uOttawa

School of electrical Engineering and Computer Science (EECS)

École de science informatique et de génie électrique (SIGE)

CEG4166/CSI4141
Real Time Systems Design (3, 1.5, 3)
Winter 2023

Instructor	Gilbert Arbez
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MS Teams	The preferred method of communication is via MS Teams chat/video.
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Office hours	By appointment

1 – COURSE DESCRIPTION

Definition of real-time systems; examples. Characteristics of real-time systems. Analysis frameworks and tools. Elements of real-time system structure. Reliability and fault tolerance. Exceptions and exception handling. Concurrency and concurrent programming in real-time systems. Synchronisation and communication, resource control, and scheduling in real-time systems. Real-time systems design methodologies. Computer assisted design of real-time systems. The course will focus on the design of an embedded real-time system which can be defined as:

> Embedded real-time Systems are comprised of computer software/hardware components embedded into larger systems composed of other sub-systems (both mechanical and electronic). Input information from ***sensors*** are fed into these systems, which compute control signals for driving the ***devices*** (e.g. an actuator); that is the system is continuously interacting with the environment. In real-time systems, correctness of operation depends not only its logical behavior, but also the time at which the results are produced.

2 – COURSE LEARNING OBJECTIVES

Upon successful completion of this course, the student

- Will be able to describe the main characteristics of a real-time embedded system
- Will be able to integrate hardware components into the design of a real-time embedded systems
- Will be able to and have applied various task scheduling methods into the design of real-time embedded systems
- Will have gained skills in utilizing a real-time operating system and software development tools to developing real-time embedded system products.
- Will have evaluated real embedded systems requirements documents
- Will have worked successfully in a team-based real-time embedded systems development project
- Will have contributed to the various designs and design documentation created to meet given requirements during team-based embedded system development project
- Will have contributed to the implementation of a real-time embedded systems from documented designs
- Will have tested and analyzed a real-time system as well as its performance
- Will have applied an iterative and agile development process (SCRUM) to developing a number of real-time embedded system products
- Will have worked as a team and with the teaching assistants to communicate their progress through regular weekly discussions (scrums) and online task tracking tool, thereby further enhancing their communication skills
- Will demonstrate a responsible and professional attitude as a team member or team leader during the real time embedded systems project
- Will have further developed life-long learning and independent study skills to master the hardware and software building blocks of real-time embedded systems

3 – PREREQUISITES

CSI 3131 Operating Systems

4 – LECTURE/TUTORIALS/LABS SCHEDULE

Section B

Lectures:	Mondays 13h00 to 14h30
	Wednesdays 11h30 to 12h50
Tutorials:	Mondays 17h30 to 18h50
Laboratories*:	Tuesdays 11h30 to 14h30
	Tuesdays 14h30 to 17h20
	Friday 14h30 to 17h20
	Thursday 13h00 to 15h50

* Participate in only one lab session.

Section C

Lectures:	Tuesdays 14h30 to 15h50
	Fridays 16h00 to 17h20
Tutorials:	Wednesdays 11h30 to 12h50
Laboratories*:	Saturdays 11h30 to 14h20
	Wednesdays 16h00 to 18h50

* Participate in only one lab session.

5 – LECTURE FORMAT

Lectures shall be used in a flipped classroom format in order to explore and discuss the principles to be applied with the real-time embedded development project. The main objective is have students engage in active participation for learning these principles rather than follow presentations of the information. It is thus expected that students prepare for class completing assigned readings, explore the project documents (requirements, hardware documentation, software tool documentation, etc.) in order to contribute to class discussions. A tentative schedule of topics for lectures is presented in this syllabus and online (Brightspace). The schedule is subject to changes.

6-TEACHING ASSISTANTS

Haopeng Wang. hwang266@uottawa.ca
Palwasha Waheed Shaikh, pshai065@uottawa.ca
Edwin Thomas, ethom123@uottawa.ca
Abhillash Paal, apaal022@uottawa.ca
To be determined (two other TAs).

