EE 376 Embedded Systems - Fall 2011

Instructor:	Jake Glower, Room 101Q
Office Hours:	t.b.d.,
Text:	*PIC18F4620 Data Sheets*, (on-line)
Lab Kit	$85 at NDSU Bookstore: required for each student. I want you to experience soldering for yourself, so borrowing or buying someone else's from a previous semester is not permitted. Think of it as a text book for $85. Plus - you'll find these boards useful for other classes - especially senior design.
Lab Sections:	ECE Room 235 - 24 max enrollment per section (there's lots of room currently)

Introduction: An embedded system is an electronic device which uses a microprocessor or microcontroller. Such systems are extremely common and becoming more and more prevalent due to the power of microprocessors, the versatility they offer, and their low cost. Similarly, this course serves to familiarize students to the design of an embedded system.

Prerequisite: EE 173 (C programming), ECE 206 (Circuits I), and ECE 275 (Digital Systems I). Most of this class is taking ECE 311 (Circuits II), ECE 321 (Electronics I), and ECE 343 (Signals and Systems) at the same time. I'll try to tie topics from these courses into this class throughout the semester. If you haven't had any of these courses, all the material you will need is presented in this course.

How to Get an A or B: Keep up and do the homework. This class involves programming and interfacing hardware to your computer board. The only way I know to understand this interaction is to do it yourself. That's what the homework problems are for. It's also a building process. We start with getting an LED to blink and end up with controlling a DC servo motor with a keypad. If you fall behind, it will be hard to catch up. Besides, getting your board to do stuff like play the NDSU fight song on your speaker is what's fun about this course.

The grades in this class are often bimodal: people who did the homework themselves tend to get either an A or a B. People who did not do the homework or copied the struggle to get a D.

Grading:

Tests	1 unit each	A	90% - 100%
Homework & Quizzes	1 unit	B	80% - 89.9%
labs	1 unit	C	70% - 79.9%
final	1 unit	D	60% - 69.9%
Total	Average	E	< 60%

Quizzes: Occasionally on Fridays there will be a quiz. The quiz is only 10 points (1/10th of one homework set) and the points count towards your homework score. The point behind quizzes is to emphasize certain concepts before you take the midterm.

Homework: Homework will be due at 4PM on the day assigned. Please turn in your homework in the boxes in the main office. Students are encouraged to work together on the homework sets, but a separate solution is required for each student. Homework turned in after the solutions are posted will not be graded.

Each homework set will have problems where you are asked to actually write and get one of the problems to work on your PIC processor board. Each student should have their own board and be able to explain how their design works. Check-off is Monday 1-3PM in room 211.

Laboratory Exercises: Approximately 6 lab exercises will be included in this course. Lab groups should be 2-3 students (ideally two), with one report due per group. Lab reports should be in the format of a formal technical report. This means sections should be clearly labeled, figures should include captions and the axis labeled, and you should explain how you collected your data, present your data, and walk the reader through how you analyzed the data. The format for lab reports are given on-line:

http://venus.ece.ndsu.nodak.edu/~glower/ECE376/labs/lab_grade.pdf

ECE 376 Course Objectives:

By the end of this semester, each student should be able to...

- 1. Explain what an embedded system is and give examples.
- 2. List the parts of a microcontroller and describe their functions.
- 3. Explain the difference between a Harvard architecture and a Memory Map architecture
- 4. Design hardware interface between a microcontroller and Light Emitting Diodes (LED's), Switches, Serial Communications Devices (such as a DS 1620), Parallel Communications Devices (such as an LCD display), Decoding Logic — A, B, D, E, I, K
- 5. Design software for the microcontroller that works with the hardware, including Requirements Capture, Flow Charting, Top Down Programming, Use of Subroutines, Use of Interrupts, A/D and D/A conversions — A, B, D, E, I, K
- 6. Implement a flow chart using Assembler, and C — E, K
- 7. Use data sheets to incorporate a device into an embedded system — I, K
- 8. Present and explain their designs in a technical presentation and in a technical report. — D, G, K

Relation of Course Objectives to ABET Criterion 3 Student Outcomes ABET Criterion 3 Student Outcomes Course Objectives	
(a) an ability to apply knowledge of mathematics, science, and engineering	4, 5
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	4, 5
(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	4, 5
(d) an ability to function on multidisciplinary teams	4, 5, 8
(e) an ability to identify, formulate, and solve engineering problems	4, 5, 6
(f) an understanding of professional and ethical responsibility	
(g) an ability to communicate effectively	8
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	
(i) a recognition of the need for, and an ability to engage in, life-long learn	4, 5, 7
(j) a knowledge of contemporary issues	
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	4, 5, 6, 7, 8
(l) an ability to grow in the knowledge of and make professional contributions to at least one specific area of ECE	

Tests:

There are three midterms this semester, during the 5th, 10th, and 15th week of the semester. These midterms will be projects along with a write-up. You may work alone or in groups of two on these midterms.

