ENGG*4420 Real Time Systems Design
Fall 2013

School of Engineering

(Revision 0: September 5, 2013)

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1 INSTRUCTIONAL SUPPORT

1.1 Instructor

Instructor: Radu Muresan, Ph.D., P.Eng.
Office: RICH 2509, ext. 56730
Email: rmuresan@uoguelph.ca
Office hours: Fridays: 1 pm to 3:30 pm; or by appointment

1.2 Lab Technician

Technician: Hong Ma
Office: THRN 1506, ext. 53873
Email: hongma@uoguelph.ca

1.3 Teaching Assistants

GTA	Email	Office Hours
Matthew Mayhew	mmayhew@uoguelph.ca	TBA on Courselink

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2 LEARNING RESOURCES

2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG*4420 Courselink site and on my personal course webpage. You are responsible for checking the sites regularly.

2.2 Required Resources

1. Radu Muresan, *Engg*4420 Real-Time Systems Design Lecture Notes*, University of Guelph, Courselink System, 2013.
2. Radu Muresan, *Engg*4420 Real-Time Systems Design Lab Manual*, Custom Course Pack, University of Guelph Bookstore, 2011.

2.3 Recommended Resources

1. Rajib Mall *Real-Time Systems Theory and Practice*, Pearson Education, 2008.
2. Giorgio C. Buttazzo, *Hard Real-Time Computing systems*, 3rd Edition, Springer, 2011.
3. Jane W. S. Liu *Real-Time Systems*, Prentice Hall, 2000.
4. C. M. Krishna, Kang G. Shin, *Real-Time Systems*, McGraw-Hill, 1997.
5. Gene F. Franklin, J. David Powell, Abbas Emami-Naeini, *Feedback Control of Dynamic Systems*, 5th Edition, Prentice Hall, 2006.
6. Jean J. Labrosse *MicroC/OS-III The Real-Time Kernel*, Micrium, 2009.
7. Nimal Nissanke, *Real-Time Systems*, Prentice Hall, 1997.
8. Stuart Bennett, *Real-Time Computer Control*, Prentice Hall, 1994.

2.4 Additional Resources

Lecture Information: All the lecture notes are posted on the ENGG*4420 Courselink system (week #1to week #12) under ENGG4420 LECTURES module.

Lab Information: The Engg*4420 Real-Time Systems Design Lab Manual can be purchased from the University of Guelph bookstore and it is also posted on the ENGG*4420 Courselink system under the LABORATORY module.

Assignments: The assignments are posted on the ENGG*4420 Courselink system under the ASSINGMENTS module.

Exams: Some solutions of previous midterm exams will be posted on the ENGG*4420Courselink system under the EXAM SOLUTIONS section. Also, after each midterm exam a complete solution of the exam with the marking scheme applied will be posted for your reference.

Miscellaneous Information: Other information related to Real-Time Systems will be posted on the web page.

2.5 Communication & Email

Please use lectures and lab help sessions as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. **It is your responsibility to check the course website regularly.** As per university regulations, all students are required to check their <uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its student.

3 ASSESSMENT

3.1 Dates and Distribution

Labs: 40%
See section 5.4 below for due dates

Midterm Test 1: 15%
Tu Oct 8th, 19:00-21:00, Room RICH 1504B

Midterm test 2: 20%
Tu Nov 5, 19:00-21:00, Room RICH 1504B

Final Exam: 25%
Thurs Dec 7th, 19:00-21:00, Room TBA on Webadvisor

3.2 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor at the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: In order to pass the course, you must meet the following conditions:

1. Students must finalize and submit all the labs (Demo + Report) and obtain a passing grade of 50% or higher in all the labs. Also the students are required to have a good participation on the work evaluation form (+/- 10% variation max allowed). The work evaluation form can be downloaded from the Engg*4420 Courselink system found under the LABORATORY module. If an overall grade of lower than 50% is obtained in any lab, the students need to arrange with the instructor and the teaching assistant to reschedule a new demo and report submission. In this case, grade penalties will be applied as appropriate.
2. Obtain a passing grade of 50% or higher in the final exam or have an average grade of 50% or higher in the midterm tests.
3. If the course passing conditions 1 and 2 are not met then the final course grade will be the average of the exams out of 100% (the laboratory grades will not be considered).

Contesting marks: All laboratory and midterm test marks must be contested within 1 day from the grade submission. Also the exams must be written in pen or ink for contest considerations.

Missed midterm tests: If you miss a test due to grounds for granting academic consideration or religious accommodation, you will need to arrange a makeup exam date with the instructor.

