Master Course Syllabus

School of Engineering and Computer Science
Washington State University Vancouver

CS 466/566
Embedded Systems

3 Semester Hours
(2 lecture hours, 3 laboratory hours)

Course Instructor

David 'Miller' Lowe, (Adjunct, Firmware Engineer, Polaris Industries)

Office Hours: Planned, Before/After Class, Contact for Other Times

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Class Hours

Tuesday (lecture) 5:45pm to 7:25pm (VSCI 19)

Thursday (lab) 5:45pm-8:15pm (VECS 221)

Catalog Description

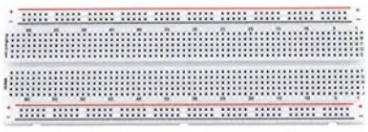
Design and development of real-time and dedicated software systems using an RTOS with an introduction to sensors and actuators and the communications they require.

Prerequisite Courses

CS 360 – Systems Programming

Required Student Lab Equipment

Single solderless proto board… Something like →



Available at Amazon in a set with Wires.

Prerequisite Topics

- Proficiency with the C programming language
- Basic digital logic understanding.
- Microprocessor systems and interfacing
- Operating systems concepts including concurrent programming, process synchronization and memory management.

Measured Course Outcomes

Students taking this course will:

1. Choose an appropriate scheduling algorithm and use it to schedule tasks in a real-time operating system, meeting the real time constraints of the system *(contributes to performance criterion* **1-C***)*.
2. Use synchronization primitives to control communications between tasks with different priorities in a real-time operating system (contributes to performance criterion **6-D**).
3. Design, implement and debug an embedded or real-time software program which controls external devices and interprets data from external sensors *(contributes to performance criterion* **6-C***)*.

Required Textbooks

None,

Old Textbook, David Simon, An Embedded Software Primer, Addison-Wesley, 1999, ISBN 0-201-61569-X, I will provide excerpts if required.

Required Hardware

The department will be providing the Raspberry Pi Pico.

For Lab4 I will provide a discrete SPI GPIO Expander

You will need a breadboard and some hook up wire.See “Required Lab Equipment” for a representative link

There will be more equipment for later labs

Reference Material

Embedded Systems Journal (various articles specified)
ARM Info Center (http://infocenter.arm.com)
Multiple Web references given during lectures
Google, YouTube, etc

Grading

Homework/Labs	30%
Midterm	30%
Final	40%

Major Topics Covered in the Course

1. Review of microprocessor architecture and interfacing
2. Hardware architectures of embedded systems
3. Software architecture of embedded systems
4. Real-time operating systems (RTOS)
5. Communication in embedded systems
6. Real-time system specifications
7. Debugging real-time systems
8. Security & protection for embedded systems
9. Object-oriented design in RTOS

10. Advanced topics in embedded systems

Laboratory Projects

The students are required to implement embedded computer systems that sample a variety of sensors and actuators, constructing hardware or software interfaces to the sensors and actuators. Students also learn to use logic analyzers and digital oscilloscopes. Typical projects are shown below.

Lab	Description	Weeks
1	Get your development environment and compile the simple blinky firmware • Get the hardware running.. • LED Output / Button Inputs • Bare-metal 'blinky' single-threaded implementation. • RP2040 microcontroller DATA SHEET • Empirical clock measurement using lab instruments	1
2	Blinky Firmware revisit under RTOS control • Setup FreeRTOS scheduler and heartbeat task. • Generic task structure and blinky.c refactor • Using USB-Serial for output. • OS clock measurement using lab instruments	1
3	RTOS Producer/Consumer using threads and Queues. • Use tasks, Queues, assert() • Connect GDB and debug over ICDI using OCD • Use GDB debugger to analyze Assert	1
	Note: The labs below were using VECS 220 Labs and all the equipment available. The lab assignment's below will be changing to lower the demand on dedicated lab equipment.	
4	Simple Remote Device Communication • Pin Muxing • SPI master communications (bitBang and ASIC peripheral) • External interrupt handling. • Use Timers to measure round trip times. • Watchdog hang protection.	2
5	Inter-Processor Communication via SPI • SPI Slave Device interface implementation. • DC Motor Operation Basics	2
6	DC Motor Control • Manual Quadrature position sensing • Position servo PID implementation • Tuning a Wikipedia PID control loop • Velocity servo PID implementation	2
7	Final Project, Connected, Multi-Processor, Lab. • Application will be determined later in the semister	5

CSAB Category Content

	FUNDAMENTAL	ADVANCED		FUNDAMENTAL	ADVANCED
Data Structures	0	0	Computer Organization and Architecture	0	1
Algorithm & Software Design	0	2	Concepts of Programming Languages	0	0

Oral and Written Communications

A single assignment is dedicated to an oral presentation. Students must obtain pre-approval from the instructor of a topic of interest in embedded systems. Student presents a PowerPoint based slide presentation of 10 to 20 minutes and must answer questions from the instructor and other students. Students are graded on the presentation and their ability to answer questions.

Social and Ethical Issues

This course contains no significant coverage of social and ethical issues.

Theoretical Content

This course contains very little theoretical content.

Problem Analysis

For the programming projects, students determine requirements for the programs in consultation with the instructor and must perform sufficient analyses of the requirements to arrive at an effective program design.

Solution Design

Programming projects require the student to perform substantial design to arrive an implementation that fulfils the functional requirements and is both robust and well organized. Typically, the final programming project consists of >500 lines of code, some of which may be assembly language.

CC2001

This course provides coverage of topics in the following areas (hours listed are minimums):

OS4. Scheduling and dispatch [core]	3
OS9. Real-time and embedded systems [elective]	16
SE12. Specialized systems development [elective]	4

CS566

This course provides additional coverage of topics in the following areas (hours listed are minimums):

ENCS-GO1 – Understanding of code generation of mundane and interrupt specific code sections.	5
ENCS-GO3 – Report and Presentation of final lab	2

Course Coordinator: John Lynch
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