A. JAMES CLARK SCHOOL OF ENGINEERING

Electrical and Computer Engineering Department @ UMD

ENEE 759I: Introduction to Cyber-Physical Systems

General Information:

Number of credits:	3
Time and location:	Tuesdays/Thursdays 2:00-3:15pm
Instructor:	Prof. Yasser Shoukry
Office hours:	TBD

Course Description:

The increasingly tight coupling of cyber (computing & communication) and physical (sensing & actuation) components has opened the door to the development of complex engineered systems. These systems (commonly termed Cyber-Physical Systems, or CPS for short) have enabled a multitude of applications (such as smart power grids, self-driving cars, tele-health, and smart cities). Advances in CPS will enable new capabilities and improved adaptability, scalability, and usability that will far exceed those current embedded systems.

This course is intended to cover principles and foundations of modeling and analysis of cyber-physical systems. This course assumes familiarity with embedded systems design and implementation and does not not cover topics like microprocessor architecture, embedded systems programming and real-time OS. Instead, this course focuses on the top-level system design and in particular on the interplay between software components and physical dynamics. The primary emphasis of this course is to teach students how to build high confidence systems using model-based design paradigm. Therefore, the course will start by reviewing the aspects of modeling both cyber components (finite state machines and Stateflow) and physical components (difference/differential equations). While these models are suitable for analyzing each component separately, they can not be used to model and analyze the system as a whole. Therefore, the more advanced models for hybrid systems and timed automata will be introduced. With this background, the course will then focus on formal languages and tools for system analysis and verification. Topics such as temporal logic, model equivalence and model checking will be covered. Time permitting, a set of special topics including security and privacy, networking, and sensor/actuator calibration will be covered.

The course is accompanied with a set of labs and projects to give hands-on experience on the covered material. Students will be asked to propose group-based projects. The main theme for the projects this year will be: smart cities and self-driving cars.

The course is offered as an undergraduate class (ENEE459-I) and as a graduate class. Students enrolled in the graduate class will be given additional assignments and will have additional expectations for the project.

Pre-Requisites:

EENE 350 (Computer Organization), ENEE 322 (Signal and System Theory), familiarity with Matlab and embedded processor programming using C.

Textbooks:

Introduction to Embedded Systems - A Cyber-Physical Systems Approach, Second Edition, by E. A. Lee and S. A. Seshia, 2015. The book can be downloaded for free from the following URL: `http://leeseshia.org/`.

Course Outline:

- Part 1: Modeling Cyber-Physical Systems
  - Continuous Dynamics (modeling physical components)
  - Discrete Dynamics (modeling cyber components)
  - Hybrid Systems
  - Composition of State Machines
- Part 2: Analysis and Verification
  - Specification and Temporal Logic
  - Equivalence and Refinement
  - Reachability Analysis and Model Checking
  - Execution Time Analysis
- Part 3: Special Topics
  - Models for Sensors and Actuators
  - Security and privacy
  - Networking

Grading:

5%	Lab 1: Hardware-in-the-loop simulation using RaspberryPi and Matlab
5%	Lab 2: Building physical models from data
5%	Lab 3: CPS design and verification: hill climbing robot
25%	Homework (approximately six assignments, 5% for each assignment, consider only best 5 assignments)
15%	In class midterm (comprehensive)
45%	Class project - Teams of 2/3 students (presentation 25%, report 20%)