EE 8205: Embedded Computer Systems

Fall 2023

VIC 302, Tuesday 3:00-6:00PM

Instructor Information

- **Instructor Name: Gul N, Khan**
- **Office Location:** ENG 448
- **Office Hours:** Tuesday 2:00-3:00PM
- **Phone:** (416) 979 – 5000, ext. 556084
- **Course Website:** my.torontomu.ca (D2L) & www.ecb.torontomu.ca/~courses/ee8205/
- **Email Address:** gnkhan@torontomu.ca

Email Policy

In accordance with the Policy on 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.

Course Description

This course focuses on the design and implementation of software for embedded systems. High performance embedded system and safety critical embedded system architecture will be introduced, Fault-tolerant and reliable embedded system design techniques are also highlighted. The main topics to be covered include embedded computer organization, hardware/software co-design of embedded systems, CAD tools for hardware/software co-design, system on chip, advance concepts of real-time operating systems and real-time scheduling. The course introduces the technologies used in the design of embedded systems such as processor cores, embedded system specification languages, and software tools for hardware/software co-verification and system partitioning. The application of embedded systems for emerging networking and medical devices will also be covered.

Course Details

Teaching Methods

Combinations of lecture, laboratory and Project, case studies, and a bit of problem-based learning.

Course Materials

Texts and readings

[1] M. Wolf, Computer as Components: Principles of Embedded Computing System Design, 4th Edition, Morgan Kaufman Publishers 2016, ISBN 978-0-12-805387-4 (TEXTBOOK)

[2] Daniel W. Lewis, Fundamental of Embedded Software with the ARM Cortex M3, 2nd Edition, Pearson 2013, ISBN 978-0-13-291654-7

[3] Z. Navabi, Embedded Core Design with FPGAs, McGraw Hill 2007, ISBN 978-0-07-147481-8

[4] SystemC: From the Ground Up, 2nd Edition, D.C. Black, J Donovan, B. Bunton, A. Keist, Springer 2010, ISBN 978-0-387-69958-5.

[5] Alan Burns and Andy Wellings, Real-time Systems and Programming Languages, Addison-Wesley 2001, ISBN 0 201 72988 1

[6] The instructor will also identify some relevant e-books and review articles.

Course Learning Outcomes

The course introduces the concepts of embedded system organization and real-time systems. The course covers the background knowledge required for understanding embedded systems, embedded system-on-chip technology, and real-time operating system

At the end of this course, students will be able to: At the end of this course, students will be able to grasp the main principles of real-time embedded systems and understand the concept of hardware-software co-design of embedded systems. Students should be able to design and program embedded systems.

Topics to be covered

- Introduction to Embedded Computer Systems
- Hardware-Software Co-design
- Embedded CPUs and IP Cores
- ARM Cortex M3 Microcontroller and Programming
- Real-time Operating System and Scheduling
- SystemC and Hardware Software Co-design
- SystemC Implementation of JPEG Compression
- Real-time Scheduling and Priority Inversion
- Hardware Software Co-synthesis and System Partitioning
- Embedded System Reliability and Fault Tolerance
- Embedded System on Programmable Chips
- Case Study of a typical Embedded System

Originality Detection

Not Applicable.

Topics and Course Schedule

Week No	Topic	Assignment, Project Issued/Due
1	Introduction to Embedded Computer Systems	
2	Hardware-Software Codesign - Introduction	
3	Embedded CPUs and ARM Cortex M3 Microcontroller	
4	ARM Cortex M3/M4 CPU Programming	
5	Real-time Operating System – RTX and VxWorks	
6	SystemC and Hardware-Software Codesign	**See Details in *Other expectations and requirements***
7	JPEG Implementation using SystemC	
8	Real-time Scheduling and Priority Inversion	
9	Hardware-Software Co-synthesis and Partitioning	
10	Embedded System Reliability and Fault Tolerance	
11	Embedded System Design Case Study	
12	Embedded System on Programmable Chips (if time permits)	

Note – Any changes and additions to this schedule will be communicated in the class and posted on the course webpage

Evaluation

Students are required to immediately 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*.
All students are expected to take note of the university policies for academic integrity.

Late work submission

Late submission will be charged with a penalty for the final project demo as well as interim project report/demo (5% per day at the maximum). There will be no late submission for the final project report.

Feedback and grades

Feedback provided regularly after assignment submission and in week 8.
Final Grade within 1-2 weeks of the final exam.

Assessment Weighting Breakdown

Evaluation Component	Percentage of Final Grade
Labs-Assignments	20%
Main Project	40%
Final Exam	40%
Total:	100%

Other expectations and requirements

Course Project

There are two parts tutorial labs to help the completion of the course project. First, students learn to program ARM Cortex M3 CPU as part of a MDK based embedded system development environment. In the main project, they design and simulate/implement an embedded system or develop a real-time embedded application.

