EECE 2160 Embedded Design: Enabling Robotics
Fall 2017 – Syllabus

Class Time: **Mon & Wed, 8:00am – 9:05am in Hayden Hall 009-C**
Thu 8:00am - 10:20am - Hayden Hall 009-PC Lab

Instructor: **Prof. John Kimani**
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Office Hours: 11:00am - 12:00pm on Mon, Wed & Thu in my office (Dana 410)
3:00pm - 4:00pm on Mon & Wed

Teaching Assistants: Chris Hashem **Email:** hashem.c@husky.neu.edu
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Prerequisite: Students should have an understanding of high-level programming language, such as C++ or Java, and must be familiar with object-oriented programming concepts.

Course Description and Overview: This class presents the fundamental concepts of Computer Engineering from a comprehensive, full-stack, software-hardware design perspective. The courses explore scripting languages, high-level programming, Unix/Linux operating systems, device drivers, software-hardware interfaces, hardware controllers, and digital circuit design. Theoretical concepts are accompanied by hands-on experiments on a full-system ZedBoard platform, featuring a programmable logic module, an ARM processor, and an Ubuntu distribution of the Linux operating system. Students will design custom creative software-hybrid designs interacting with a variety of hardware devices connected to the ZedBoard, including LEDs, push buttons, switches, OLED screens, VGA Display, a Wiimote, and a remote-controlled robotic arm.

The Objectives of this course are to enable students to:
1. To introduce students to many of the fundamental concepts in Computer Engineering.
2. To become familiar with Unix/Linux and embedded programming.
3. To introduce students to digital design principles.
4. To acquire knowledge of embedded system design.
5. To be exposed to wireless networking and robotic control.
6. To develop an appreciation for the software/hardware interface.

Textbook: The course will cover materials from various books and sources. A sample list of recommended books is given below:
1. Y. Patt and S. Patel, "*Introduction to Computing Systems: From Bits and Gates to C and Beyond*", 2nd edition, August 2003, ISBN 978- 0072467505
2. Etter and Ingber, "*Engineering Problem Solving with C++*", Third Edition, Pearson, 2012, ISBN 978-0-13-249265-2
3. P. Deitel and H. Deitel, "*C++, How to Program*", 9th Edition, ISBN 978-0133378719
4. M. M. Mano and M. D. Ciletti, "*Digital Design*", 5th Edition, January 2012, ISBN 9780132774208

Grading:	Homework	20%
	Quizzes	15%
	Laboratory Assignments (Pre-Lab: 5%, Lab: 25%)	30%
	Technical Project/Paper	5%
	Final Exam	30%

Your numerical semester grade is converted to a letter grade based on the following scale (your numerical grade is rounded to the nearest percent):
95%-100% = A 90%-94% = A- 87%-89% = B+ 83%-86% = B 80%-82% = B- 77%-79% = C+
73%-76% = C 70%-72% = C- 67%-69% = D+ 63%-66% = D 60%-62% = D- range < 59% = F

Course Policies:

- **Homework** will be assigned to help students practice and master the theory presented in class. You will learn to navigate Linux, develop C/C++ programs on Linux, and will design and simulate digital designs in software (Simulink). Late homework, submitted after the given due date, will be penalized at 20% for each day that it's late, and will not be accepted after the 3th day.

- **Quizzes** (10-15 minutes) may be given at the beginning of any class. There are no make-up quizzes. Please inform the instructor beforehand if you are going to miss the class because of some important reasons.

- **Laboratory:** This class includes a 2 hour lab on Thursdays 8:00am – 10:20am in 009 Hayden-PC Lab. The lab provides students with hands-on experience on an actual embedded platform, a Zedboard that is based on the xiLinux Zynq system on a 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. The lab exercises are designed to follow the classroom topics, and will provide open-ended design experience. The final lab will involve controlling a robotic arm with both hardware and software.

  Students will be assigned a pre-lab, which they should complete before coming to the laboratory. The grade received in the lab will be a combination of the pre-lab preparation, progress made on the laboratory experiment and the write-up submitted in class/Blackboard a week later.

- **A Technical Project** covering the main objectives and concepts of the class will be assigned. It is mandatory that the technical report be typed up in a professional manner and follow the report writing guidelines outlined.

- **Final Exam** date: Dec 8th to Dec 15th, 2017. Actual day will be announced later. The exam will be closed book and closed notes. Last day to file a Final Exam Conflict Form is September 29th.

Computing and Course Resources:

- This course will use the Northeastern University Blackboard Course Management System accessible through MyNEU or by going to https://blackboard.neu.edu/. Check the course site regularly for class materials and additional resources. Discussions will be conducted on Piazza.

- All homework that involves a computer should be done on the College of Engineering Linux systems or on the Zedboard. Students may use their own computer for development, but need to verify that each assignment compiles and runs on the COE systems. All Northeastern COE students have an account on the COE Linux system. It is your responsibility to obtain this account and use it to complete homework assignments.

Course Topics
(Note: Schedule is subject to changes according to students' needs.)

Unit 1 – The ZedBoard, Linux and C++ Review

- Organization of a computing system
- The ZedBoard architecture
- The Linux shell and file system
- Arrays and pointers
- Data structures and Dynamic Memory
- C++ Classes and Objects
- Inheritance
- Templates
- Header files and Makefiles

Unit 2 – Combinational Logic

- Logic gates
- Boolean postulates and theorems
- Karnaugh maps
- The full adder
- Binary adder
- Binary subtractor Binary multiplier
- Magnitude comparator
- Decoder
- Encoder
- Multiplexer
- Demultiplexer

U**nit 3 – Hybrid Software-Hardware Combinational Designs**

Interacting layers in a full-stack design:

- Hardware controller, Device driver, Operating system, Memory-mapped I/O, Low-level library functions, User-level API

Design of an arithmetic co-processor:

- Floating-point arithmetic and circuits, Parallel floating-point accelerator, Software-hardware co-processor interface, Co-processor driver design, Acceleration of compute-intensive floating-point applications

Unit 4 – Sequential Logic

- Combinational vs. sequential logic
- Latches: simple latch, S-R latch, S'-R' latch, S'-R' latch with Enable, D latch
- Clock signals
- Flip-flops: D flip-flop, J-K flip-flop, T flip-flop
- Asynchronous inputs for flip-flops

Unit 5 – Registers and Counters

- Registers
  - 4-bit register
  - Adding a *load* input
  - Shift register
  - Shift register with parallel load
- Finite State Machines
- PWM signal generator
- Counters
  - Ripple counter
  - Synchronous counter
  - Limited-range counter
  - Counter with direction control

Unit 6 – Hybrid Software-Hardware Sequential Designs

- Case study I: Hybrid robotic arm control, Hardware controller, Driver functions, User-level API, Applications
- Case study II: VGA display
- Case study III: OLED display
- Case study IV: USB keyboard

Accommodations for Disabilities:
Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify to participate fully in the activities of the university. Students with documented disabilities who may need accommodations, or any student considering obtaining documentation should visit the DRC website at www.northeastern.edu/drc or contact their staff at 617.373.2675.

Statement on Academic Integrity:
A commitment to the principles of academic integrity is essential to the mission of Northeastern University. The Academic Integrity Policy can be found in the undergraduate student handbook (pages 38-41), or from the Office of Student Conduct & Conflict Resolution (OSCCR) http://www.northeastern.edu/osccr/academic-integrity-policy/. I encourage you to familiarize yourself with it. If a student violates this policy in any way, I reserve the right to impose a sanction of failure on the assignment/assessment or failure in the course. If you have questions about appropriate citations, please ask."