Carleton UNIVERSITY | Department of Systems and Computer Engineering

SYSC 3310
Introduction to Real-Time Systems

Calendar description

Principles of event-driven systems. Microcontroller organization. Development of embedded applications. Programming external interfaces, programmable timer. Input/output methods: polling, interrupts. Real-time issues: concurrency, mutual exclusion, buffering. Introduction to concurrent processes.

Lectures three hours a week, laboratory two hours a week.

http://calendar.carleton.ca/undergrad/courses/SYSC/

Prerequisites

SYSC 2320.

Precludes additional credit for SYSC 2003, SYSC 3006.

Prior knowledge

Students should:

- Have knowledge and experience in the C programming language, especially regarding pointer use and manipulation.
- Understand and show at least basic proficiency on assembly programming.

Course objectives

- Understand the complexities and nuances of embedded programming.
- Gain experience in the implementation of event-driven systems, i.e., interrupt-driven.
- Gain experience in the implementation of diverse I/O strategies, e.g., PWM, debouncing.
- Understand real-time issues (e.g., priority inversion) and implement appropriate solutions.

List of topics

- Revision of C programming
- Basic I/O and interrupts
- Timers
- Analog I/O

- State machines and revisions for midterm
- Race conditions and introduction to scheduling
- Rate monotonic scheduling and priority inversion
- Dynamic scheduling and soft/hard scheduling
- WCET analysis and future of embedded systems

Learning outcomes

By the end of this course, students should have:

- Advanced proficiency in embedded programming using C.
- A comprehensive understanding of interrupt behavior and operation.
- Ability to interface with embedded hardware (peripheral devices) within a microcontroller.
- Experience in I/O implementation strategies.

Graduate Attributes (GAs)

The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes at the time of graduation. Activities related to the learning outcomes listed above are measured throughout the course and are part of the department's continual improvement process. Graduate attribute measurements will not be taken into consideration in determining a student's grade in the course. For more information, please visit: https://engineerscanada.ca/.

Graduate Attribute	Learning outcome(s)
1.5.S: Knowledge Base: Developed: Computer Systems	1-4
2.4: Problem Analysis: Developed: Interpreting the solution – validity of results	2
3.2: Investigation: Developed: Design of experiment	2, 3
4.2: Design: Developed: Detailed design specifications and requirements	3, 4
5.1: Use of Engineering Tools: Developed: Diagrams and engineering sketches	1-4

Accreditation Units (AUs)

For more information about Accreditation Units, please visit: https://engineerscanada.ca/.

The course has a total of 49 AUs, divided into:

- Engineering Science: 60%
- Engineering Design: 40%

Instructor and TA contact

Instructor: Paulo Garcia (paulo.garcia@carleton.ca)

Textbook (or other resources)

Michael Barr - “Programming Embedded Systems in C and C++”, O’Reilly, 1999, ISBN-13: 978-1565923546, ISBN-10: 1565923545

Jonathan Valvano - Introduction to the MSP432 Microcontroller - Embedded Systems, (Volume 1) 2nd Edition

Jonathan Valvano - Real-Time Interface to the MSP432 Microcontroller - Embedded Systems (Volume 2) , 2015

Ying Bai - Microcontroller Engineering with MSP432: Fundamentals and Applications, CRC Press, ISBN 9781498772983

Evaluation and grading scheme

This course will have 6 assessment components: 3 short midterm exams, 1 individual project, laboratories, and 1 final exam. The default calculation of your final grade will be:

10% midterm1 + 10% midterm2 + 15% midterm3 + 20% project + 10% labs + 35% final.

Midterm exams will be short (approximately 30minutes) quizzes on cuLearn, which will be open for a certain time period (tentatively, 16 hours) during lecture day. Deferred midterms, due to the circumstances described below in the “General regulations” section, will be offered a week after the original midterm exam.

The project will be described on cuLearn: it should be performed individually, and you must submit code, a short report/presentation explaining your code/logic, and a short video showing the project working. Project should be submitted by December 5$^{th.}$

You will receive full marks for the lab section, as long as you submit all the labs, regardless of the quality of code. Failing to submit lab assignments will result in the grade being downgraded accordingly. Submitting plagiarized work will result in a mark of 0 for the entire lab component.

Final exam will follow University procedures for regularly scheduled final exams.

During exams, you may consult all course slides available on cuLearn, as well as the provided code examples (e.g., lab solutions). No other materials my be consulted. You may not communicate with each other or anyone else during an exam.

Breakdown of course requirements

Please purchase the board we will be using:

MSP-EXP432P401R Launchpad, available here (Digikey):

https://www.digikey.ca/en/products/detail/texas-instruments/MSP-EXP432P401R/5170609

We will buy back the boards from you at the end of the term, if you want.

We will set up a pickup system during the week of September 9 to 14 (more details on this as soon as we know them).

Tentative week-by-week breakdown

This course will be offered in a hybrid format (asynchronous self-learning combined with synchronous sessions). Recommended dates for completion of each topic are displayed on the cuLearn page.

Important Information

We will hold virtual classes over Zoom once a week. The corresponding link is on cuLearn.

At each virtual class, you are expected to have read all the materials available on cuLearn corresponding to the topics up to that class (the instructor will make periodic announcements about which materials you are expected to have read by what time). Virtual classes will not be Zoom versions of a face-to-face lecture: the instructor will provide a brief overview or a demonstration of concepts, and the remainder of the time will be used for discussions and questions, similar to office hours. Please come to each virtual class prepared, having studied the materials and attempted the lab exercises to make the most of them.

Zoom operation: please keep your microphones muted at all times. When you wish to ask a question or make a comment, just type “question” in the chat. A TA will keep a list of who wants to speak, in what order, and then call upon you. At that time, un-mute your microphone.

We will make every effort to record Zoom lectures and make them available to you, so you can revise discussions later or observe the lecture if you were not able to participate.

General regulations

Attendance: Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, see the current *Undergraduate Calendar, Academic Regulations of the University, Section 2.1.3, Course Selection and Registration and Section 2.1.7, Deregistration.*

Health and Safety: Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: http://sce.carleton.ca/courses/health-and-safety.pdf

Deferred Term Work : Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be

made before the last day of classes in the term as published in the academic schedule. For more information, see the current *Undergraduate Calendar, Academic Regulations of the University, Section 4.4, Deferred Term Work.*

Appeal of Grades : The processes for dealing with questions or concerns regarding grades assigned during the term and final grades is described in the *Undergraduate Calendar, Academic Regulations of the University, Section 3.3.4, Informal Appeal of Grade and Section 3.3.5 Formal Appeal of Grade.*

Academic Integrity: Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: https://carleton.ca/registrar/academic-integrity/. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

Plagiarism: Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offense that will not be tolerated.

Academic Accommodation: You may need special arrangements to meet your academic obligations during the term. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://www.carleton.ca/equity/ For an accommodation request, the processes are as follows:

- **Pregnancy or Religious obligation**: Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf
- **Academic Accommodations for Students with Disabilities**: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your ***Letter of Accommodation*** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (*if applicable*).
- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment

where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/sexual-violence-support/.

- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf