EECE 2160 Embedded Design: Enabling Robotics
Syllabus

Prerequisite: GE 1111 or GE 1502 or CS 2500 or instructor approval

Course Description and Overview: This class presents the fundamental concepts of Computer Engineering from a comprehensive, full-stack, software-hardware design perspective. The course 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 DE1-SoC 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 DE1-SoC, including LEDs, push buttons, switches, 7-segment displays, and 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. M. M. Mano and M. D. Ciletti, "*Digital Design*", 5th Edition, January 2012, ISBN 9780132774208
2. Y. Patt and S. Patel, "*Introduction to Computing Systems: From Bits and Gates to C and Beyond*", 2nd edition, August 2003, ISBN 978- 0072467505
3. S. Lippman, J. Lajoie and B. Moo, "*C++ Primer*", 5th Edition, 2013, ISBN 978-0321714114
4. B. Kernighan and D. Richie, "*The C Programming Language*", Second Edition, Prentice Hall Software Series, 1988, ISBN 0-13-110370-9

Grading:		
	Homework	20%
	Laboratory Assignments (including pre-labs)	25%
	Technical Project/Paper (Lab 10)	10%
	Midterm Exam – Date: 10/24/2022	20%
	Final Exam	25%

Your numerical semester grade is converted to a letter grade based on the following scale (your numerical grade is rounded up to the nearest percent):
93%-100% = A 90%-92% = 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 (Intel Quartus Prime). Homework due dates are strict deadlines with no exceptions. Late homework will not be accepted under any circumstances. Lowest homework grade will be dropped.

- **Laboratory:** This class includes a 2 hour lab on Thursdays 4:35pm - 6:55pm in 009 Hayden. The lab provides students with hands-on experience on an actual embedded platform, a DE1-SoC that is based on the ARM processor (CPU) and the Cyclone V FPGA. The platform runs DE1-SoC-UP Linux, an Ubuntu distribution of the Linux operating system. Students will write C++ programs on Linux in the DE1-SoC board, will develop digital designs that are embedded to run on the FPGA of the DE1-SoC, will interface to read/write switches/buttons/LEDs/7-Segement displays on the DE1-SoC and control a robotic arm. The lab exercises are designed to follow the classroom topics, and will provide open-ended design experience. The final lab will involve both hardware and software on the board.

  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/Canvas a week later. Late lab report submission will result in a 20% penalty deduction. Lab reports can be submitted upto the last day of classes (Dec 7th) after which no assignments will be accepted.

- **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.

- **A Midterm Exam** (Tentative date: 10/24/2022) will cover the first part of the course material. The exam will be approximately one hour.

- **Final Exam** date: December 9th to 16th, 2022. Actual day will be announced later. Last day to file a Final Exam Conflict Form is Sept 30th.

Computing and Course Resources:

- This course will use the Northeastern University Canvas Learning System accessible through MyNortheastern or by going to https://canvas.northeastern.edu/. Check the course site regularly for class material and additional resources. Discussions will be conducted on **Piazza** course page linked through Canvas.

- All homework that involves a computer should be done on the College of Engineering Linux systems (gateway system). Students may use their own computer for development but need to verify that each assignment compiles and runs on the COE systems or the DE1-SoC board. 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 – Linux and the DE1-SoC board

- Organization of a computing system
- The DE1-SoC architecture
- The Linux shell
- The Linux file system
- The *vi* (vim) editor
- The *gcc* compiler
- File commands

Unit 2 – Arrays, Pointers and Dynamic Memory in C++

- Arrays
- Pointers
- Dynamic memory allocation
- Data structures
- Linked lists
- Working with multiple source files

Unit 3 – C++ Object-Oriented Programming

- Classes and Objects
- Constructors and destructors
- Virtual functions and Abstract classes
- Inheritance
- Templates
- Makefiles

Unit 4 – Information Representation

- Base conversion
- Binary arithmetic
- Signed numbers
- Signed binary arithmetic
- Overflow
- Sign extension

Unit 5 – Boolean Algebra and Logic Gates

- Postulates and truth tables
- Logic gates
- Boolean function to logic circuits
- Theorems
- Canonical forms
- From truth tables to Boolean functions
- 2-, 3-, and 4-variable Karnaugh maps
- Undefined outputs (don't cares)

Unit 6 – Combinational Logic

- The full adder
- Binary adder
- Binary subtractor
- Binary multiplier
- Magnitude comparator
- Decoder
- Encoder
- Multiplexer
- Demultiplexer

Unit 7 – 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
- Registers
- Counters

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

Other Topics

- Memory-mapped I/O
- Programmable logic and CPU overview – FPGA and ARM
- Hardware/software interfacing
- CPU architectures – ARM vs. X86

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."