7 – TEXTBOOK AND LECTURE NOTES

The following book is required. Students are expected to complete reading assignments before class.

Phillip Laplante and Seppo Ovaska. *Real-Time Systems Design and Analysis*, *Tools for the Practitioner*, Wiley, 4th edition, 2012.

A copy of the e-book is available at the following link. A copy of the book may be downloaded for free from the university; using the following link (select O-Book):

https://www.wiley.com/en-us/Real+Time+Systems+Design+and+Analysis%3A+Tools+for+the+Practitioner%2C+4th+Edition-p-9781118136607

8 – ADDITIONAL READING

Documentation on software tools, hardware, and the system used during the embedded system project development is provided online through Brightspace.

9 – TUTORIALS/LABS

Groups of 4-6 students participate in a Real-Time Embedded Systems Design and Implementation project; the project experience will mimic a professional process including a methodology, programming/documentation standards and management/tracking time with a project management software.

The tutorial and lab sessions are dedicated to the real time embedded systems project. The tutorial shall be used for planning, research, design, documentation, software development, etc. These activities can also be undertaken during the lab session; in addition, the system is tested during these sessions. The hardware system is shared among all team members. Two different products shall be developed during 2 Sprints throughout the session.

10 – ASSIGNEMENTS

Assignments are not used in this course. For each Sprint of the project, 4 deliverables shall be submitted for review.

11 – EXAMS/LABORATORY REPORTS/PROJECT REPORTS

Project: The project work is mandatory. For each sprint, each project teams shall provide the following deliverables to be submitted to Brightspace:

- Deliverable 1 – Draft Design.
- Deliverable 2 – Reviewed design and implementation
- Deliverable 3 – Demonstration of unit tests and final product
- Deliverable 4 – Final version (release document and implementation.
- Notes:
    - The design is documented in the release document. For the first two deliverables, only the design sections of new modules are included in a PDF document. For the final deliverable, the **complete** release document is submitted in PDF format; be sure to supply the complete release document and not only the sections developed by the team.
    - The implementation consists of a zipped file of a Code Composer project. This project contains the complete source code for the Sprint's software product as well as the API HTML documentation generated with Doxygen. Be sure to update the Doxygen documentation to reflect changes and additions made to the software. Run a "Project Clean" to keep the size of the project to a minimum.
    - For each deliverable, the form "**Personal Ethics Agreement Concerning University Assignments**", signed by all team members.

Project deliverables are evaluated using a Rubric scheme (posted on Brightspace).

Midterm Quiz: This quiz shall given in Brigthspace and contain questions on fundamentals of real time systems topics studied in the first part of the course. The midterm exam is scheduled on Sunday, March 5 between 10h00 and 11h30.

Final Exam: This exam will be open book. It will consist of an analysis and design exercise of a real time embedded system using the software tools (e.g. real-time OS), hardware, and design methods applied during the term project. The University will release the time and date of the final exam during the semester

12 – IN-CLASS EXPECTATIONS

Be prepared before class. An active participation, both individual and especially as a team, is expected. Arrive in class with questions to help advance the work in the project.

13 – GRADING SCHEME

Project	50%
Mid-term Exam	15%
Final Exam	35%

14 – PASSING GRADE

The passing grade for this course is 55% (D+).

15 – ATTENDANCE AND CLASSROOM ETIQUETTE

- ***Attendance at lectures, labs and tutorials is mandatory. As per academic regulations, students who do not attend 80% of these class activities will not be allowed to write the final examination.***
- Time spend on all course activities shall be reported via a project management software.
- Cell-phones should be turned to silent.

