ELC 411 (1.0 CU)
Embedded Systems
Professor: Larry Pearlstein
Fall 2015

Meeting Times:

TF 8:00AM–9:20AM/AR148   (Section 1)
TF 11:00AM–12:20AM/AR148   (Section 2)

Course Description:

Designing with embedded systems. Basics of programming for embedded systems and assembly language programming. Using microcontroller features such as interrupts, GPIO, timers, direct memory access, data conversion and serial communication.

4th Hour Statement:

This class contains one intensive design or analytical experience or other appropriate activity that requires each student to significantly increase out-of-class learning.

Instructor Information:

Office Location: AR 130B
Phone: (267) 566-5699 (cell)
E-Mail: pearlstl@tcnj.edu

Office Hours:

Tuesdays   2:00 PM - 3:20 PM
Thursdays   2:00 PM - 3:20 PM

By appointment (send me email)
And whenever my office door is open

Textbook:

[ZHU] *Embedded Systems with ARM® Cortex-M3 Microcontrollers in Assembly Language and C*, by Dr. Yifeng Zhu, E-Man Press, 2015
ISBN 978-0-9826926-2-2

Prerequisite:

Electronics I (ELC 251), Digital Circuits and Microprocessors (ENG 312)

Corequisite:

Microcomputer Systems (ELC 343)

Grading Policy:

Homework	10%
Design Projects	25%
Midterm Exam	30%
Final Exam	35%

Tips for Success:

Read the book sections prior to their discussion in class.
Do as much homework as possible.
Do not be shy about asking questions, either during class or outside of the class.

College Level Policies:

Attendance Policy: http://www.tcnj.edu/~recreg/policies/attendance.html
Academic Integrity Policy: http://www.tcnj.edu/~academic/policy/integrity.html
Americans with Disabilities Act (ADA) Policy: http://www.tcnj.edu/~affirm/ada.html

Tentative Agenda:

Week	Topics	Reading/Exercises
1 Week of 8/24	Intro to embedded systems. Building and running an application. Address space and memory map. ARM registers.	[ZHU] Chapter 1

2
Week of 8/31
	Data representation
	
	ELC411 Lab: Embedded C programming basics
	    Data types, signed and unsigned
	    Register addressing, PSoC and #defines
	    Hexadecimal
	    Bitwise operations, register field setting
	    Cycle counting
		[ZHU] Chapter 2

3 Week of 9/7 (Follow Monday schedule on Tuesday)	ARM ISA and ALU	[ZHU] Chapters 3 & 4 ELC343: Intro lab due
4 Week of 9/14	ARM ISA load and store, and branching (Sep 18) Guest speaker: Boris Valerstein, The Vanguard Group "The Benefits of Being Agile" This talk will present a real-world introduction to the Agile development methodology and will highlight both the strengths and potential pitfalls with the approach	[ZHU] Chapter 5
5 Week of 9/21	Structured programming in assembly language.	[ZHU] Chapters 6, 7 ELC343: Assembly lab due
6 Week of 9/28	Subroutines Mixing 'C' and assembly	[ZHU] Chapters 8 & 10

Week	Topics	Reading/Exercises
7 Week of 10/5	Review and Midterm Exam	ELC343: LCD lab due
8 Week of 10/12 (short week)	Fixed-point and floating point arithmetic	[ZHU] Chapter 11
9 Week of 10/20	Fixed-point and floating point arithmetic ELC411 Lab: Fixed point arithmetic	[ZHU] Chapter 11 ELC343 DAC/ADC lab due
10 Week of 10/27	Interrupts ELC411 Lab: Interrupts	[ZHU] Chapter 12
11 Week of 11/3	General purpose I/O ELC411 Lab: RTS/RTR fully handshaked communication	[ZHU] Chapter 14
12 Week of 11/10	General-purpose timers ELC411 Lab: Use Timer to implement Delay()	[ZHU] Chapter 15
13 Week of 11/17	Stepper motor control ELC411 Lab: Stepper motor control	[ZHU] Chapter 16
14 Week of 11/24 (short week)	Direct Memory Access and memories	[ZHU] Chapter 19
15 Week of 12/1	Serial communication and REVIEW	[ZHU] Chapter 22
Week of 12/8	Final Exam	

