CME 331.3 (3L-3P alt week)
Microprocessor Based Embedded Systems

Department of Electrical and Computer Engineering
Fall 2014

Description: Covers the architecture and operation of microcontrollers used in embedded systems. The course focuses on hardware and software techniques used to program a microcontroller and interface it with external devices. Emphasis is placed on using both assembly language and C to program the microcontrollers. Microcontroller architecture is discussed in general with certain internal peripherals discussed in detail.

Prerequisites: EE 232

Corequisites: None

Instructor:
Khan A. Wahid, PhD, PEng, SMIEEE
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Lectures: Monday-Wednesday-Friday, 12:30 pm -1:20 pm, Room ENG 2B53

Tutorials: None

Laboratory: Section 03: Tuesday, Sept 9, 23; Oct 7, 21; Nov 4, 25, 8:30 am-11:20 am, ENG 2C61 (tau)
Section 05: Wednesday, Sept 10, 24; Oct 8, 22; Nov 5, 26, 8:30 am-11:20 am, ENG 2C61 (tau)

Website: Assignments, solutions, lecture slides, lab manuals, lab codes, general course information, and all announcements will be posted on the course website. Students are responsible for keeping up-to-date with the information on the course website.

http://www.engr.usask.ca/classes/CME/331/

Course Reference Numbers (CRNs): 89878 (lectures), 89945, 89946, 89947 (laboratory)

Textbook: Introduction to ARM Cortex-M Microcontrollers, Jonathan Valvano, Vol 1, 978-1477508992, 4th edition, May 2013

The textbook is required. Lecture slides are prepared with selected material from the textbook and posted on the course website. Sample codes and lab manuals will also be posted on the course website as needed. You must follow these lecture materials as we progress. The materials are protected. Use NSID and password to access.

The following book is not required but may be useful for some advanced materials:

Real-Time Interfacing to ARM Cortex-M Microcontrollers, Jonathan Valvano, Vol 2, 978-1463590154, 3rd edition, June 2013

Office Hours: There is no formal office hour. Students are welcome and encouraged to stop by the instructor's office at their convenience for help. Students can also email the instructor to make an appointment.

Reading List: None

Assessment: The methods of assessment and their respective weightings are given below:

Assignments	10%
Midterm	20%
Lab experiments* (performance, lab notebook)	15%
Lab exam	15%
Final exam	40%

*students must attend lab experiments on scheduled time to get credit for labs. Instructions on lab notebook and evaluation of lab performance will be posted on the course website under "Labs".

Final Grades: The final grades will be consistent with the "literal descriptors" specified in the university's grading system.

http://students.usask.ca/current/academics/grades/grading-system.php

For information regarding appeals of final grades or other academic matters, please consult the University Council document on academic appeals.

http://www.usask.ca/university_secretary/honesty/StudentAcademicAppeals.pdf

Course Content:
Microprocessor - introductory concepts
Intro to Stellaris LaunchPad
Microcontroller architecture
Intro to ARM architecture (ARM7)
ARM Cortex-M4 architecture
Display system, 7-segment
ARM assembly language
PLL, SysTick timer, Array, Structure, FSM
4x4 Keypad, LCD driver
Interrupt handling, I/O synchronization, interrupt demo
Timer, PWM, WDT
Serial communication (SSI/SPI, UART, I2C)

Assignments: Assignments will be handed out approximately every two weeks, depending on the pace of the course content covered in the lectures. All assignments are due within one week of the posting date (unless specified otherwise). Paper assignments must be submitted on time in CME331 assignment box opposite to Room ENG 2C94. Online assignments must be submitted through blackboard. Late assignments will not be marked (graded as zero).

Tutorials: None

Quizzes: None

Exams: The midterm exam is tentatively scheduled as given below. All exams (midterm and final) are closed book and closed notes. A cheat (formula) sheet is allowed. Calculators are allowed but any other electronic and handheld devices are not allowed.

Important Dates:

Date	Details
Wed, Sept 3, 2014	Class begins
Tues, Sept 9, 2014	Labs begin
Fri, Oct 24, 2014	Midterm exam (time: 6-8pm, location: TBD)
Dec 2-3, 2014	Lab final exam (time: TBD, location: TBD)

Student Conduct: Ethical behaviour is an important part of engineering practice. Each professional engineering association has a Code of Ethics, which its members are expected to follow. Since students are in the process of becoming Professional Engineers, it is expected that students will conduct themselves in an ethical manner.

The APEGS (Association of Professional Engineers and Geoscientists of Saskatchewan) Code of Ethics states that engineers shall "conduct themselves with fairness, courtesy and good faith towards clients, colleagues, employees and others; give credit where it is due and accept, as well as give, honest and fair professional criticism" (Section 20(e), The Engineering and Geoscience Professions Regulatory Bylaws, 1997).

The first part of this statement discusses an engineer's relationships with his or her colleagues. One of the ways in which engineering students can demonstrate courtesy to their colleagues is by helping to maintain an atmosphere that is conducive to learning, and minimizing disruptions in class. This includes arriving on time for lectures, turning cell phones and other electronic devices off during lectures, not leaving or entering the class at inopportune times, and refraining from talking to others while the instructor is talking. However, if you have questions at any time during lectures, please feel free to ask (chances are very good that someone else may have the same question as you do).