For each project, you are to design, build, program, test, and demonstrate a working device which could be marketed and incorporates material from the previous 5 weeks. For example, when we're covering light-emitting diodes and timing, you might build under-dash lights for your car that allow you to vary the color of your car's interior. When we're covering filters, you might add to this design so that the color varies depending upon the frequency of the music playing. The projects may be related to previous projects you built in class or they may be separate ideas. Just try to pick something that is tied to your hobbies and interests.

Grading will be based upon your write-up for

- Description: (10%) What your device does and the requirements it needs to meet.
- Analysis (30%): What a typical midterm is. Schematics and calculations for the resistors, capacitors, transistor gains, etc.
- Software: (30%) Flow charts and description of how your code works and incorporated features covered in class,
- Verification (20%): Collect data to verify your design works. (Loop times, voltages, currents, etc.)
- Instructor Discretion (10%): A way to add a degree of difficulty factor. If your project is just to get a light to turn on, the best you can get is a B.
- In-class presentation: showing off your design and the number of 'ooohs' and 'aaahs' you receive.

(If you work in a group of two, *both* of you need to know how the hardware and software work.) You are free to design anything you like - just make sure it's ***your*** design. If you turn in someone else's design (say, a project a student did last semester), you'll receive a zero for your midterm grade. (This is part of the reason for the check-off and oral quiz for each group. If you don't know what your code does, I'm pretty suspicious it's not your code.) You're free to get ideas for a project from wherever you like - just make sure you demonstrate ***your*** ability to design hardware and software to meet your design requirements.

Special Needs - Any students with disabilities or other special needs, who need special accommodations in this course are invited to share these concerns or requests with the instructor as soon as possible.

Academic Honesty - All work in this course must be completed in a manner consistent with NDSU University Senate Policy, Section 335: Code of Academic Responsibility and Conduct. Violation of this policy will result in receipt of a failing grade.

ECE Honor Code: On my honor I will not give nor receive unauthorized assistance in completing assignments and work submitted for review or assessment. Furthermore, I understand the requirements in the College of Engineering and Architecture Honor System and accept the responsibility I have to complete all my work with complete integrity.

Syllabus:

Aug 24	W	Introduction - PIC EVB
Aug 26	F	PCB Layout
Aug 29	M	Architecture & Boolean Math
Aug 31	W	MPLAB & PIC C
Sep 2	F	Binary Inputs
Sep 5	M	Holiday!
Sep 7	W	Keypads
Sep 9	F	Binary Outputs – LEDs
Sep 12	M	Binary Outputs - LCD Display
Sep 14	W	Binary Outputs – Transistors
Sep 16	F	Stepper Motors
Sep 19	M	Brushless DC Motors
Sep 21	W	Shift Registers
Sep 23	F	Stacks
Sep 26	M	Class Presentations (Test #1)
Sep 28	W	Class Presentations (Test #1)
Sep 30	F	Timer2 Interrupts
Oct 3	M	Timer2 Examples
Oct 5	W	D/A & A/D Conversions
Oct 7	F	Instrumentation Amplifiers
Oct 10	M	Calibration
Oct 12	W	SCI Data Communications
Oct 14	F	INT Interrupts
Oct 17	M	DC Servo Motors & Optical Encoders
Oct 19	W	Timer 0/1/2/3 Interrupts
Oct 21	F	Timer1 Capture
Oct 24	M	Timer1 Compare
Oct 26	W	Class Presentations (Test #2)
Oct 28	F	Class Presentations (Test #2)
Oct 31	M	Passive Filters & LaPlace Transform
Nov 2	W	Active Filters
Nov 4	F	Fourier Series
Nov 7	M	Digital Filters & z-transform
Nov 9	W	Converting G(s) to G(z)
Nov 11	F	Holiday!
Nov 14	M	FIR Filters
Nov 16	W	Butterworth, Elliptic, Chebychev Filters
Nov 18	F	PIC Assembler
Nov 21	M	Compiling C to Assembler
Nov 23	W	C vs. Assembler
Nov 25	F	Hoiday!
Nov 28	M	PCB Layout
Nov 30	W	Low Power Operation
Dec 2	F	Other Microcontrollers
Dec 5	M	Class Presentations (Test #3)
Dec 7	W	Class Presentations (Test #3)
Dec 9	F	Class Presentations (Test #3)
Dec 14	W	Final Exam: 8-10AM