CME 332.3 (3L-1.5P)
Real Time Computing

Department of Electrical and Computer Engineering
Winter 2015

UNIVERSITY OF SASKATCHEWAN

Description:	Provides the foundations for the multi-disciplinary field of real-time systems. In addition to basic time-constrained design and analysis techniques, the course addresses the issues of hardware/software tradeoffs, static and dynamic scheduling algorithms, features of real-time operating system kernels, and common design problems in multitasking systems; topics are supplemented by examples of real-time applications.
Prerequisites:	(CMPT 115 or CMPT 117), CME 331, and CME 341 (taken)
Corequisites:	None
Instructor:	Daniel Teng Associate Professor, Department of Electrical and Computer Engineering Office: Room 3B03, Engineering Building Phone: (306) 966-2889 Email: d.teng@usask.ca
Lectures:	Monday-Wednesday-Friday, 10:30 - 11:20 am, ENGR 2C44
Tutorials:	TBD
Laboratory:	Thursday, Jan 8, 22; Feb 5, 26; Mar 12, 26, 8:30 am-11:20 am, Room 2C80
Website:	Assignments, solutions, lab schedules, general course information, and announcements will be posted on the course website. Students are responsible for keeping up-to-date with the information on the course website. http://www.engr.usask.ca/classes/CME/332
Course Reference Numbers (CRNs):	30519 (lectures), 30582 (laboratory)
Textbooks:	1. "*Hard Real-Time Computing Systems*", 2011, G. C. Buttazzo, Springer.
Office Hours:	Monday-Wednesday, 4:30 - 5:20 pm, or email for appointment
Reading List:	1. "*Real-Time Systems*", 2000, Jane Liu, Prentice Hall. 2. "*Real-Time Concepts for Embedded Systems*", 2003, Qing Li and Caroline Yao, CMP Books. 3. "*Embedded Systems Building Blocks*", 2002, Jean J. Labrosse, CMP Books 4. Altera manuals, user guides, tutorials and other related documents
Assessment:	The methods of assessment and their respective weightings are given below:

Assignments	10%
Laboratories	10%
Midterm Written and Lab Exam	30%
Final Written and Lab Exam	50%

To receive credit for the course, all the exams and labs must be completed.

Final Grades: The final grades will be consistent with the "literal descriptors" specified in the university's grading system.

http://students.usask.ca/current/academics/grades/grading-system.php

For information regarding appeals of final grades or other academic matters, please consult the University Council document on academic appeals.

http://www.usask.ca/secretariat/student-conduct-appeals/StudentAcademicAppeals.pdf

Course Content: CME 332 will help you to learn about the real-time systems. A real-time system is one in which the overall correctness of the system depends on both the functional correctness and the timing correctness. In other words, a late answer is a wrong answer.

Real-time system design is a complex discipline that is also influenced by software engineering, operations research and control theory. We will focus on different approaches to real-time system design and analysis, and real-time operating system.

Module 1: Design of Multitasking in Real Time Systems
Design Architecture of Real Time Systems
Clock-Driven Cyclic Executive Approach
Real-Time Operating Systems Kernel Objects

Module 2: Priority assignment algorithms and schedulable utilization
Rate-Monotonic Algorithm and Schedulable Utilization
Deadline-Driven Algorithms and Schedulable Utilization
Schedulability Analysis
Time-Demand Analysis
Clock Tick and Time Jitters in Real-Time Operation System Kernel

Module 3: Handling Non-Periodic Tasks
Slack Stealing and Acceptance Test
System Loading Factor, Overload Value and Rejection Policies
Task Server Techniques and Acceptance Test

Module 4: Common Design Issues in Real Time Systems
Semaphore and Resource Synchronization
Priority Inversion and Types of Blocking
Block Time and Associated Time Demand Analysis and Schedulability Analysis
Resource Control Protocols and Associated Blocking Times
Intertask Communications
Counting Semaphore and Access Control of Multiple-Unit Resources

Assignments: Assignments (analysis, labs, tutorials, etc.) will become available on the class website and must be submitted prior to 11:59 p.m. on the date shown. No assignments will be accepted late without legitimate justification.

Tutorials: Tutorial sessions will be scheduled as needed.

