Cyber-Physical Systems: Computation, Control, and Communication (CSE 6359, Special Topics in Advanced Systems and Architecture)
Spring 2014
University of Texas at Arlington
Computer Science and Engineering

Instructor:

Taylor Johnson

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Section Information:

CSE 6359-001 (*26407*)

Course Website:

http://www.taylortjohnson.com/class/cse6359/s14/

Time and Place of Class Meetings:

ERB 129, Mondays/Wednesdays 1pm-2:20pm

Office Hours:

ERB559, Mondays/Wednesdays 2:30pm-3:30pm and by appointment (email me to schedule appointments)

CSE Concentration Areas: Computer Systems/Architecture and Software Engineering

Course Schedule (*Syllabus*; note that all information appearing on this website supersedes that appearing in the syllabus PDF, that is, the website is more up-to-date):

The instructor for this course reserves the right to adjust this schedule in any way that serves the educational needs of the students enrolled in this course. All readings refer to Lee and Seshia unless otherwise noted. All assignment dates are approximate at this point and will be updated on this website as the semester progresses.

- 1/13: Introduction: What Are Cyber-Physical Systems?
- 1/15: Modeling Cyber-Physical Systems: Overview of Continuous, Discrete, and Hybrid Models
- 1/20: No Classes (Martin Luther King, Jr. Day)
- 1/22: CPS Modeling: Continuous Dynamics and Lyapunov Stability
- 1/27: CPS Modeling: Discrete Dynamics, Reactivity, and Termination
- 1/29: CPS Modeling: Hybrid Dynamics
- 2/3: CPS Modeling: Composition
- 2/5: CPS Design: Architectural Choices
- 2/10: CPS Design: Real-Time Operating Systems
- 2/12: CPS Design: Networking Embedded Systems
- 2/17: CPS Design: Sensors and Actuators
- 2/19: CPS Design: Holistic System Design
- 2/24: CPS Analysis: Real-Time Tasks and Worst-Case Execution Time
- 2/26: CPS Analysis: Finding and Proving Invariants
- 3/3: CPS Analysis: Convergence, Liveness, and Termination using Lyapunov Functions, Multiple Lyapunov Functions, Common Lyapunov Functions, and Ranking Functions
- 3/10: No Classes (Spring Break)
- 3/12: No Classes (Spring Break)
- 3/17: CPS Review of Concepts
- 3/19: Paper Presentations
- 3/24: Paper Presentations
- 3/26: Paper Presentations
- 3/31: Paper Presentations
- 4/2: Paper Presentations
- 4/7: Paper Presentations
- 4/9: Paper Presentations

- 4/14: Paper Presentations
- 4/16: Paper Presentations
- 4/21: Paper Presentations
- 4/23: Paper Presentations
- 4/28: Course Review and Summary
- 4/30: Traveling (No Class or Guest Lecture TBD)
- 5/2: University Last Day of Classes
- 5/5, *11am to 1:30pm*: Final Exam Scheduled Time (Final Project Presentations and Final Project Reports Due)
- 5/9: Last Day of Final Exams

Textbooks and Other Course Materials:

- Edward A. Lee and Sanjit A. Seshia, *Introduction to Embedded Systems: A Cyber-Physical Systems Approach*, http://LeeSeshia.org, ISBN 978-0-557-70857-4, 2011. (Main Textbook)
- Papers to be presented will be decided by the instructor and students based on interests

Description of Course Content:

Cyber-physical systems (CPS) involve the coordination of cyber (software) and physical state, and are becoming prevalent due to the proliferation of devices for control (sensing / actuation), computation, and communications. This seminar course introduces CPS fundamentals, covering relevant topics on: embedded systems (real-time operating systems), control theory (control systems modeling, analysis, and design), networking (layers, protocols, and wireless), reliability, and software engineering (testing and formal analysis of CPS). The course will begin with lectures on CPS fundamentals, followed by a student-led portion with summaries and presentations of select research papers. The grading for the course will be based on a few homeworks, paper summaries and presentations, along with a semester project.

Prerequisites:

Students from all branches of engineering are welcome. All students are expected to have experience programming in C. Knowledge of embedded systems design and modeling (such as real-time operating systems), will be useful, but not strictly required. If you have any questions or concerns, please email the instructor to discuss your background.

