EECE 2160  
Embedded Design Enabling Robotics  
Fall 2015

Instructor  
Prof. Rafael Ubal (ubal@ece.neu.edu)

Office  
140 The Fenway, 3rd floor (see detailed directions below)

Phone  
617-373-3895

Office hours  
Tuesday 11am-12pm, Wednesday 10-11am

Class schedule  
Monday, 11:45am-12:55pm, 009 Hayden Hall, Room 13A  
Wednesday, 11:45am-12:55pm, 009 Hayden Hall, Room 009C  
Thursday, 10:30am-12:55pm, 009 Hayden Hall, Room 009C

Teaching assistants  
Maruf Hasan (hasan.md@husky.neu.edu)  
Tuan Dao (dao.tua@husky.neu.edu)

Overview

This class presents many of the fundamental concepts of computer engineering. The course covers an introduction to programming, operating systems, digital design, embedded systems, and networking, in a way that students can combine them all together to acquire a broad understanding of a full system design and implementation. An emphasis is made in the interaction between hardware and software.

The class is taught in our integrated lab-classrooms in 009 Hayden Hall. This allows the class to move easily between theoretical concepts and their practice, both for software and hardware topics. The course leverages the ZedBoard platform controlling a robotic arm in order to illustrate all components of a programmable embedded system based on an ARM processor.
Course Objectives

- Become familiar with the Unix/Linux command-line interface
- Improve C/C++ programming skills acquired in previous prerequisite courses
- Understand the principles of digital logic design
- Acquire knowledge of embedded system design
- Get exposed to wireless networking and robotic control
- Develop an appreciation for the software/hardware interface

Prerequisites

This course assumes a basic understanding of the structure of a C/C++ program, as taught in the General Engineering introductory courses.

- Course GE-1111 – Problem Solving and Computation
Textbooks

The core material presented in this course is extracted from the following textbook, though the order of concepts will differ to adjust to our lab experiments.


Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>Labs</td>
<td>20%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>20%</td>
</tr>
<tr>
<td>Project</td>
<td>20% (+10% extra credit)</td>
</tr>
<tr>
<td>Midterm exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final exam</td>
<td>20%</td>
</tr>
</tbody>
</table>

Note: Both EECE2160 (lectures) and EECE2161 (lab) will receive identical grades, as both components are tightly integrated.

Lab assignments

This class includes a weekly lab session that provides students with hands-on experience on an actual embedded platform: a ZedBoard based on the Zynq system-on-chip (SoC). The platform runs xiLinux, a flavor of the popular Ubuntu Linux distribution. Students will write C programs on Linux for the ZedBoard, will develop digital designs that are embedded to run on the FPGA of the Zynq SoC, will interface to a wireless Wii remote, will interface to read/write switches/buttons/LEDs on the ZedBoard, and will control a robotic arm with the ZedBoard.

Each lab session has an associated assignment (lab report) that students must submit on Blackboard in PDF format, one week after the corresponding lab session at the latest. There is a total of 11 lab reports that students must submit throughout the course by the due dates specified below. For those students working in groups of at most two people, only one person must submit the report, and both students will share the same grade.

Due dates for lab reports are strict deadlines with no exceptions, specified at the end of this document. Late reports will not be accepted under any circumstances. Please make sure that you submit your reports in advance in order to avoid unexpected submission problems due to Internet connectivity issues, trouble with PDF document generation, etc.

To add some flexibility to this policy, the average grade for lab reports will be calculated by discarding either that which received the lowest grade, or which was not submitted on time or at all. This exception is aimed at covering any inevitable situation that prevented you from submitting a lab report on time, while it also benefits those students with no missing assignment.

Midterm and final exams

A midterm exam will cover the first part of the course material. A comprehensive final exam will focus on the second part of the course, but will also include the material corresponding to the first part.
**Course projects**
Students can work individually or in groups of at most 2 people on a final course project. Groups do not necessarily have to be the same as the lab groups. There will be a set of proposed project topics to choose from, published at least two weeks before the project due dates. The project due dates will be announced in class during the second half of the semester.

