU faculty or staff be sent from their official university email account;
2. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented;
3. Assignments, projects, reports and other deadline-bound course assessment components handed in past the due date will receive a mark of ZERO, unless otherwise stated. Marking information will be made available at the time when such course assessment components are announced.
4. Familiarize yourself with the tools you will need to use for remote learning. The Continuity of Learning Guide for students includes guides to completing quizzes or exams in D2L or Respondus, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
5. The University has issued a minimum technology requirement for remote learning. Details can be found at: https://torontomu.ca/covid-19/students/minimum-technology-requirements-remote-learning. Please ensure you meet the minimum technology requirements as specified in the above link.
6. Toronto Metropolitan University COVID-19 Information and Updates (available https://www.torontomu.ca/covid-19/students) for Students summarizes the variety of resources available to students during the pandemic.
7. Refer to our **Departmental FAQ** page for information on common questions and issues at the following link: https://www.ecb.torontomu.ca/guides/Student.Academic.FAQ.html.

Missed Classes and/or Evaluations

When possible, students are required to inform their instructors of any situation which arises during the semester which may have an adverse effect upon their academic performance, and must request any consideration and accommodation according to the relevant policies as far in advance as possible. Failure to do so may jeopardize any academic appeals.

1. **Academic Consideration Requests for missed work** (e.g. missing tests, labs, etc) - According to Senate Policy 134, Section 1.2.3, if you miss any exams, quizzes, tests, labs, and/or assignments for health or compassionate reasons you need to inform your instructor(s) (via email whenever possible) in advance when you will be missing an exam, test or assignment deadline. When circumstances do not permit this, you must inform the instructor(s) as soon as reasonably possible". *In the case of illness, a Toronto Metropolitan Student Health Certificate, or a letter on letterhead from an appropriate regulated health professional with the student declaration portion of the Student Health Certificate attached. For reasons other than illness, proper documentation is also required (e.g. death certificate, police report, TTC report).* ***ALL supporting documentation for illness or compassionate grounds MUST be submitted within three (3) working days of the missed work.*** " **NOTE: You are required to submit all of your pertinent documentation through the University's online Academic Consideration Request system at the following link:** prod.apps.ccs.ryerson.ca/senateapps.
2. ***Religious, Aboriginal and Spiritual observance*** - If a student needs accommodation because of religious, Aboriginal or spiritual observance, they must submit a Request for Accommodation of Student Religious, Aboriginal and Spiritual Observance AND an Academic Consideration Request form within the first 2 weeks of the class or, for a final examination, within 2 weeks of the posting of the examination schedule. If the requested absence occurs within the first 2 weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these forms should be submitted with as much lead time as possible in advance of the absence. Both documents are available at

www.torontomu.ca/senate/forms/relobservforminstr.pdf. **If you are a full-time or part-time degree student, then you submit the forms to your own program department or school;**

3. ***Academic Accommodation Support*** - Before the first graded work is due, students registered with the Academic Accommodation Support office (AAS - prod.apps.ccs.ryerson.ca/senateapps) should provide their instructors with an Academic Accommodation letter that describes their academic accommodation plan.

Virtual Proctoring Information (if used in this course)

Online exam(s) within this course may use a virtual proctoring system. Please note that your completion of any such virtually proctored exam may be recorded via the virtual platform and subsequently reviewed by your instructor. The virtual proctoring system provides recording of flags where possible indications of suspicious behaviour are identified only. Recordings will be held for a limited period of time in order to ensure academic integrity is maintained and then will be deleted.

Access to a computer that can support remote recording is your responsibility as a student. The computer should have the latest operating system, at a minimum Windows (10, 8, 7) or Mac (OS X 10.10 or higher) and web browser Google Chrome or Mozilla Firefox. You will need to ensure that you can complete the exam using a reliable computer with a webcam and microphone available, as well as a typical high-speed internet connection. Please note that you will be required to show your Toronto Metropolitan University OneCard prior to beginning to write the exam. In cases where you do not have a Toronto Metropolitan University OneCard, government issued ID is permitted.