Educational Objectives

(What TCNJ ECE engineers should be able to accomplish during the first few years after graduation)

- To contribute to the economic development of New Jersey and the nation through the ethical practice of engineering;
- To become successful in their chosen career path, whether it is in the practice of engineering, in advanced studies in engineering or science, or in other complementary disciplines;
- To assume leadership roles in industry or public service through engineering ability;
- To maintain career skills through life-long learning.

Electrical and Computer Engineering Student Outcomes

(What TCNJ Electrical and Computer Engineering students are expected to know and be able to do at graduation. What knowledge, abilities, tools and skills the program gives the graduates to enable them to accomplish the Educational Objectives)

The Student Outcomes listed below are expected of all graduates of the Electrical or Computer Engineering Program.

ECE graduates will have:
a. **an ability to apply knowledge of mathematics, science and engineering;**
b. **an ability to design and conduct experiments, as well as to analyze and interpret data;**
c. **an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;**
d. an ability to function in multidisciplinary teams;
e. **an ability to identify, formulate and solve engineering problems;**
f. an understanding of professional and ethical responsibility;
g. **an ability to communicate effectively;**
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context;
i. a recognition of the need for and an ability to engage in life-long learning;
j. a knowledge of contemporary issues;
k. **an ability to use the techniques, skills and modern engineering tools necessary for engineering practice;**

Course Objectives*:

Objective 1:	The student will understand the assembly language programmer's model of a microcontroller, and will be able to write software for the embedded environment. (a,b,c,e,g,k)
Objective 2:	The student will be able to design embedded systems using interrupts, timers, GPIO and serial communication. (a,c,e,g,k)
Objective 3:	The student will understand the use of data conversion units and DMA. (a,e,g,k)

Topics Covered:
1. Designing with embedded systems.
2. Basics of programming for embedded systems and assembly language programming.
3. Using microcontroller features such as interrupts, GPIO, timers, direct memory access, data conversion and serial communication.

Evaluation:

    A.   Design Projects
    B.   Midterm Examination
    C.   Final Examination

Performance Criteria**:

Objective 1a:
An understanding of the assembly language programmer's model of a microcontroller. (B)

Objective 1b:
The ability to write software for the embedded environment. (A)

Objective 2:
The ability to design embedded systems using interrupts, timers, GPIO and serial communications. (A,C)

Objective 3:
An understanding of analog-to-digital conversion and digital-to-analog conversion, and direct memory access. (C)

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* Small letters in brackets refer to the Student Outcomes
** Capital letters in brackets refer to the evaluation methods used to assess student performance

ELC 411: ADDITIONAL INFORMATION

1. DESCRIPTION OF DESIGN ACTIVITY

The students will design and implement embedded subsystems to meet various requirements.

2. ENGINEERING STANDARDS

Serial communication (UART, related to EIA RS-232).

3. REALISTIC CONSTRAINTS

Economic: The cost constraints for high-volume embedded systems are covered in this course.
Environmental: The use of embedded systems to optimize power efficiency of physical systems is discussed, as well as low-power system design techniques.
Sustainability: N/A.
Ethical: N/A.
Social Impact: The impact of embedded systems in the world is discussed.

4. MODERN AND PROFESSIONAL ENGINEERING TOOLS USAGE

An advanced integrated development environment, based on the PSoC platform, is used.

5. COMPUTER USAGE

Students use computers during to prepare reports on reading assignments and the system architecture project.

6. FEEDBACK MECHANISMS

Examinations: Students are given a midterm and final examinations.
Reports: Students are graded on reports, which include not only the technical aspects, but also the level of communication skills. There are at least two assignments.
Homework: Homework problems are assigned and graded.