CMSE 423 Embedded Systems Design (Hi-End)

Department: Computer Engineering

Instructor Information
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Meeting times and places: 4 hrs Lecture, 2 hrs Lab (for 14 weeks)

Program Name: Software Engineering | **Program Code:** 29

Course Code	**Credits**	**Year/Semester**
CMSE 423	4	2021-2022 Fall

☒ Required Course ☐ Elective Course

Prerequisite(s):
CMPE/CMSE 223

Catalog Description
Application areas, common characteristics, and challenges in embedded system design. Requirement specification, models of computation and modeling methods such as automata, and state charts, data flow modeling. High End Embedded Systems (HES) hardware, ASICs, processors, memories, communication, conversion between analog and digital inputs and outputs, sampling, and actuators, secure hardware. Embedded operating systems, general requirements, RTOS, virtual machines, real time databases. IoT projects and implementation. Evaluation and validation, performance evaluation, energy and power models, simulation, rapid prototyping, emulation. Test, test pattern generation, evaluation of test patterns, design for testability. (CMSE223).

Course Web Page
https://staff.emu.edu.tr/mehmetbodur/en/teaching/cmse423

Textbook(s)
E.A. Lee and S.A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, 2Ed, MIT Press, 2017.

Indicative Basic Reading List
Course Notes by M. Bodur.

Topics Covered and Class Schedule
(4 hours of lectures per week)

Week 1	Trends in Embedded Systems Industry, application areas. Common challenges in (High End) Embedded Systems design and applications [Survey and Ch0]
Week 2	Importance of modeling the real world, and cyber world, for given requirement specifications[Ch1]
Week 3	Modeling the continuous physical world: physical laws and constraints, kinematics, and dynamics. Signal flow diagrams [Ch2].
Week 4	Discrete Systems Modeling, Discrete and Hybrid systems, automata, and statecharts [Ch3, Ch4].
Week 5	Commons of HEES Projects, Simulation, Emulation, and Rapid Prototyping, Sensors and Actuators, sampling [Ch7] (quiz-1)
Week 6	HES hardware, Input-Output Ports, analog, digital, and serial input-outputs and communication, [Ch10].
Week 7	Processors and Memory systems, RTOS, virtual machines, real time databases [Ch8, Ch9]
Week 8	(Midterm Exam)
Week 9	IoT projects and implementation: NodeRED on Raspberry and on PC. Team project discussions [project introduction].
Week 10	Incremental Design, test, test pattern generation, evaluation of test patterns, design for testability, [project implementation and verification]
Week 11	Evaluation and validation: performance evaluation, energy and power models [project evaluation]
Week 12	Security of Embedded Systems, Cryptographics, Symmetric and Public Key encryption, Kerckhoff's principle, Confidentiality, Integrity, Authenticity. Software Security, Attacker and Threat models, Security in Embedded Industry [Ch 17]
Week 13	Student Prototype Project Discussions, (project reporting)
Week 14	(Final Exam, Final revision of project reports)

Laboratory Schedule:
(2 hours of laboratory per week)

Week 4	Modeling and control of continuous systems by Signal Flow Diagrams.
Week 5	Modeling and control of hybrid systems by Signal Flow Diagrams.
Week 6	ESD application on Arduino, using digital inputs, LCD display, PWM outputs, etc
Week 7	ESD application on Arduino, analog input interfacing (reading temperature by using a thermistor).
Week 10	Raspberry (Raspi) LED, button and Serial port interfacing by NodeRED ,
Week 11	Raspi: building a web based dashboard for high-end applications
Week 12	Discussions on Team Projects -2,

Course Learning Outcomes

Upon successful completion of the course, students are expected to have the following competencies
(1) Perform kinematic and dynamics modelling of simple physical systems for HES design (1).
(2) Know typical structure of a HES, and use simple digital i/o ports in C (1).
(3) Know analogue, digital and hybrid approaches, and use a typical AD converter of a HES (1).
(4) Know typical control, and monitoring approaches for High End Embedded Systems (HES) (1).
(5) Know common cyber modelling tools and methods, and apply FSM techniques on HES (1).
(6) Know common principles of IoT systems, and apply them on an IoT platform (1).
(7) Analyse technical requirements and design a HES using indicators, displays, sensors and actors (1).
(8) Analyse and comment on ethical social and environmental responsibilities of an embedded system design (4).
(9) Practice an embedded system preliminary design starting from technical requirements (2).
(10) Practice an embedded system design in teams including its tests (5).

(11) Prepare a team design report to document hardware/software development of a HEES, including its tests (6).

	Method		Percentage
Assessment	Labs		10%
	Quiz, and Homework		15%
	Midterm Exam		20%
	Design Project		25%
	Final Examination		30%

Quiz and HW grading: Unscheduled 10-min Pop Quizzes at the end of the lecture hours. Two home works before midterm and before final. Reading home-works, and small project-home works related to details of the calculations for HLES design.

Lab grading: Lab attendance (3p), reports of labs (6p), and implementation (about 1p). Missing more than 2 labs resets lab grade.

Policy on makeups: For eligibility to take a makeup exam, the student should bring a valid excuse (medical report) within 3 working days of the missed exam. No make-up exam for quizzes. Final and midterm make-up exams are conducted after final exam. Students may get NG if they miss both midterm and final exam.

Policy on cheating and plagiarism: Any student caught cheating at the exams or assignments will automatically fail the course and may be sent to the disciplinary committee at the discretion of the instructor.

Updated by: Assoc. Prof. Dr. Mehmet Bodur **Update Date:** 19.04.2019
Contribution of Course to ABET Criterion 5
Credit Hours for:

Mathematics & Basic Science : 0
Engineering Sciences and Design : 4
General Education : 0

Relationship of the course to Program Outcomes

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Prepared by: Assoc. Prof. Dr. Mehmet Bodur	**Date Prepared:** 19 April 2019 Last modification: 28 August 2021