Student Learning Outcomes:

The objective of this course is to introduce students to cyber-physical systems modeling, analysis, and design. Students should be able to:

- Define embedded systems and cyber-physical systems (CPS) and give examples
- Understand various modeling formalisms for CPS, such as hybrid automata, state-space methods, etc.
- Understand CPS design, modeling, and analysis
- Compare architectural design trade-offs in CPS
- Design CPS and analyze models of CPS to see if they meet their specifications and requirements
- Understand methods for verification and validation of CPS such as simulation, testing, model checking, etc.
- Understand and appreciate engineering design and analysis difficulties in CPS disciplines (computer science / embedded software engineering, electrical engineering, mechanical engineering, etc.)
- Evaluate, understand, and critique recent research papers in embedded systems, verification, and CPS
- Present research papers and verbally communicate research results effectively
- Write research project reports and communicate written research results effectively

Descriptions of major assignments and examinations:

Coursework for roughly the first half of the course will include a few homeworks on materials from lectures, all of which is designed to aid projects. Students will summarize (as a document) and present papers based on their research interests that coincide with the course content. The semester project will be a major component of the grade. Since this is a research-oriented course, students are expected to actively participate in discussions and take notes to be shared. In the event that the instructor decides the class is not performing satisfactorially with the open-ended second half of the course, the instructor reserves the right to utilize additional homework assignments and an exam for grading evaluation instead of paper summaries and presentations for grading evaluation.

Attendance:

Students are strongly encouraged to attend lectures and come to office hours.

Other Requirements:

Students are expected to check the course website for updates to the course schedule throughout the semester.

Grading:

Grade percentages will be calculated based on the following weights:

- Class Participation and Note-Taking: 5%
- Semester Project: 50%
- Paper Presentation and Summaries: 25%
- Homework: 20%

Letter grades will be determined based on the following ranges:

- 100 >= A >= 90
- 90 > B >= 80
- 80 > C >= 70
- 70 > D >= 60
- 60 > F >= 0

The instructor reserves the right to move the thresholds down based on the distribution of final percentages (i.e., curve), but they will not move up (e.g., if a grade percentage is between 90 and 100, this will receive an A). Students are expected to keep track of their performance throughout the semester and seek guidance from available sources (including the instructor) if their performance drops below satisfactory levels.

Make-Up Assignments:

If you miss any course assignment (exam, quiz, presentation, homework, etc.) to unavoidable circumstances (e.g., health), you must notify the instructor in writing via email as soon as possible and request a makeup approval. If it is a planned (non-emergency) abcense, you must inform the instructor ahead of time! Do NOT ask for make-ups if you do not complete something due to travel (except when you are required to travel to represent the university or department on official business, but request at least 3 days ahead of the due date or exam time).

Grade Grievances:

Any appeal of a grade in this course must follow the procedures and deadlines for grade-related grievances as published in the current undergraduate catalog (see *here*).

The first step is as follows. If you do not believe a grade on a particular assignment is correct, you may appeal the grade in writing (by email) within 5 days. Grade appeals must be appealed to the appropriate GTA first (if applicable), then to the instructor if necessary.

Drop Policy:

Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. Students will not be automatically dropped for non-attendance. Repayment of certain types of financial aid administered through the University may be required as the result of dropping classes or withdrawing. For more information, contact the *Office of Financial Aid and Scholarships*.

Americans with Disabilities Act:

The University of Texas at Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including the Americans with Disabilities Act (ADA). All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of that disability. Any student requiring an accommodation for this course must provide the instructor with official documentation in the form of a letter certified by the staff in the Office for Students with Disabilities, University Hall 102. Only those students who have officially documented a need for an accommodation will have their request honored. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found *here* or by calling the Office for Students with Disabilities at 817-272-3364.

Academic Integrity:

Students enrolled in this course are expected to adhere to the UT Arlington Honor Code: I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence. I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code. UT Arlington faculty members may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System Regents' Rule 50101, Section 2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University.

Student Support Services:

UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals, students may visit the reception desk at University College (Ransom Hall), call the Maverick Resource Hotline at 817-272-6107, send a message to *resources@uta.edu*, or view the information *here*.

Electronic Communication:

UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available *here*.

Student Feedback Survey:

At the end of each term, students enrolled in classes categorized as "lecture," "seminar," or "laboratory" shall be directed to complete an online Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student's feedback enters the SFS database anonymously and is aggregated with that of other students enrolled in the course. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law; students are strongly urged to participate. For more information, visit *here*.

Final Review Week:

A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week unless specified in the class syllabus. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

Emergency Exit Procedures:

Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit, which is located to the south side of Engineering Research Building. When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist handicapped individuals.