The list of proposed projects will be only aimed at giving the student an idea of the expected complexity and topics to choose from. However, students will be encouraged to be creative and propose their own project ideas. Projects will be evaluated based on the quality and quantity of the work, and especially on the student's creativity. One full lab session will be available during the last week of the semester for the students to use the lab equipment should a particular project require it.

**Quizzes**
There will be a total of 4 quizzes during the semester, on the dates specified in the schedule at the end of this document. Quizzes will have an approximate duration of 20 minutes, and will start in the beginning of the lecture time.

**Grade conversion**
Your final grade is calculated as a numeric grade between 0 and 100 based on the percentages shown above, and then converted into a letter grade using the following scale:

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
<th>Grade</th>
<th>High</th>
<th>Low</th>
<th>Grade</th>
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</thead>
<tbody>
<tr>
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<td>66.66</td>
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<td>80</td>
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<td>70</td>
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**Attendance and Punctuality**
While attendance to the lectures is highly recommended, punctuality in class is indispensable, and constitutes a basic rule of respect toward your instructor and class mates. If any particular reason forces you to come in late to class, please notify your instructor in advance.
Course Topics

Part I: The Software

- The Linux operating system, standard *shell* commands, text editors, users and groups, file permissions, the ZedBoard architecture
- C language review, input/output, control flow, arrays, pointers, the *gcc* compiler
- The *gdb* debugger, value trace, breakpoints, debugging techniques
- Dynamic memory, data structures in C, linked lists
- C++ language review, object-oriented programming, inheritance, virtual functions, constructors and destructors, function templates
- Memory-mapped input/output, controlling the ZedBoard input and output devices

Part II: The Hardware

- Boolean algebra, Boolean postulates and theorems, logic gates
- Gate-level minimization, canonical forms, Karnaugh maps, undefined outputs
- Combinational logic, adders, subtractors, multiplexers, demultiplexers, encoders, decoders
- Sequential logic, latches, clock signals, flip-flops, finite-state machines (FSM), design of FSMs
- Computer organization, Von Neumann architecture, memories, instructions, the processor
Office Location

1) Find the office building at 140 The Fenway (TF), and enter the main door located at the parking lot.

2) Take the main elevator to the 3rd floor.

3) Once on the 3rd floor, call me at 617-373-3895. My office is in a locked research laboratory. I will meet you on the hallway right by the elevator and let you in.
## Important Dates

<table>
<thead>
<tr>
<th>Week 1</th>
<th>9/6</th>
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<tbody>
<tr>
<td>Week 2</td>
<td>9/13</td>
<td>Thursday 9/17 – Report for Lab #1 due</td>
</tr>
<tr>
<td>Week 3</td>
<td>9/20</td>
<td>Thursday 9/24 – Report for Lab #2 due</td>
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</table>
| Week 4 | 9/27 | Wednesday 9/30 – Quiz #1  
Thursday 10/1 – Report for Lab #3 due |
| Week 5 | 10/4 | Thursday 10/8 – Report for Lab #4 due |
| Week 6 | 10/11 | Wednesday 10/14 – Quiz #2  
Thursday 10/15 – Report for Lab #5 due |
| Week 7 | 10/18 | Thursday 10/22 – Report for Lab #6 due |
| Week 8 | 10/25 | Wednesday 10/28 – Midterm  
Thursday 10/29 – Report for Lab #7 due |
| Week 9 | 11/1 | Thursday 11/5 – Report for Lab #8 due |
| Week 10 | 11/8 | Thursday 11/12 – Report for Lab #9 due |
| Week 11 | 11/15 | Monday 11/16 – Quiz #3  
Thursday 11/19 – Report for Lab #10 due |
| Week 12 | 11/22 | 11/25-11/28 Thanksgiving break  
Thursday 11/26 – Report for Lab #11 due |
| Week 13 | 11/29 | Wednesday 12/2 – Quiz #4 |
| Week 14 | 12/6 | – |
|  |  | 12/11 through 12/18: Final exams (exact date TBD) |