King Fahd University of Petroleum & Minerals
College of Computer Sciences Engineering
Computer Engineering Department

COE 306: Introduction to Embedded Systems
Syllabus — Term 151

Catalog Description

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

Prerequisite: COE 301 and COE 203

Instructor

Dr. Ahmad Khayyat. Office: 22/150. Phone: 8234. Email: akhayyat@kfupm.edu.sa.
Website: `http://www.ccse.kfupm.edu.sa/~akhayyat/`.

Office Hours

Sunday, Tuesday, Thursday 9:30 AM – 10:30 AM.

Course Website

- `https://blackboard.kfupm.edu.sa/`
- Additionally, we will be using Piazza for discussion; a system for getting you help fast and efficiently from classmates, the TA, and the instructor. Rather than emailing questions, post your questions on Piazza.

  Course page on Piazza: `https://piazza.com/kfupm.edu.sa/fall2015/coe306/`

Textbook

Wayne Wolf, *“Computers as Components: Principles of Embedded Computing System Design”*, Third Edition, Morgan Kaufmann, 2012.

The textbook is fully available online through the university library (KFUPM Portal login required): `http://academic.safaribooksonline.com.extoljp.kfupm.edu.sa/book/electrical-engineering/computer-engineering/9780123884367`

Course Learning Outcomes

- Understand the design process and some of the related UML models.
- Understand the interrupt mechanism, and develop interrupt-driven C programs.
- Understand memory systems: cache mapping, virtual memory, and address translation.
- Understand various system buses, protocols, and peripheral interaction.
- Implement and use various common software components of embedded systems.
- Understand the software compilation process and various compiler optimizations.

- Understand context switching and scheduling of periodic processes in real-time operating systems.
- Ability to analyze performance at the CPU, platform, and program levels, and to optimize various aspects of embedded programs.
- Ability to develop ARM-based bare-metal embedded software in C.

Grading Policy

Assignments	10%
Quizzes	10%
Exam I	15%
Exam II	15%
Final Exam	25%
Lab and project	25%

- Attendance is required. For each three missed classes, a penalty of 0.5 points will be deducted. The tenth unexcused absence results in a DN grade.
- Late assignments penalty: 20% per day.
- Cheating in one assignment or quiz will result in a zero in all assignments or quizzes. Any identical solutions are considered cheating.
- No makeup will be made for missed quizzes or exams.
- Some in-class activities may contribute to the assignments and quizzes grades.

Course Topics

- **Introduction to Embedded Systems**

  Introduction to embedded systems; requirements analysis; specifications; design methodologies overview.
- **Microcontroller Organization**

  Computer architectures, ARM organization, ARM instruction set, data operations, control flow, PIC, TI DSPs.
- **CPUs**

  I/O and memory mapping, addressing modes, interrupts and traps, caches, co-processors, memory management unit, virtual memory, address translation, CPU performance, pipelining.
- **Embedded Platforms**

  Hardware and software components of embedded platforms, bus protocols, DMA, system bus configurations, the AMBA and AHB buses, memory devices, example embedded platforms, bandwidth, bus and memory performance, performance bottleneck.
- **Program Design and Analysis**

  State machines, circular buffers, queues, models of programs, the compilation process, program performance and optimization, power analysis, program size analysis, validation and testing.
- **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.
- **Networks and Multiprocessors**

  Multiprocessor systems, distributed embedded systems, CAN bus, I2C bus, multiprocessor system-on-chip (MPSoC), accelerators.

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