Lab Work: You must attend and complete all laboratories. If you miss a laboratory demo due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup lab demo.

Late Lab Reports: Late submissions of lab reports will be accepted only with the approval of the course instructor. However, penalties on late submissions will be applied. Applied penalties will be posted on Engg*4420 Courselink system.

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4 AIMS, OBJECTIVES & GRADUATE ATTRIBUTES

4.1 Calendar Description

This course teaches real-time concepts from a system and computing perspective covering topics related to four major areas. Real-time computer control and system modeling area teaches basic real-time design and system modeling concepts for hard and soft real-time computer control applications. Real-time Operating Systems (RTOS) area introduces common kernel objects and inter-task communication and synchronization using examples from current commercial RTOS. Topics in the area of scheduling present theoretical results related to uniprocessor and multiprocessor scheduling algorithms and topics in the area of fault tolerance and reliability present current techniques at software and hardware level.

Prerequisite(s): ENGG*2400, ENGG*3640
Corequisite(s): None

4.2 Course Aims

This course is a senior level course in most electrical and computer engineering programs and in most computer science programs. The main goals of the course are (1) to teach students the fundamental concepts in real-time systems from a system and computing perspective (2) to teach students how to develop real-time applications using modern real-time operating systems.

4.3 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability to:

1. Efficiently model a system for the purpose of implementing a real-time control system.
2. Efficiently design and implement a real-time control algorithm.
3. Differentiate between different types of tasks (i.e., periodic, aperiodic, soft, hard, non-real time) and properly use these tasks in the design.
4. Choose the appropriate RTOS (real-time operating system) for a specific application.
5. Design and implement real-time applications using commercial RTOS such as uC/OSIII, MQX, and Real-Time LabView. Use of kernel objects and services.
6. Understand and apply in the design of real-time systems the mechanisms of resource access protocols such as priority inversion protocol, the priority ceiling protocol and others.

7. Understand and apply in the design of real-time systems common uniprocessor and multiprocessor scheduling algorithms.
8. Understand the design safety and reliability components in real-time systems.
9. To apply the concept of simulation/experimentation for the purpose of designing and testing real-time systems.
10. Model using LabView a hot air plant system and an automotive suspension system.
11. Design a real-time controller for a hot air plant and for a semi active suspension system using uC/OSIII and Real-Time LabView.
12. Design real-time embedded applications for systems control.
13. Implement and demonstrate specified real-time control systems.

4.4 Graduate Attributes

Successfully completing this course will contribute to the following CEAB Graduate Attributes:

Graduate Attribute	Learning Objectives	Assessment
1. Knowledge Base for Engineering	1, 2, 3, 4, 5, 6, 7, 8	Exams, Labs
2. Problem Analysis	3, 4, 5, 9, 10	Labs
3. Investigation	10, 11	Labs
4. Design	2, 5, 9, 10, 11, 12	Exams, Labs
5. Use of Engineering Tools	9, 10, 11, 12	Labs
6. Communication	13	Labs
7. Individual and Teamwork	9, 10, 11, 12, 13	Labs
8. Professionalism	-	-
9. Impact of Engineering on Society and the Environment	8	Exams
10. Ethics and Equity	-	-
11. Environment, Society, Business, & Project Management	-	-
12. Life-Long Learning	4, 5, 12	Labs

4.5 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. All lecture notes plus various exercises, examples and referenced resources will be made available to students on Courselink system in the appropriate module. However, these are not intended to be stand-alone course notes. During lectures, the instructor will expand and explain the content of notes and provide in class solutions to problems that supplement posted notes. Scheduled classes and labs will be the principal venue to provide information and feedback for tests and labs.

4.6 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and labs. In addition students are encouraged to consult the instructor and the TA during the scheduled office hours or to contact the instructor or TA for any help needed. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

4.7 Relationships with other Courses & Labs

Previous Courses:

ENGG*2400 (Engineering Systems Analysis): Analytical description and modeling of engineering systems such as electrical, thermal, automotive, and other control systems.

ENGG*3640(Microcomputer interfacing): Interfacing microcomputers to I/O external equipment, developing interfacing routines, understanding of the fabrics of the microcontroller architecture and programming. Understand synchronous and asynchronous serial communication and data acquisition topics.

