EC 545 – Cyber-Physical Systems – Fall 2022

Instructor: Prof. Wenchao Li

Email	wenchao@bu.edu
Office Location	PHO 336
Office Hours	TBD

Course Description:

This course introduces students to the principles underlying the design and analysis of cyber-physical systems (CPSs) – computational systems that interact with the physical world. We will study a wide range of applications of such systems ranging from robotics, through medical devices, to smart manufacturing plants. A strong emphasis will be put on building high-assurance systems with real-time and concurrent behaviors. The students will gain both in-depth knowledge and hands-on experience on the specification, modeling, design, and analysis of representative cyber-physical systems. A new addition to the course materials this semester is content on learning-enabled CPSs, e.g. dynamical plants controlled by a neural network controller.

Prerequisites:

ENG EC 327, CAS MA 193, and ENG EC 401 (recommended); or equivalent basic knowledge of programming, data structure and algorithms, discrete mathematics, and signals and systems.

References:

Textbook: Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978-0-262-53381-2, 2017.
https://ptolemy.berkeley.edu/books/leeseshia/releases/LeeSeshia_DigitalV2_2.pdf

Additional reading materials will be posted on Blackboard.

List of Topics:

We may cover only a subset of the following.

- Modeling of dynamical behaviors:
  - continuous dynamics, e.g. actor models
  - discrete systems, e.g. extended finite state machines
  - timed automata
  - hybrid systems, i.e. systems with both discrete and continuous-time behaviors
  - concurrent model of computation, e.g. synchronous-reactive models
- Design of CPS:
  - sensor and actuators
  - embedded processors, with an emphasis on parallelism
  - memory architectures and models
  - I/O, with an emphasis on concurrency
  - scheduling of real-time systems
  - design of learning-enabled CPS
- Specification and analysis of CPS:
  - temporal logic, e.g. linear temporal logic
  - simulation and refinement, e.g. simulation and bisimulation

- reachability analysis
- model checking
- timing analysis, e.g. worst-case execution time analysis
- security properties, e.g. formalization using hyperproperties

Grading:

Homework assignments: 40% (10% × 4)
Midterm: 25% (Date TBD)
Team-based project: 35% (More details about this later in the semester)

Assignments:

Homework assignments will be posted on Blackboard and are due at the beginning of class. They must be turned in online on Gradescope. You will be given two 'late-day's which you must use as a whole (i.e. you cannot split a late-day into two half late-days but you can use the two late-days separately for two different assignments or for a single assignment). This is intended to handle any contingency that you might have. Late-days will be automatically applied to late submissions on Gradescope unless you explicitly specify that you don't want them to be applied to your submission. Other than the two late-days, no late homework will be accepted, except for legitimate excuses backed by written and dated documentation (e.g. COVID-related situations).

We take cheating very seriously. You must clearly acknowledge all sources (e.g., textbooks, websites) at the top of your homework. You are encouraged to discuss the problems with your classmates but you must write all the answers in your own words, and you may not share your answer/code with any of your classmate. You must also be able to fully explain your answers upon demand.

Academic Honesty:

All students are responsible for reading Boston University's academic conduct policy. If you are unclear about any item related to academic honesty, you should immediately ask the instructor. Dishonesty in representing one's academic work is a serious ethical violation, and will be reported according to university policy. The university's Academic Conduct Code can be found at https://www.bu.edu/academics/policies/academic-conduct-code/.

Course Website and Communication:

You are required to periodically check the course website on BU Blackboard (learn.bu.edu) and your e-mail. Blackboard will have the course schedule, slides, links to reading materials, assignments, announcements, and a discussion board. Please use email or post on Piazza for class-related questions.

When emailing the instructor, you should put "EC545-Fall22" in the subject line to ensure a timely response.

COVID-related Policies and Exceptions:

Safety: Refer to https://www.bu.edu/covid/ for BU's COVID policy. As of September 6, 2022, there is no mask mandate for classrooms although you are still encouraged to weak high-quality masks in crowded settings (with classroom being one such setting).
COVID-related absence: In cases when you need to miss a lecture, an exam, or the class for an extended amount of time (e.g., 1 week) due to a COVID-related situation, we offer the following accommodations and suggestions.

- Missing a lecture: Lecture slides will be posted on Blackboard. You are encouraged to reach out to a fellow classmate or the instructor to discuss any questions that you may have on the lecture materials.
- Missing an exam: A different exam will be given to all who missed the original exam on a later date in the semester. You must email or speak to the instructor to explain the reason for missing the exam. Written and dated documentation will be required for obtaining this accommodation.
- Missing the class for an extended period: We understand that this can a difficult situation since you may end up missing several lectures, a homework assignment, and even an exam. Please reach out to the instructor directly to discuss remedial options.