## Carleton University Department of Systems and Computer Engineering SYSC 3310 Introduction to Real Time Systems – Fall Term 2019 Course Outline

### **Instructor Information and Office hours**

Dr. Paulo Garcia

Office Hours: Mondays and Wednesdays, 10:00 to 12:00, Mackenzie Building 4476

### **TA Information and Office hours**

### **Calendar Information**

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.

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

## Prerequisites

SYSC 2320. Knowledge and experience in the C programming language.

Students who have not satisfied the prerequisites for this course must either withdraw from the course or obtain a prerequisite waiver by visiting the Engineering Undergraduate Academic Support Office.

#### **Course Objectives**

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

In order to meet these objectives, lectures throughout this course will describe the concepts of embedded programming, how interrupts behave and how they form the basis of event-driven systems, and an overview of different I/O strategies and their implications. Laboratory work will provide meaningful practical assignments that exercise these concepts.

# **Learning Outcomes**

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

Students will achieve this course's learning outcomes through active learning. In other words, to fully achieve the learning outcomes, students are expected to perform substantial work outside of class; namely, coding and debugging on the simulator and physical microprocessor. Only through hands-on experience can engineering expertise fully be developed: lectures and laboratories will provide as much knowledge and feedback to students as possible, but embedded programming can only be mastered through self-study and hard work.

## Graduate Attributes (GA's)

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
	<b>Outcome</b> (s)
<b>1.5.S</b> Knowledge Base: Discipline-Specific Concept SCE-5: <i>Computer Systems</i>	1-2-3-4
2.4 Interpreting the Solution: Validity of Results	2
<b>3.2</b> Investigation: <i>Design of Experiment</i>	2-3
<b>4.2</b> Design: Detailed Design Specifications and Requirements	3-4
5.1 Use of Engineering Tools: Diagrams and Engineering Sketches	1-2-3-4

## Textbooks (or other resources) if applicable

Course material will be provided through CULearn. Lecture material, lab information, labs and assignments will all be posted on CULearn. Major announcements and errata will also be posted through CUlearn. You are expected to remain current with all information posted there.

There is no mandatory textbook in this course, but there are several highly recommended books. The books are readable and informative adjuncts to the original technical documents that will be used. The technical documents – technical reference manuals, user guides and data sheets - are all

free for download from Texas Instruments (TI), and easy links are provided on the course's CULearn webpage.

Recommended books:

Jonathan Valvano – "Introduction to the MSP432 Microcontroller - Embedded Systems", (Volume 1) 2nd Edition (Recommended for purchase)

Ying Bai – "Microcontroller Engineering with MSP432: Fundamentals and Applications", CRC Press. ISBN 9781498772983

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

## **Evaluation and Grading Scheme**

If the student does not write the midterm and the final exam, the student earns an F in the course.

For those students who pass at least one of the midterm or the final exam, the marks will be calculated as follows:

Lab Exercises 20% Mid-term test 35% Final exam: 45%

For those students who do not pass at least one of the midterm or the final exam, the marks will be calculated as follows:

Mid-term test 50% Final exam: 50%

In other words, the marks for the lab exercises will only be counted towards the final grade, if the student earns a passing grade in at least one of the course's examinations where it is known that the work is the student's own effort.

#### **Breakdown of course requirements**

There will be one closed-book midterm test. The date will be announced in class and posted on cuLearn. Computers, smartphones and calculators are not allowed during the midterm test.

A closed-book final exam will be held during the University's **December** examination period. The Academic Regulations of the University permit instructors to specify requirements that must be satisfied for students to be eligible to write the final examination or, where circumstances warrant, the deferred final examination.

All students are eligible to write the final examination, regardless of the marks they received during the term.

The final examination is for evaluation purposes only and will not be returned to students. You will be able to make arrangements with the instructor or with the department office to see your marked final examination after the final grades have been made available.

# Labs

The purpose of the labs is to have students work on applied problems related to the lecture material, giving the student practical experience on the course topics.

