Electrical & Computer ENGINEERING

Carnegie Mellon University Course Syllabus

18-349: Introduction to Embedded Real-Time Systems

Fall Semester, 2015

Course Personnel:

Instructor:

Anthony Rowe
Collaborative Innovation Center (CIC) 2217
Email: agr@ece.cmu.edu
Office Hours: Tuesday 1-2pm

Teaching Assistants:	Email	Office Hours (HH1303)	
Ian Hartwig	ihartwig@andrew.cmu.edu	Monday	5-6pm
Aaron Reyes	areyes@andrew.cmu.edu	Tuesday	5-6pm
Misha Kutsovsky	mksutsovs@andrew.cmu.edu	Wednesday	5-6pm
Kenneth Li	kyli@andrew.cmu.edu	Thursday	5-6pm
Hing On Miu	hmiu@andrew.cmu.edu	Friday	5-6pm
ALL	(day before lab due date)	Sunday	5-6pm

Class Schedule:
Lecture: Monday and Wednesday 3:00-4:20 MM 103
Pre-requisites: (18-213 and 18-240)
Anti-requisites: (18-342 and 18-348)

Course Description:
This practical, hands-on course introduces the various building blocks and underlying scientific and engineering principles behind embedded real-time systems. The course covers the integrated hardware and software aspects of embedded processor architectures, along with advanced topics such as real-time, resource/device and memory management. Students can expect to learn how to program with the embedded architecture that is ubiquitous in cell-phones, portable gaming devices, robots, tablets, etc. Students will then go on to learn and apply real-time principles that are used to drive critical embedded systems like automobiles, avionics, medical equipment, wearables, etc. Topics covered include embedded architectures (building up to modern 16/32/64-bit embedded processors); interaction with devices (buses, memory architectures, memory management, device drivers); concurrency (software and hardware interrupts, timers); real-time principles (multi-tasking, scheduling, synchronization); implementation trade-offs, profiling and code optimization (for performance and memory); embedded software (exception handling, loading, mode-switching, programming embedded systems). Through a series of laboratory exercises with state-of-the-art embedded processors and industry-strength development tools, students will acquire skills in the design/implementation/debugging of core embedded real-time functionality.

Course Calendar (Tentative)

Date	Day	Class Activity	Lab Activity
August			
31	M	L1: Introduction – Course Overview	
September			
2	W	L2: ARM Architecture	
7	M	No Class - Labor Day	
9	W	L3: ARM asm Overview	Lab 0 Released
14	M	L4: Memory Mapped I/O and Buses	
16	W	L5: Serial Buses	
21	M	L6: Timers and Interrupts	Lab 0 Due, Lab 1 Released
23	W	L7: ARM SWI	
28	M	L8: Sampling, ADCs, DACs	
30	W	L9: Sensors and Actuators	
October			
5	M	L10: ARM Profiling and Optimization	Lab 1 Due, Lab 2 Released
7	W	L11: Processes	
12	M	L12: Mid-term Review	Lab 2: Checkpoint 1 Due
14	W	Mid Term	
19	M	L13: Scheduling and Concurrency	Lab 2 Due, Lab 3 Released
21	W	L14: Real-Time Scheduling 1-2	
26	M	L15: Real-Time Scheduling 2-2	
28	W	L16: Memory Management	
November			
2	M	Lab 3 Discussion	
4	W	No Class	
9	M	L17: Embedded Linux	
11	W	L18: Multi-Core and SoC	
16	M	No Class	
18	W	L19: Low Power Embedded	
23	M	L20: Real-Time Communication	Lab 3 Due, Lab 4 Released
25	W	No Class – Thanksgiving	
30	M	L21: Wireless Communication	
December			
2	W	L22: Case Study: PID Controller	
7	M	Course Wrap-up	Lab 4 Due
9	W	Exam Review	Lab Redemption Due
14	M	Final Exam	

Course Blackboard:
In order to access the course blackboard from an Andrew Machine, go to the login page at: http://www.cmu.edu/blackboard. You should check the course blackboard daily for announcements and to download copies of papers and review templates.

Communication:
For course communication, we will be using Piazza. Be sure when asking questions not to publically post any source code or assembly.

Reference Books and Materials:

Recommended references (not required) for background information:

1. Hermann Kopetz, "Real-Time Systems: Design Principles for Distributed Embedded Applications". Kluwer, 1997
2. Jon S. Wilson, "Sensor Technology Handbook", Newnes, ISBN 0750677295, 704 pages, 2004.

Grading:

60% Lab Assignments (Lab 0=5%, Lab 1=10%, Lab 2=10%, Lab 3=20%, Lab 4=15%)
20% Midterm
20% Final

Late Policy: There are no late days; you cannot submit any lab material past the deadline (midnight the due date). You have one redemption lab due at the end of the semester that can be used to *replace* any previous lab for up to 85% of its original value.

While lower cutoffs may be used, the following maximum grade cutoffs are guaranteed:

> 90 A
> 80 B
> 70 C
> 60 D

Academic Integrity:
Students at Carnegie Mellon are engaged in preparation for professional activity of the highest standards. Each profession constrains its members with both ethical responsibilities and disciplinary limits. To assure the validity of the learning experience a university establishes clear standards for student work.

In any presentation, creative, artistic, or research, it is the ethical responsibility of each student to identify the conceptual sources of the work submitted. Failure to do so is dishonest and is the basis for a charge of cheating or plagiarism, which is subject to disciplinary action.

Cheating includes but is not necessarily limited to:

1. Plagiarism, explained below.
2. Submission of work that is not the student's own for papers, assignments or exams.
3. Submission or use of falsified data.
4. Theft of or unauthorized access to an exam.
5. Use of an alternate, stand-in or proxy during an examination.
6. Use of unauthorized material including textbooks, notes or computer programs in the preparation of an assignment or during an examination.
7. Supplying or communicating in any way unauthorized information to another student for the preparation of an assignment or during an examination.
8. Collaboration in the preparation of an assignment. Unless specifically permitted or required by the instructor, collaboration will usually be viewed by the university as cheating. Each student, therefore, is responsible for understanding the policies of the department offering any course as they refer to the amount of help and collaboration permitted in preparation of assignments.
9. Submission of the same work for credit in two courses without obtaining the permission of the instructors beforehand.

Plagiarism includes, but is not limited to, failure to indicate the source with quotation marks or footnotes where appropriate if any of the following are reproduced in the work submitted by a student:

1. A phrase, written or musical.
2. A graphic element.
3. A proof.
4. Specific language.
5. An idea derived from the work, published or unpublished, of another person.

This policy applies, in all respects, to 18-349.

Revision History

9-10-15 *Changed Lab due dates to accommodate for Lab 0 late release.*

10-7-15 Adjusted October Schedule to allow for exam review and Lab 2 checkpoint

11-12-15 Adjusted Lab 4 due date and last few lectures.