Information will be provided prior to the exam date by your instructor who may provide an opportunity to test your set-up or provide additional information about online proctoring. Since videos of you and your environment will be recorded while writing the exam, please consider preparing the background (room / walls) so that personal details are not visible, or move to a room that you are comfortable showing on camera.

Academic Integrity

Toronto Metropolitan University's Policy 60 (the Academic Integrity policy) applies to all students at the University. Forms of academic misconduct include plagiarism, cheating, supplying false information to the University, and other acts. The most common form of academic misconduct is plagiarism - a serious academic offence, with potentially severe penalties and other consequences. It is expected, therefore, that all examinations and work submitted for evaluation and course credit will be the product of each student's individual effort (or an authorized group of students). Submitting the same work for credit to more than one course, without instructor approval, can also be considered a form of plagiarism.

Suspicions of academic misconduct may be referred to the Academic Integrity Office (AIO). Students who are found to have committed academic misconduct will have a Disciplinary Notation (DN) placed on their academic record (not on their transcript) and will normally be assigned one or more of the following penalties:

1. A grade reduction for the work, ranging up to an including a zero on the work (minimum penalty for graduate work is a zero on the work);
2. A grade reduction in the course greater than a zero on the work. (Note that this penalty can only be applied to course components worth 10% or less, and any additional penalty cannot exceed 10% of the final course grade. Students must be given prior notice that such a penalty will be assigned (e.g. in the course outline or on the assignment handout);
3. An F in the course;
4. More serious penalties up to and including expulsion from the University.

The unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited, in accordance with Policy 60 (Sections 2.8 and 2.10). Intellectual property includes, but is not limited to:

1. Slides
2. Lecture notes
3. Presentation materials used in and outside of class
4. Lab manuals
5. Course packs
6. Exams

For more detailed information on these issues, please refer to the Academic Integrity policy(https://www.torontomu.ca/senate/policies/pol60.pdf) and to the Academic Integrity Office website (https://www.torontomu.ca/academicintegrity).

Academic Accommodation Support

Toronto Metropolitan University acknowledges that students have diverse learning styles and a variety of academic needs. If you have a diagnosed disability that impacts your academic experience, connect with Academic Accommodation Support (AAS). Visit the AAS website or contact aasadmin@ryerson.ca for more information.

Note: All communication with AAS is voluntary and confidential, and will not appear on your transcript.

Important Resources Available at Toronto Metropolitan University

1. The Library provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service at https://library.torontomu.ca/ask to speak with a librarian.

2. Student Life and Learning Support offers group-based and individual help with writing, math, study skills, and transition support, as well as resources and checklists to support students as online learners.

3. You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radial button on the top right hand side entitled: Academic Consideration Request (ACR) to submit this request).

   Please note that the Provost/Vice President Academic and Deans approved a COVID-19 statement for Fall 2022 related to academic consideration. This statement will be built into the Online Academic Consideration System and will also be on the Senate website (www.ryerson.ca/senate) in time for the Fall term:

   Policy 167: Academic Consideration for Fall 2022 due to COVID-19: Students who miss an assessment due to cold or flu-like symptoms, or due to self-isolation, are required to provide a health certificate. All absences must follow Senate Policy 167: Academic Consideration.

   Also NOTE: Policy 167: Academic Consideration does allow for a once per term academic consideration request without supporting documentation if the absence is less than 3 days in duration and is **not for a final exam/final assessment**. If the absence is more than 3 days in duration and/or is for a final exam/final assessment, documentation is required. For more information please see Senate Policy 167: Academic Consideration.

4. TMU COVID-19 Information and Updates for Students summarizes the variety of resources available to students during the pandemic.

5. TMU COVID-19 Vaccination Policy.

6. If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.

7. Information on Copyright for students.

8. At Toronto Metropolitan University (TMU), we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

   If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:
   - **Distress Line:** 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)

- **Good2Talk:** 24/7 hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- Centre for Student Development and Counselling: 416-979-5195 or email csdc@ryerson.ca
- Consent Comes First - Office of Sexual Violence Support and Education: 416-919-5000 ext: 553596 or email osvse@ryerson.ca

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.