

Course Outline (F2026)

COE718: Embedded Systems Design

Instructor(s)	Dr. Gul Khan [Coordinator] Office: ENG448 Phone: (416) 979-5000 x 556084 Email: gnkhan@torontomu.ca Office Hours: 12:15PM-1:15PM Wednesday Dr. Arghavan Asad Office: EPH432 Phone: TBA Email: arghavan.asad@torontomu.ca Office Hours: Thursdays 6:00pm-7:00pm
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 (Paperback cost \$93.77 on Amazon)
Reference Text(s):	1. T. Martin, The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach, Elsevier, 2013, ISBN 978-0080982960 (optional/not-required) 2. M. Wolf, Computer as Components: Principles of Embedded Computing System Design, 4th Edition, Morgan Kaufman Publishers 2016, ISBN 978-0-12-805387-4 (optional/not-required) 3. J. Yiu, The Definitive Guide to the ARM Cortex-M3, 2nd Edition, Elsevier, 2010, ISBN 978-1856179638 (optional/not-required) 4. Alan Burns and Andy Wellings, Real-time Systems and Programming Languages, Addison-Wesley 2001, ISBN 0 201 72988 (optional/not-required)

	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 border="1"> <thead> <tr> <th colspan="2">Theory</th></tr> </thead> <tbody> <tr> <td>Midterm Exam</td><td>25 %</td></tr> <tr> <td>Final Exam</td><td>40 %</td></tr> <tr> <th colspan="2">Laboratory</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> </tbody> </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).	Theory		Midterm Exam	25 %	Final Exam	40 %	Laboratory		Lab	20 %	Project	15 %	TOTAL:	100 %
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Examinations	Midterm exam is in Week 7 during lecture time slot, 70-90 minutes, (covers Weeks 1-6 lectures). Final exam, during exam period, 120 minutes, close book (covers Weeks 1-13 lectures and Labs).														
Other Evaluation	There will be a 5% per day penalty for late submission of labs and project.														

Information	
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 Embedded Processor Architecture ARM7 and Cortex M3/M4 CPU Cores.
2	3		ARMv7 and Cortex M3/M4 CPU Cores. ARM Cortex M3 Architecture and Programming.
3	3		ARM Cortex M3 for Multitasking Applications.
4	3		RTOS: Real time Operating Systems. RTX operating system environment.
5	3		Introduction to Real-time Scheduling. Preemptive and Non-preemptive Scheduling.
6	3		Real-time Scheduling Techniques.
7	3		Mid-term Exam (during the lecture time slot)
8	3		Rate-Monotonic and Earliest-Deadline-First Scheduling (RMS and EDF). Priority Inversion.
9	3		Priority Inversion Problem and its Solutions.

10	3		Hardware Software Co-design and Embedded System on Programmable Chips.
11	3		Accelerator based Embedded System.
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	ENG411	Lab-1: Introduction to uVision
3	ENG411	Lab-2: Exploring ARM Cortex-M3 Features Lab-1: Due
4	ENG411	Lab-3a: RTX based Task Scheduling Lab-2: Due
5	ENG411	Lab-3a: RTX based Task Scheduling
6	ENG411	Lab-3b: Real-time Scheduling for Multi-threaded Application Lab-3a: Due
7	ENG411	Lab-3b: Real-time Scheduling for Multi-threaded Application Start of Course Project

8	ENG411	Lab-4: Real-time Scheduling and Priority Inversion Lab-3b: Due Course Project Summary 1-2 pages
9	ENG411	Course Project Progress Lab-4: Due
10	ENG411	Course Project Progress
11	ENG411	Course Project Interim Report
12	ENG411	Project Demo and presentation
13	ENG411	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 further information on common questions.

Important Resources Available at Toronto Metropolitan University

- [The University Libraries](#) provide research [workshops](#) and individual consultation appointments. There is a drop-in Research Help desk on the second floor of the library, and students can use the [Library's virtual research help service](#) to speak with a librarian, or [book an appointment](#) to meet in person or online.
- [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, always require documentation. Students must notify their faculty/contract lecturer once a request for academic consideration is submitted. See Senate [Policy 167: Academic Consideration](#).

Longer absences are not addressed through Policy 167 and should be discussed with your Chair/Director/Program to be advised on next steps.

- [FAQs Academic Considerations and Appeals](#)

- Information on Copyright for [Faculty/Contract Lecturers](#) and [students](#).
- Information on Academic Integrity for [Faculty/Contract Lecturers](#) and [students](#).

Academic Program Advising Contacts

Visit the Electrical, Computer and, Biomedical Engineering department's [faculty page](#) for contact information.

Lab Safety

Students are to strictly adhere and follow:

- a. The Lab Safety information/guidelines posted in the respective labs,
- b. provided in their respective lab handouts, and
- c. instructions provided by the Teaching Assistants/Course instructors/Technical Staff.

During the lab sessions, to avoid tripping hazards, the area around the lab stations should not be surrounded by bags, backpacks etc, students should place their bags, backpacks etc against the walls of the labs and/or away from their lab stations in such a way that it avoids tripping hazards.

Accessibility

Please see the Toronto Metropolitan University's Accessibility [website](#) for the university's statement on accessibility.

Academic Accommodation Support

[Academic Accommodation Support](#) (AAS) is the university's accessibility services office, supporting students with disabilities. AAS works with students, faculty, and staff to create inclusive learning environments, reduce barriers, and promote accessibility across the university.

If you have (or suspect you may have) a disability, AAS can provide consultation, guide you through registration, develop accommodation plans where appropriate, and connect you with supports and services. For information about eligibility, documentation requirements, registration, deadlines, and available services, visit AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for short-term extenuating circumstances) are governed by *different university policies*. Learn more about each process and how to access support. Students registered with AAS may request academic consideration (related or unrelated to their disability) if they experience extenuating circumstances that impact their ability to meet their shorter term academic obligations. This includes short term physical or mental health issues that are sudden/acute (e.g, the flu), unexpected illness or injury, hospitalization or treatment, and significant aggravation of a pre-existing condition. Please see [Policy 167: Academic Consideration](#) for more information and details.

Please note that there is no accommodation for missing/rescheduling or reweighting of tests - this is considered an alternate arrangement. Any student who misses a test/exam will be directed to submit an ACR to explore if possible alternate arrangements under [Policy 167: Academic Consideration](#) can apply .

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 Wellbeing Central](#) website.