Labs/Tutorials for Project:

Study of ARM Cortex M3/M4 processor and embedded operating system - RTX.

Main Project: Details and Selection

Please choose a topic from any one of the following areas for your project. The project topics include but not limited to the following areas:

1. Case study and review of a specific embedded system related to aerospace, biomedical, space, multimedia, or consumer electronics (smart-phone, HDTV, etc.) device.
2. Development of a μcLinux based Real-time/Embedded Multitasking Application of your choice by employing an SoPC, System on Programmable Chip.
3. Developing a Real-time/Embedded Multitasking Embedded Application of your choice by using an ARM Cortex Microcontroller.
4. Embedded System Architecture for one of the following or any other industrial application of your interest:
   - Smart Home Controllers.
   - Multimedia Applications including MP3, MPEG and JPEG 2000.
   - RFID based Embedded Systems.
5. Codesign of a specific embedded system for a particular application including signal and image processing, image compression, multimedia, or any other interesting application.
6. Study and Implementation of a Real-time Scheduling Technique using an RTX (RTOS) for ARM Cortex M3 Microcontroller.
7. Multitasking Embedded Application of your choice by employing RTX (RTOS) system for ARM Cortex M3 Microcontroller.
8. Case study of a Fault-tolerant Embedded System of your choice. (such as aerospace, military, banking or biomedical applications)

9. Modeling Embedded System of your choice or one of the following using UML, SystemC or any other simulation environment:
   - JPEG 2000, MPEG-1, MPEG-2 or MP3 encoder and decoder
   - RFID based embedded systems.
10. Any other approved project on Hardware-software Codesign and System on Chip (SoC) areas including:
   - Embedded System Co-Specification and Using SystemC for Embedded System Modeling.
   - Embedded System Partitioning into Hardware and Software Modules.
   - Embedded System Co-synthesis.

Timeline of Independent Project Selection, Design and Development

- Submit Title of the Project before or start of week-5
- Submit (1-2 pages) summary of the approach to the project during week-5
- Demo and or submit your project progress report in week-9.
- The interim project report should be 4-6 typed pages.
- Final project demo and/or presentation due by the end of Last week of the semester.
- Final project report due by the final exam day.
- The final project report should be 10-15 pages and in a typical IEEE paper style (single column).
- Late submission will be charged with a late submission penalty for the final project demo as well as interim project report/demo. There will be no late submission for the final project report.

Short Presentations of some projects will be scheduled in the last two weeks.

University Policies

Students must be 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.

The most relevant policies

(Faculty members may choose to exclude the following part from the course outline, up to the Important Resources, and leave it to students to familiarize themselves with policies from the link above. However, it is strongly recommended that every instructor goes over the most crucial requirements such as Student accommodation, Academic integrity and TMU (Ryerson) e-mail, during the 1st class, regardless if they leave it in the course outline or not).

For information on academic policies pertaining to issues such as course management, grading practices, and appeals, students are to refer to the Ryerson Senate Policies: Policy 164 – Graduate Status, Enrolment, and Evaluation, Policy 166 – Course Management , and Policy 167 – Academic Consideration.

Academic Integrity and Plagiarism

TMU's Policy 60 - 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. Plagiarism is a serious academic offence and penalties can be severe. In any

academic exercise, plagiarism occurs when one offers as one's own work the words, data, ideas, arguments, calculations, designs, or productions of another without appropriate attribution or when one allows one's work to be copied.

All academic work must be submitted using the citation style approved by the instructor. Students may refer to the TMU Library's list of Citations and Style Guides for more information.

It is assumed that all examinations and work submitted for evaluation and course credit will be the product of individual effort, except in the case of group projects arranged for and approved by the course instructor. Submitting the same work to more than one course, without instructor approval, is also considered a form of plagiarism.

Furthermore, the unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited. Intellectual property includes, but is not limited to: slides, lecture notes, presentation materials used in and outside of class, lab manuals, course packs, exams, etc.

Students are advised that suspicions of academic misconduct may be referred to the Academic Integrity Office (AIO). If there is a finding of academic misconduct, ***the minimum penalty for misconduct with respect to work submitted in a course by a graduate student is a grade of "zero" (0) on the work***. Graduate students who are found to have committed academic misconduct may also have a Disciplinary Notation (DN) placed on their academic record, **which will exclude them to be eligible for any scholarships and/or awards**. In addition, they may be assigned one or more of the penalties ranging from a**, a grade of "F" in the course, to DA (Disciplinary action), DA-S (Disciplinary action with suspension), (DW) Disciplinary withdrawal, up to an expulsion or even revocation of a degree.**

For more detailed information on these issues, please refer to the full online text for the Toronto Metropolitan University Senate Policy 60: Academic Integrity. For more information on how to avoid academic misconduct situations, for clues and tips, visit the Academic Integrity website.

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 go to Library Online Workshops.
- **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 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 Dean's 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.

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