16 – REMINDERS

- All components of the course (i.e., laboratory reports, assignments, etc.) must be fulfilled; otherwise, students may receive an INC as a final mark (equivalent to an F). *This is also valid for a student who is taking the course for the second time*.
- Information on academic fraud can be found at the following link:

  https://www.uottawa.ca/about-us/policies-regulations/academic-regulation-i-14-academic-fraud

  Students are to become familiar with the Faculty of Engineering rules and regulations; you may refer to them if you happen to miss an exam. These are within the University of Ottawa's regulations sections 9.4, 9.5, 9.6, 14.2 and 14.3, which define conduct during an examination, academic fraud, the sanctions and the decision and appeal processes: https://www.uottawa.ca/about-us/policies-regulations/academic-regulation-i-9-evaluation-student-learning
- Students are to familiarize themselves with the University of Ottawa's policy on plagiarism https://www.uottawa.ca/current-students/academic-integrity. This policy will be strictly enforced in this course.
- Important dates and deadlines for the academic year can be found at the following link: https://www.uottawa.ca/important-academic-dates-and-deadlines/.
- Several resources from the faculty of engineering can be found at the following link: https://www.uottawa.ca/en/students
- If necessary, the instructor will contact students through their official University of Ottawa's e-mail address (username@uottawa.ca). If you are using a personal e-mail address, please go to the university mail management web site to set a forwarding address (https://www.uottawa.ca/about-us/information-technology/services/account/email). You are responsible for ensuring you are receiving official course information in an efficient and timely manner.

17 – TOPICS AND TENTATIVE SCHEDULE†

Course Schedule

- Subject to changes

Week	Lecture Modules	Tutorial	Labs	Sprint
Jan 9 to 14	Introduction, team organization Fundamentals of Real-Time Systems	No Tutorial	No Lab	Sprint 1 - Data acquisition
Jan 16 to 21	C-Programming Hardware for real-time systems	1) Introduction to SCRUM, Sprint Planning	1) Sprint Scrum, Project tasks	Jan 21 - Sprint 1 - Deliverable 1 - Draft Design
Jan 23 to 28	AM335x Hardware	2) Sprint Scrum, Project tasks	2) Sprint Scrum, Project tasks	
Jan 30 to Feb 4	RTOS: pseudokernels and co-routine scheduling	3) Sprint Scrum, Project tasks	3) Sprint Scrum, Project tasks, Unit Testing Demos (Sprint 1 Deliverable 3)	Feb 4- Sprint 1 - Deliverable 2 - Design/Implementation
Feb 6 to 11	RTOS: interrupts and tasks, scheduling framework	4) Sprint Retrospective/Planning	4) Sprint Scrum, Project tasks, Unit Testing Demos (Sprint 1 Deliverable 3)	
Feb 13 to 18	RTOS: Cyclic Scheduling	5) Sprint Scrum, Project tasks	5) Sprint Scrum, Project tasks, Unit Testing Demos, Product Demonstration (Sprint 1 Deliverable 3)	Feb 18 - Sprint 1 Deliverable 3 - Test Demos Feb 18 - Sprint 1 Deliverable 4 - Release documentation and CCS project Sprint 2 - Continous data acquisition/technician interface
Feb 20 to 25	Study Week			
Feb 27 to March 4	Introdution to Sprint 2	6) Sprint Scrum, Project tasks	6) Sprint Scrum, Project tasks	Midterm exam: Sunday, March 5, 10h00 to 11h30, CRX 140 and CRX 240 (See Brightspace for assigned room)
March 6 to 11	Software Design Approaches	7) Sprint Scrum, Project tasks	7) Sprint Scrum, Project tasks	March 11 - Sprint 2 - Deliverable 1 - Draft Design
March 13 to 18	RTOS: Scheldluing with priorities	8) Sprint Retrospective/Planning	8) Sprint Scrum, Project tasks	
March 20 to 25	RTOS: Other Services	9) Sprint Scrum, Project tasks	9) Sprint Scrum, Project tasks, Testing Demos (Sprint 2 Deliverable 3)	March 25 - Sprint 2 - Deliverable 2 - Revised Design/Implementation
March 27 to April 1	RTOS: Other Services	10) Sprint Scrum, Project tasks	10) Sprint Scrum, Project Tasks (Tuesday Labs), Testing Demos (Sprint 2 Deliverable 3)	
April 4 to April 8 (Easter holiday from April 7 to 11, thus all activites on April 7/8 are moved to April 11/12)	Potential Subjects: • Programming Languages • Performance Analysis Techniques • Software Testing and Systems Integration • Control Systems • Future of Real-Time Systems	11) Sprint Scrum, Project tasks, Sprint 2 Retrospective	10) Sprint Scrum, Project Tasks, Testing Demos (Sprint 2 Deliverable 3)	April 12 - Sprint 2 Deliverable 3 - Test Demos April 14 - Sprint 2 Deliverable 4 - Release documentation and CCS project