Quizzes: N/A

Exams: Examination questions will be mainly based on information given in lectures, assignments, and labs. If you must miss the midterm exam for a university-sanctioned reason, provide appropriate documentary evidence and your final exam score will substitute for the midterm.

The midterm written exam will be held on Wednesday, February 11, 5:00 – 7:00 p.m. in ENGR 2C44. The final written exam (3 hours) will be scheduled by central university administration. Lab examination dates and locations will be announced during lecture.

Important Dates:

February 11	Midterm written examination
February 11 and 13	No lecture in lieu of midterm examination

Student Conduct: Ethical behaviour is an important part of engineering practice. Each professional engineering association has a Code of Ethics, which its members are expected to follow. Since students are in the process of becoming Professional Engineers, it is expected that students will conduct themselves in an ethical manner.

The APEGS (Association of Professional Engineers and Geoscientists of Saskatchewan) Code of Ethics states that engineers shall "conduct themselves with fairness, courtesy and good faith towards clients, colleagues, employees and others; give credit where it is due and accept, as well as give, honest and fair professional criticism" (Section 20(e), The Engineering and Geoscience Professions Regulatory Bylaws, 1997).

The first part of this statement discusses an engineer's relationships with his or her colleagues. One of the ways in which engineering students can demonstrate courtesy to their colleagues is by helping to maintain an atmosphere that is conducive to learning, and minimizing disruptions in class. This includes arriving on time for lectures, turning cell phones and other electronic devices off during lectures, not leaving or entering the class at inopportune times, and refraining from talking to others while the instructor is talking. However, if you have questions at any time during lectures, please feel free to ask (chances are very good that someone else may have the same question as you do).

For more information, please consult the University Council Guidelines for Academic Conduct.

http://www.usask.ca/secretariat/student-conduct-appeals/academic-misconduct.php

Academic Honesty: The latter part of the above statement from the APEGS Code of Ethics discusses giving credit where it is due. At the University, this is addressed by university policies on academic integrity and academic misconduct. In this class, students are expected to submit their own individual work for academic credit, properly cite the work of others, and to follow the rules for examinations. Academic misconduct, plagiarism, and cheating will not be tolerated. Copying of assignments and lab reports is considered academic misconduct. Students are responsible for understanding the university's policies on academic integrity and academic misconduct. For more information, please consult the University Council Regulations on Student Academic Misconduct and the university's examination regulations.

http://www.usask.ca/secretariat/student-conduct-appeals/StudentAcademicMisconduct.pdf
http://policies.usask.ca/policies/academic-affairs/academic-courses.php

Safety: The APEGS Code of Ethics also states that Professional Engineers shall "hold paramount the safety, health and welfare of the public and the protection of the environment and promote health and safety within the workplace" (Section 20(a), The Engineering and Geoscience Professions Regulatory Bylaws, 1997).

Safety is taken very seriously by the Department of Electrical and Computer Engineering. Students are expected to work in a safe manner, follow all safety instructions, and use any personal protective equipment provided. Students failing to observe the safety rules in any laboratory will be asked to leave.

Laboratory Learning Outcomes:

Upon successful completion of the laboratory, students should be able to

1. Build a real-time system using clock-driven cyclic execution approach
2. Build a real-time system using a real-time operating systems

Learning outcome(s) for each of the scheduled labs

1. Develop software for a multitasking, preemptive real-time operating system
2. Develop software for a system based on Nios II processor
3. Develop software for a system based on Altera Nios II processor
4. Build a computer hardware system based on Altera Nios II processor
5. Configure µC/OS-II for a system based on Altera Nios II processor
6. Develop a real-time system based on µC/OS-II running Nios II processor

Course Learning Outcomes:

Upon successful completion of the course, students should be able to

1. Design a simple real-time system using cyclic executive approach and its variants
2. Design a real-time system using a preemptive, multitasking, real-time operating system kernel
3. Assign priorities to tasks in a multitasking real time system and calculate schedulability utilization under different scheduling algorithms
4. Calculate worst-case response time of a task for different system design
5. Use different protocols for resource control and determine worst-case blocking times of a task under different resource control protocols
6. Determine overload value and system laxity of a multitasking real time system
7. Detect and avoid potential deadlock in a multitasking system
8. Use real time operating system kernel objects for intertask communication, resource control, and other applications
9. Use task server technique to handle sporadic and aperiodic tasks
10. Perform real-time scheduling simulations