Follow-on Courses:

NA

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5 TEACHING AND LEARNING ACTIVITIES

5.1 Timetable

Lectures:

Tuesday	Sec 01	14:30 – 15:50	MACN 118
Thursday	Sec 01	14:30 – 15:50	MACN 118

Laboratory:

Wednesday	Sec 01	8:30 - 11:20	RICH 1504B

5.2 Lecture Schedule

Lectures	Lecture Topics	References	Learning Objectives
1-3	Definitions, Classifications and Characteristics of Real-time Systems and Real-Time Tasks	Lecture Notes	3
4	Design Example, Generalized Computer Approach, System Implementation Approach	Lecture Notes, Lab Manual	1, 2, 9, 11

5-7	Dynamic Models Approach for Real-Time Systems Control, Theory and Examples	Lecture Notes	1, 2, 9, 11, 12
8-9	Feedback Control, PID, Tuning, Application to Digital Real-Time Controllers	Lecture Notes	1, 2, 9, 11, 12
10-11	DDC Control – Implementation of Real-Time Control Algorithms	Lecture Notes	1, 2, 9, 11, 12
12	Implementation of Real-Time Controller Designs Based on Plant Models	Lecture Notes	1, 2
13	Survey of Contemporary Real-Time Operating Systems, Benchmarks	Lecture Notes	4
14	Defining an RTOS, µC/OSIII RTOS Architecture and Application Types	Lecture Notes	5
15-16	Critical Sections, Task Management, Special Tasks, Scheduling, Context Switch, Interrupt Management, Time Management	Lecture Notes	5, 7
17	Resource Management, Priority Inversion, Deadlocks, Synchronization	Lecture Notes	5, 6
18	Message Passing, Flow Control, Complex Example	Lecture Notes	5
19	MQX Basics: an RTOS for Uni-Processor, Multi-Processor and Distributed Processor Embedded Real-Time Systems	Lecture Notes	5, 7
20-21	Uniprocessor Scheduling: Theory and Applications	Lecture Notes	7
22	Real-Time Task Scheduling in Multiprocessor and Distributed Systems	Lecture Notes	7
23	Fault Tolerant Schedulability, Safety and Reliability in Real-Time Systems	Lecture Notes	8
24	Modeling Timing Constraints in Real-Time Systems	Lecture Notes	1

5.3 Design Lab Schedule

Week	Activity	References	Learning Objectives
1	Introduction to Lab 1 design requirements, equipment and design tools	Lab Manual	9, 12
2-3	Lab 1 implementation	Lab Manual	9, 10, 11, 12
4	Lab 1 demo		13
4	Introduction to Lab 2 design requirements and plant modeling	Lab Manual	9, 10, 11, 12
5	Lab 2 implementation	Lab Manual	9, 10, 11, 12
6	Lab 2 demo.		13
6	Introduction to Lab 3 design requirements and time constraints for the control algorithm design	Lab Manual	5, 9, 11, 12
7-8	Lab 3 implementation	Lab Manual	5, 9, 11, 12
9	Lab 3 Demo		13
9	Introduction to Lab 4 design requirements and real-time LabView	Lab Manual	5, 9, 11, 12
10	National Instruments industry presentation		5
10-11	Lab 4 implementation	Lab Manual	5, 9, 11, 12
12	Lab 4 demo		13

5.4 Lab Schedule

Week	Topic	Due
1	Introduction to Lab Equipment and Safety Training	
1-3	Lab 1: Modeling and control of a Hot Air Plant using LabView with serial communication to the real-time embedded platform	Week 4: Demo Week 4: Report
4-5	Lab 2: Real-time automotive suspension system simulation and control	Week 6: Demo Week 6: Report
6-8	Lab 3: Real-time embedded controller of a Hot Air Plant using an RTOS	Week 9: Demo Week 10: Report
9-11	Lab 4: Multi-core real-time suspension controller using real-time LabView OS	Week 12: Demo Week 12: Report

5.5 Other Important Dates

Thursday, 5 September 2013: First class

Monday, 14 October 2013: Thanks giving holiday

Thursday, 31 October 2013: Drop date – 40th class

Thursday, 28 November 2013: Last class (Monday Schedule in effect)

You can refer the student undergraduate calendars for the semester scheduled dates.

6 LAB SAFETY

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

7 ACADEMIC MISCONDUCT

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member.

7.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/

Please also review the section on Academic Misconduct in your Engineering Program Guide.

The School of Engineering has adopted a Code of Ethics that can be found at:
http://www.uoguelph.ca/engineering/undergrad-counselling-ethics

8 ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact the Centre for Students with Disabilities as soon as possible.
For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: http://www.csd.uoguelph.ca/csd/