Toronto Metropolitan University

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

Course Outline (F2024)

COE718: Embedded Systems Design

Instructor(s)	Dr. Gul Khan [Coordinator] Office: ENG448 Phone: (416) 979-5000 x 556084 Email: gnkhan@torontomu.ca Office Hours: 11:45AM-1:00PM Monday
Calendar Description	This course will cover the basics of embedded system organization, system on programmable-chip technologies and real-time systems. It provides the advance knowledge required for embedded computer design and development as well as real-time operating systems. Students are introduced to software development concepts applicable to real-time and embedded systems. Particularly ARM Cortex M3 will be studied as a representative embedded processor and embedded software development is carried out for ARM Cortex CPUs. The students will be able to grasp the main principles of embedded system design and understand the concept of hardware-software codesign, system on programmable chip (SoPC), real-time operating systems and scheduling techniques. Embedded system co-specification and partitioning is also introduced in the course. SystemC or other languages (e.g. UML, C, etc.) can be employed to present a unified view of the embedded systems. SystemC is introduced as a representative Co-specification language. Embedded hardware-software design and development tools (such as Altera Quartus II and SOPC builder) will be introduced.
Prerequisites	COE538
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	1. Daniel W. Lewis, Fundamentals of Embedded Software with the ARM Cortex M3, 2nd Edition Pearson 2013, ISBN 978-0-13-291654-7
Reference Text(s):	1. T. Martin, The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach, Elsevier, 2013, ISBN 978-0080982960 2. M. Wolf, Computer as Components: Principles of Embedded Computing System Design, 4th Edition, Morgan Kaufman Publishers 2016, ISBN 978-0-12-805387-4 3. J. Yiu, The Definitive Guide to the ARM Cortex-M3, 2nd Edition, Elsevier, 2010, ISBN 978-1856179638 4. Alan Burns and Andy Wellings, Real-time Systems and Programming Languages,Addison-Wesley 2001, ISBN 0 201 72988 5. Some relevant data sheets and review articles to be identified by the instructor will be available at the course web page.http://www.ee.ryerson.ca/~courses/coe718/support.html
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Interconnect engineering concepts related to microprocessors, computer hardware and real-time software systems to design embedded systems for real-world applications. Learn

	to employ specialized knowledge of subsystems like processor cores and other hardware/software system components to design an embedded computer system. (**1c**), (**1d**) 2. Improve capabilities of using the technical knowledge of processor architecture, peripherals, programming, and CAD tools to design specific embedded computer systems. Solve various challenges of embedded software system design by employing real-time system software design methodologies to design, test and verify embedded software system design. (**4a**), (**4c**), (**4b**) 3. Demonstrate the main features of the course-project and answer critical and project specific questions during project demo and oral sessions. Write project report by following a standard IEEE like format, where all the reports are evaluated based on their completeness, English, and citations. (**7a**), (**7b**) **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	<table><tr><th>**Theory**</th><th></th></tr><tr><td>Midterm Exam</td><td>25 %</td></tr><tr><td>Final Exam</td><td>40 %</td></tr><tr><th>**Laboratory**</th><th></th></tr><tr><td>Lab</td><td>20 %</td></tr><tr><td>Project</td><td>15 %</td></tr><tr><td>TOTAL:</td><td>100 %</td></tr></table> **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 is in Week 8 during lecture time slot, 70-90 minutes, (covers Weeks 1-7 lectures). Final exam, during exam period, 120 minutes, close book (covers Weeks 1-13).
Other Evaluation Information	There will be a 5% per day penalty for late submission of labs and project.
Teaching Methods	Lecture slides will also be posted on Open Course Webpage before the lecture. Annotated Lectures will be posted on D2L after the lectures
Other Information	None

Course Content

Week	Hours	Chapters / Section	Topic, description
1	3		Introduction to Embedded and Real-time Systems
2	3		Introduction to Embedded and Real-time Systems Embedded Processor Architecture ARM7 and Cortex M3/M4 CPU Cores
3	3		ARM Cortex M3 Architecture and Programming
4	3		ARM Cortex M3 for Multitasking Applications
5	3		RTOS: Real time Operating Systems Pre-emptive and Non-preemptive Scheduling
6	3		Introduction to Real-time operating system, RTX
7	3		Real-time Scheduling
8	3		Mid-term Exam (October 21, 2024 during the lecture time slot) Real-time Scheduling
9	3		Rate-Monotonic and Earliest-Deadline-First Scheduling. Priority Inversion Problem and its Solutions
10	3		Hardware Software Co-design and Embedded System on Programmable Chips
11	3		Accelerator based Embedded System Fault-tolerant Embedded Systems

12	3		Fault-tolerant Embedded Systems.
13	3		Catching up and Course review

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

Week	L/T/A	Description
2	ENG408	Lab-1: Introduction to uVision
3	ENG408	Lab-2: Exploring ARM Cortex-M3 Features Lab-1: Due
4	ENG408	Lab-3a: RTX based Task Scheduling Lab-2: Due
5	ENG408	Lab-3a: RTX based Task Scheduling Lab-3a: Due
6	ENG408	Lab-3b: Real-time Scheduling for Multi-threaded Application
7	ENG408	Lab-3b: Real-time Scheduling for Multi-threaded Application Lab-3b: Due Start of Course Project
8	ENG408	Lab-4: Real-time Scheduling and Priority Inversion Start of Course Project Course Project Summary 1-2 pages
9	ENG408	Course Project Progress Lab-4: Due
10	ENG408	Course Project Progress

11	ENG408	Course Project Interim Report
12	ENG408	Project Demo and presentation
13	ENG408	Project presentation 12/13 Project report submission - End of Week 13

University 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

Refer to the Departmental FAQ page for furhter information on common questions.

Important Resources Available at Toronto Metropolitan University

- 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 to speak with a librarian.
- 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.
- 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 radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

  For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate Policy 167: Academic Consideration.
- 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.
- Information on Copyright for Faculty and students.

Accessibility

- Similar to an accessibility statement, use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic

accommodation regardless of program or course load.

- Learn more about Academic Accommodation Support.
- Learn how to register with AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about Academic Accommodations versus Academic Consideration and how to access each.

Wellbeing Support

At Toronto Metropolitan University, 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@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

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.