**ELC 411 (1.0 CU)**

**Embedded Systems**

**Course Information Professor: Larry Pearlstein**

**Fall 2014:**

**MR 8:00AM–9:20AM/AR148**

**MR 9:30AM–10:50AM/AR148**

**Course**

**Description:**

**4th Hour Statement:**

**Instructor**

**Information:**

**Office Hours:**

**Textbook:**

**Prerequisite:**

**Corequisite:**

**Grading Policy:**

**Tips for Success:**

**College Level Policies:**

Topics in embedded systems and their interactions with their physical environments. It focuses on embedded system design issues such as limited memory, cost, performance guarantees, real-time operations, power, and reliability..

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

Office Location: AR 130B

Phone: (267) 566-5699 (cell)

E-Mail: [pearlstl@tcnj.edu](mailto:pearlstl@tcnj.edu)

Mondays 4:00 PM - 5:20 PM

Tuesdays 10:00 AM - 11:20 AM

By appointment (send me email)

And whenever my office door is open

*Computers As Components: Principles of Embedded Computing System Design*, Third Edition, by Marilyn Wolf, Morgan Kaufmann Publishers, 2012.

ISBN 978-0-12-388436-7

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

Microcomputer Systems (ELC 343)

Homework 20%

Homework assignments will be announced on an ongoing basis, and will be posted to the web site.

Midterm Exam 30%

Final Exam 30%

Miscellaneous 20%

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.

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** |
| --- | --- | --- |
| 1  Week of 8/25  (short week) | Introduction to embedded systems  Design process and example | [Wol12] Chapter 1 |
| 2  Week of 9/1  (Follow Monday schedule on Tuesday) | Instruction sets and computing architectures  ARM ISA and examples | [Wol12] Chapter 2 |
| 3  Week of 9/8 | ARM ISA continued  I/O  UART  Interrupts & Timers  Memory systems | [Wol12] Chapters 2&3 |
| 4  Week of 9/15 | CPU performance  Stalling  Power mgt.  I2C, CAN bus | [Wol12] Chapter 3  [Wol12] Chapter 8 |
| 5  Week of 9/22 | GPIO, reading mfrs. specs for Voh, Vol, Vih, Vil, drive strength, power, absolute maximum ratings. | Supplemental |
| 6  Week of 9/29 | Lab project: fully handshaked parallel interface. Examine drive strength, slew rate, capacitive loading, compiler efficiency | Supplemental |
| 7  Week of 10/6 | Review and Midterm Exam |  |
| 8  Week of 10/13  (short week) | 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. | None. |
| 9  Week of 10/20 | Driving LEDs, displays, motors, speakers, reading keyboards/buttons.  Analog conversion details, ADC (sigma delta, SA, flash) and DAC (I or V). Antialiasing, reconstruction filters.  Fixed point arithmetic. | Supplemental |
| 10  Week of 10/27 | Clock sources, crystal oscillators, PLLs, etc.  Signal conditioning and analog considerations  Switched capacitor filters, intro | Supplemental |
| 11  Week of 11/3 | Computing platforms  Busses  Memory arch.  Choosing a platform  Debugging  Performance | [Wol12] Chapter 4 |
| 12  Week of 11/10 | State machines  Circular buffer  FIR/IIR filter  Queues  Assembler/linker  Build flow | [Wol12] Chapter 5 |
| 13  Week of 11/17 | Program design and analysis  Optimizing  Verification  Examples | [Wol12] Chapter 5 |
| 14  Week of 11/24  (short week) | Real-time software  RTOS  IPC  IPC mechanisms  Power management | [Wol12] Chapter 6 |
| 15  Week of 12/1 | System design techniques  QA  DV | [Wol12] Chapter 7 |
| 16  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:**

1. **an ability to apply knowledge of mathematics, science and engineering;**

**Binary math used extensively in homework problems and exams.**

1. **an ability to design and conduct experiments, as well as to analyze and interpret data;**
2. **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;**

**Students do design in homework problems.**

1. an ability to function in multidisciplinary teams;
2. **an ability to identify, formulate and solve engineering problems;**

**Students do homework problems.**

1. an understanding of professional and ethical responsibility;
2. **an ability to communicate effectively;**

**Students do assignments involving the documentation of embedded designs.**

1. the broad education necessary to understand the impact of engineering solutions in a global and societal context;
2. a recognition of the need for and an ability to engage in life-long learning;
3. a knowledge of contemporary issues;
4. **an ability to use the techniques, skills and modern engineering tools necessary for engineering practice;**

**Modern design tools are discussed throughout the course.**

**Course Objectives\*:**

Objective 1: To introduce students to the basic principles of system design. [a, b, c, e, k, l, m]

Objective 2: To develop students’ ability to identify, formulate and solve design problems for analog-digital systems constituted as embedded systems. [a, b, c, e, g, k, l, m]

**Topics Covered:**

1. System modeling and design concepts
2. Design and/or selection of real-time embedded systems for digital control and/or processing of analog system signals:
   1. Data Acquisition elements: transducers, amplifiers, filters, and A/D converters in conjunction with concomitant digital data processing elements
   2. Digital Signal Processing Module specifications: CPU speed with memory requirements for specific, real-time digital control and/or processing applications.
3. Embedded System integration

**Evaluation:**

A. Midterm Examination

B. Final Examination

C. Homework assignments

D. System Architecture Project

**Performance Criteria\*\*:**

Objective 1:

An understanding of the application of microcontrollers for solving system design problems. (A)

Objective 2

An understanding of the ARMv7 Instruction Set Architecture (A,C)

The ability to analyze the performance requirements of an application, and select appropriate ADC and DAC conversion technology. (B,C)

The ability to analyze the performance and power requirements of an application, and select a microcontroller based on CPU architecture and clock rate. (B)

The ability to analyze a system architecture to determine whether and how to use interrupt-based processing. (B)

An understanding of communication protocols commonly used in embedded systems. (B, C)

The ability to design and analyze a real-time hardware/software architecture for an embedded system. (D)

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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**

# DESCRIPTION OF DESIGN ACTIVITY

Students architect a practical microcontroller-based system.

# ENGINEERING STANDARDS

Serial communication (UART, related to EIA RS-232), Inter-Integrated Circuit communication (I2C, UM10204), Controller Area Network PHY (ISO 11898)

# 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.

# MODERN AND PROFESSIONAL ENGINEERING TOOLS USAGE

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

# COMPUTER USAGE

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

# 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.