Electrical & Computer ENGINEERING

Carnegie Mellon University Course Syllabus

18-349: Introduction to Embedded Real-Time Systems

Fall Semester, 2016

Course Personnel:

Instructor:

Anthony Rowe
Collaborative Innovation Center (CIC) 2217
Email: agr@ece.cmu.edu
Office Hours: Tuesday 4-5pm

Teaching Assistants:	**Email**	**Office Hours (HH1303)**
Mark McElwaine	mmcelwai@andrew.cmu.edu	Monday 5-6pm
Udaya Malik	umalik@andrew.cmu.edu	Tuesday 5-6pm
Adwait Dongare	adongare@andrew.cmu.edu	Wednesday 5-6pm
Vivek Sridhar	viveksri@andrew.cmu.edu	Thursday 7:30-8:30pm
Karthic Palaniappan	kapalani@andrew.cmu.edu	Friday 5-6pm
All	(Sunday before lab due date)	Sunday 5-6pm

Class Schedule:

Lecture: Monday and Wednesday 3:00-4:20 BH A51

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			
29	M	L1: Introduction – Course Overview	
31	W	L2: ARM Architecture	
September			
5	M	No Class - Labor Day	
7	W	L3: ARM asm Overview	Lab 0 Released
12	M	L4: Memory Mapped I/O and Buses	
14	W	L5: Serial Protocols	
19	M	L6: Timers and Interrupts	Lab 0 Due, Lab 1a Released
21	W	L7: ARM Profiling and Optimization	
26	M	L8: ARM SWI	Lab 1b Released
28	W	L9: Sampling, ADCs, DACs	
October			
3	M	L10: Sensors and Actuators	Lab 1 Due, Lab 2 Released
5	W	L11: Processes	
10	M	L12: Mid-term Review	Lab 2: Checkpoint 1 Due
12	W	Mid Term	
17	M	L13: Scheduling and Concurrency	Lab 2 Due, Lab 3 Released
19	W	L14: Real-Time Scheduling 1-2	
24	M	L15: Real-Time Scheduling 2-2	
26	W	Lab 3 Design Review	
31	M	No Class	
November			
2	W	L16: Embedded Linux	
7	M	L17: Multi-Core and SoC	
9	W	L18: Embedded Power Management	
14	M	L19: Embedded Control	Lab 3 Due, Lab 4 Released
16	W	TA Lecture: PCB Design and Manufacturing	
21	M	L20: Real-Time Communication	
23	W	No Class – Thanksgiving	
28	M	L21: Embedded Wireless Communication	
30	W	L22: Security for Embedded Systems	
December			
5	M	Course Wrap-up	Lab 4 Due
7	W	Exam Review	Lab Redemption Due
15	R	Final Exam 5:30-8:30pm	

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

8-29-16	*Fall 2015 to Fall 2016 date updates…*
9-18-16	*Updated TA office hours and moved Optimization Lecture earlier. Lab 1 broken into two parts.*
10-24-16	*Reorganized lectures in second half of semester. Changed office hours.*