KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF COMPUTER SCIENCES & ENGINEERING

COE 306 Introduction to Embedded Systems

Syllabus - Term 191

Catalog Description

Introduction to Embedded Systems, Embedded system design methodologies, Microcontroller Hardware, ARM Processor, Memory and I/O, Interfacing: Parallel and Serial Communication, Pulse Width Modulation, A/D and D/A conversion, Designing robust software for embedded systems, RTOS features.

Prerequisite: COE 301 and COE 203

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Office Hours *MW 11:00-12:00 PM and by appointment*

Text Books

Marilyn Wolf, "Computers as Components: Principles of Embedded Computing System Design", Third Edition, Morgan Kaufmann, 2012

Course Objectives

The objectives of this course are to introduce students to embedded systems characteristics, microcontrollers functionality, writing embedded software to interface with I/O devices using various standards.

Course Learning Outcomes

After completing the course, students should be able to:

i. Understand the embedded system design process and some of the related UML models.
ii. Understand the interrupt mechanism, and develop interrupt-driven C programs.
iii. Understand memory systems: cache mapping, virtual memory, and address translation.
iv. Understand various system bus designs and protocols, and peripheral interaction mechanisms.
v. Understand and use common peripheral interfaces in embedded systems, such as analog-to-digital (ADC), digital-to-analog (DAC), pulse-width modulation (PWM), and various serial communication protocols, e.g. SPI, I2C, UART.
vi. Implement and use various common software components of embedded systems.

vii. Understand context switching and scheduling of periodic processes in real-time operating systems.
viii. Analyze performance at the CPU, platform, and program levels.
ix. Develop ARM-based bare-metal embedded software in C.

Grading Policy

Discussions	3%	
Programming Assignments	12%	
Quizzes	10%	
Midterm	25%	**(Sun. Nov. 3, 7:00 PM)**
Laboratory & Project	25%	
Final	25%	

- Attendance will be taken regularly. The tenth unexcused absence results in a DN grade
- Excuses for officially authorized absences must be presented no later than one week following resumption of class attendance.
- Late assignments will be accepted (up to 3 days) but you will be penalized 10% per each late day.
- A student caught cheating in any of the assignments will get 0 out of 12%.
- No makeup will be made for missing Quizzes or Exams.

Course Topics

List of Topics	**Contact Hours**
Embedded Computing: What is an Embedded System, application examples, characteristics of embedded systems, challenges in embedded system design, embedded system design process, UML.	3
Microcontroller Organization: Computer architectures, ARM organization, ARM instruction set, PIC instruction set, TI DSPs.	7
CPUs: I/O and memory mapping, busy-wait (Polling) I/O, interrupt I/O, interrupt implementation, supporting multiple I/O devices, Interrupt priorities, exceptions, traps, co-processors, caches, memory management unit, virtual memory, address translation, CPU performance, CPU power consumption.	5
Embedded Platforms: Hardware and software components of embedded platforms, bus protocols, DMA, system bus configurations, the AMBA AHB and APB buses, memory devices, example embedded platforms, bandwidth, bus and memory performance, performance bottleneck.	5
Embedded Software: State machines, circular buffers, queues.	7
ADC and DAC: Analog-to-Digital Conversion (ADC) and Digital-to-Analog Conversion (DAC) fundamentals, DAC and ADC architectural approaches.	3
Pulse Width Modulation: Types of pulse width modulation, PWM generation, applications of pulse width modulation, use of pulse width modulation for external device control.	2
Asynchronous and synchronous serial communication: Parallel I/O versus serial I/O tradeoffs, asynchronous serial interface, synchronous serial interface, SPI, I^2C, UART.	7

Processes and Operating Systems: Tasks and processes, process timing requirements, real-time operating systems, preemptive execution, context switching, scheduling processes, priority scheduling, inter-process communication, shared-memory systems, message passing.	6
Total	45

Course Project

Each student must participate in a group project. The project must involve applying some of the topics covered in the lab to create a useful system.

Lab Topics

- **Getting familiar with the development platform**
- **General-purpose input/output (GPIO)**
- **Interrupts**
- **Hardware timers**
- **Analog input and output**
- **Pulse-width modulation**
- **Serial communication**
- **Building a microcontroller system on an FPGA**