The above schedule is available on Brightspace.

18 – OTHER INFORMATION

- The University of Ottawa provides, upon request, appropriate academic adjustments for students who have learning disabilities, health, psychiatric or physical conditions. For more information, please contact Access Service (http://www.sass.uottawa.ca/access/). The Student Academic Success Service provides many more services to help you succeed (http://www.sass.uottawa.ca/about/our-services.php).

† Exact Content and dates may vary from this list: refer to course website for notifications

19 – GRADUATE ATTRIBUTES ASSESSMENT

1 **A knowledge base for engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

1.1 Will be able to describe the main characteristics of a real-time embedded system

2 **Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions

2.1 Will have further developed independent study skills to master the hardware and software building blocks of real-time embedded systems

3 **Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions
3.1 Will have tested and analyzed a real-time system as well as its performance

4 **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

4.1 Will be able to integrate hardware components into the design of real-time embedded systems
4.2 Will be able to and have applied various task scheduling methods into the design of real-time embedded systems
4.3 Will have contributed to the various designs and design documentation created to meet given requirements during team-based embedded system development project

5 **Use of engineering tools:** An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

5.1 Will have gained skills in utilizing a real-time operating system and software development tools to developing real-time embedded system products
5.2 Will have contributed to the implementation and testing of a real-time embedded system from documented designs

6 **Individual and team work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
6.1 Will have worked successfully in a team-based real-time embedded systems development project

7 **Communication skills:** An ability to communicate complex engineering concepts within the profession and with society. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

7.1 Will have contributed to the various designs and design documentation created to meet given requirements during team-based embedded system development project
7.2 Will have evaluated real embedded systems requirements documents
7.3 Will have worked as a team and with the teaching assistants to communicate their progress through regular weekly discussions (scrums) and online task tracking tool, thereby further enhancing their communication skills

8 **Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

8.1 Will demonstrate a responsible and professional attitude as a team member or team leader during the real time embedded systems project

9 **Impact of engineering on society and the environment:** An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

10 **Ethics and equity:** An ability to apply professional ethics, accountability, and equity.

11 **Economics and project management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

11.1 Will have applied an iterative and agile development process (SCRUM) to developing a number of real-time embedded system products

12 **Life-long learning:** An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

20-PERSONNAL ETHICS AGREEMENT CONCERNING UNIVERSITY ASSIGNMENTS/PROJECTS

See following pages

Personal Ethics Agreement Concerning University Assignments

Individual Assignment

I submit this assignment and attest that I have applied all the appropriate rules of quotation and referencing in use at the University of Ottawa, https://www.uottawa.ca/current-students/academic-integrity. I attest that this work conforms to the regulations on academic integrity of the University of Ottawa.

_____ _____

Name, Capital letters Student number

_____ _____

Signature Date

Personal Ethics Agreement Concerning University Assignments

Group Project

We submit this assignment and attest that we have applied all the appropriate rules of quotation and referencing in use at the University of Ottawa, https://www.uottawa.ca/current-students/academic-integrity. We attest that this work conforms to the regulations on academic integrity of the University of Ottawa. We understand that this assignment will not be accepted or graded if it is submitted without the signatures of all group members.

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