Lab assignments should not be performed during lab hours. Embedded software is complicated, requiring careful consideration in the design and meticulous debug It is very unlikely you will be able to start and finish your assignment during lab hours. Assignments should be done at home, prior to the lab. The purpose of the labs is to show your work to the TAs, who will record that you finished your assignment, and give you feedback in order to improve your work.

**Ideally,** you will arrive at the lab with your assignment prepared, show it to the TA who will record your grade, and you are free to leave. **The end of each lab period is the deadline for presenting its corresponding assignment.** 

All labs will be performed with a partner. You and your lab partner must be registered for the same lab section. The lab partnership must be registered with your TA during your first lab section. Once registered, the partnership will continue. A partnership can be dissolved only after discussion with the TA.

It is expected that both partners will contribute to all aspects of each lab, and both partners are expected to be present during the demonstration. If a partner is missing during the lab period, s/he receives zero for the demonstration regardless of the reason, although s/he may receive points for the remaining aspects of the work, if the other partner verifies that s/he contributed to the work. If there is an imbalance in the contributions of partners to the lab, each partner will have separate marks.

Requests for missing a lab due to work or job interviews or other non-medical reasons will not be accepted. You (and your partner) must attend and demonstrate your work in your registered lab section each and every week.

If you wish to change lab sections, before making any changes at the Registrar's office or on Carleton Central, you must get the change pre-approved by a TA in the section to which you want to move. Basically, you will need another student (not your lab partner) with whom you will switch sections. If this is not possible, you cannot change lab sections.

### Lab Kits

Each pair of lab partners will have a lab kit. A deposit of \$99 must be paid. The deposit will be returned when the hardware is returned at the end of term. The full deposit will only be returned if the full inventory contents are received and if a TA can run a full test program on the hardware demonstrating that it still works. Dollar amounts will be withheld if parts are missing or if parts are not working.

1. In your first lab, register your lab partner.

2. Before your second lab, get your lab kit from the Systems Departmental Office ME4456

a. Prepare \$99 on one person's debit card.

b. Print a copy of the Lab Kit Deposit Sheet and fill in your names and student numbers.

c. Go to the office during office hours with your debit card and the completed Lab Kit Deposit Sheet

d. Once approved, pick up your Kit from the technical office (ME4224a).

e. When you leave with your kit, you and your lab partner are fully responsible for the care of the entire lab kit. Full details on the Deposit Sheet.

3. In the last lab, bring your lab kit and a printed copy of the Lab Kit Return Sheet

a. During the lab, prepare your hardware for a test and wait your turn.

b. A TA will run programs on your hardware to ensure that all parts are working.

c. The TA will fill in – and sign – your Lab Kit Return Sheet with the status of your hardware.

4. Take your kit to the technical office.

5. Bring the signed Lab Kit Return Sheet to the Systems Departmental Office ME4456 for your refund.

#### Week-by-Week breakdown

This schedule and class content are tentative, and subject to change.

Week 1: Course introduction and revision of C programming.

Week 2: Basic I/O and interrupts.

Week 3: Interrupts continued. Timers.

Week 4: Timers continued. Analog I/O.

Week 5: State machines and revisions for midterm.

#### Week 6: Midterm exam.

Week 7: Race conditions and introduction to scheduling.

Week 8: Rate monotonic scheduling and priority inversion.

Week 9: Dynamic scheduling and soft/hard scheduling.

Week 10: WCET analysis and future of embedded systems.

### Week 11: Revisions for final exam.

### **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: <u>http://sce.carleton.ca/courses/health-and-safety.pdf</u>

**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: <u>https://carleton.ca/registrar/academic-integrity/</u>. 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 <a href="http://www.carleton.ca/equity/">http://www.carleton.ca/equity/</a> 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 <u>https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf</u>
- 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: <a href="https://carleton.ca/sexual-violence-support/">https://carleton.ca/sexual-violence-support/</a>.
- 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 <a href="https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf">https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf</a>

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