

COE 306: Introduction to Embedded Systems

Syllabus — Term 142

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

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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/spring2015/coe306/>

Textbook

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

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

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|-----------------|-----|--------------------------------|
| Assignments | 10% | |
| Quizzes | 10% | |
| Exam I | 15% | Monday March 9, 2015, 6 PM |
| Exam II | 15% | Sunday April 19, 2015, 6:30 PM |
| Final Exam | 25% | Tuesday May 26, 2015, 8 AM |
| 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.

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

- Development platform
- Embedded development APIs
- General-purpose input/output (GPIO)

- Interrupts
- Hardware timers
- Analog input
- Pulse-width modulation
- Serial communication