For more information, please consult the University Council Guidelines for Academic Conduct.

http://www.usask.ca/university_secretary/council/reports_forms/reports/guide_conduct.php

Academic Honesty: The latter part of the above statement from the APEGS Code of Ethics discusses giving credit where it is due. At the University, this is addressed by university policies on academic integrity and academic misconduct. In this class, students are expected to submit their own individual work for academic credit, properly cite the work of others, and to follow the rules for examinations. Academic misconduct, plagiarism, and cheating will not be tolerated. Copying of assignments and lab reports is considered academic misconduct. Students are responsible for understanding the university's policies on academic integrity and academic misconduct. For more information, please consult the University Council Regulations on Student Academic Misconduct and the university's examination regulations.

http://www.usask.ca/university_secretary/honesty/StudentAcademicMisconduct.pdf
http://www.usask.ca/university_secretary/council/academiccourses.php

Safety: The APEGS Code of Ethics also states that Professional Engineers shall "hold paramount the safety, health and welfare of the public and the protection of the environment and promote health and safety within the workplace" (Section 20(a), The Engineering and Geoscience Professions Regulatory Bylaws, 1997).

Safety is taken very seriously by the Department of Electrical and Computer Engineering. Students are expected to work in a safe manner, follow all safety instructions, and use any personal protective equipment provided. Students failing to observe the safety rules in any laboratory will be asked to leave.

Course Learning Outcomes:

Upon successfully completing this course, the students will be able to:

1. Understand the architecture of a general purpose microcontroller and ARM7 microprocessor and be familiarized with Stellaris LaunchPad and its peripherals
2. Use different components in a microcontroller such as, PWM, A/D, Timer, interrupt, serial communication, etc. to perform specific tasks
3. Interface a microprocessor with other external devices or components such as, keypad, switches, LCD display, motor, analog sensors, etc.
4. Write both assembly and C code to program a microprocessor
5. Design a small to medium size embedded system with a microprocessor (such as, pedestrian controller, traffic display system, digital temperature logger, and similar)

Laboratory Learning Outcomes:

Lab 1: Introduction to Stellaris LaunchPad and ARM CortexM4F
Upon completion of this lab, the students will be able to:

- Be familiarized with Stellaris LM4F120 LaunchPad and ARM CortexM4F microcontroller (MCU)
- Write C code using Keil uVision to program the Launchpad MCU to sense and control I/O ports (using switch and onboard LED)

Lab 2: Design of a 7-segment display system
Upon completion of this lab, the students will be able to:

- Be familiarized on how to interface the Launchpad MCU with multiple 7-segment displays
- Write C code using Keil uVision to program MCU to display numbers and characters on a 7-segment display board

Lab 3: Design of a stepper motor controller
Upon completion of this lab, the students will be able to:

- Be familiarized on how to interface the Launchpad MCU with an external motor and its driver
- Write C code using Keil uVision to program MCU to drive a stepper motor
- Learn debugging techniques using Stellaris In Circuit Debugging Interface (ICDI)

Lab 4: LCD display driver with 4x4 keypad
Upon completion of this lab, the students will be able to:

- Be familiarized with a TFT LCD display using SSI protocol and ST7735 driving chip
- Know how to interface the Launchpad MCU with the TFT LCD display and a 4x4 keypad
- Write C code using Keil uVision to print characters and shapes on a TFT LCD display

Lab 5: Real-time stopwatch with LCD (uses internal interrupt)
Upon completion of this lab, the students will be able to:

- Know how to use internal interrupt in an ARM CortexM4F microprocessor
- Learn proper configuration setting to use system timer (known as SysTick)
- Write C code using Keil uVision to use internal timer and print timer data on the LCD display

Lab 6: Customer counting system for a shop (uses GPIO external interrupt)
Upon completion of this lab, the students will be able to:

- Know how to use GPIO external interrupt in an ARM CortexM4F microprocessor
- Learn proper configuration setting to prioritize different interrupt sources
- Write C code using Keil uVision to handle multiple interrupts and display customer information on TFT LCD display

Attribute Mapping:

*Level of Performance**

Learning Outcome	Attribute**											
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
1	2		1	1	3							
2	2		2	3	3							
3	3		2	3	3							
4	3		2	4	4							
5	2		1	3	2							

****Attributes:**

- **A1** Knowledge base for engineering
- **A2** Problem analysis
- **A3** Investigation
- **A4** Design
- **A5** Use of engineering tools
- **A6** Individual and team work
- **A7** Communication skills
- **A8** Professionalism
- **A9** Impact of engineering on society and the environment
- **A10** Ethics and equity
- **A11** Economics and project management
- **A12** Life-long learning

*Levels of Performance:

1 - **Knowledge** of the skills/concepts/tools but not using them to solve problems.

2 - **Using** the skills/concepts/tools to solve directed problems. (*"Directed" indicates that students are told what tools to use.*)

3 - **Selecting** and using the skills/concepts/tools to solve non-directed, non-open-ended problems. (*Students have a number of S/C/T to choose from and need to decide which to employ. Problems will have a definite solution.*)

4 - **Applying** the appropriate skills/concepts/tools to solve open-ended problems. (*Students have a number of S/C/T to choose from and need to decide which to employ. Problems will have multiple solution paths leading to possibly more than one acceptable solution.*)

Accreditation Unit (AU) Mapping: (% of total class AU)

Math	Natural Science	Complementary Studies	Engineering Science	Engineering Design
-	-	-	29.7 AU (65%)	16 AU (35%)

Assessment Mapping:

Component	Weighting	Methods of Feedback***	Learning Outcomes Evaluated
Assignments	10%	S	1,2,3,4
Midterm	20%	S, F	1,2,3,4
Lab experiments	15%	S, F	1,2,3,4,5
Lab exam	15%		2,3,4
Final exam	40%		1,2,3,4

***Methods of Feedback:

F – *formative* (written comments and/or oral discussions)

S – *summative* (number grades)