North Carolina State University, Department of Electrical and Computer Eng.

Syllabus for ECE306: Introduction to Embedded Systems
Fall 2024

https://moodle-courses2425.wolfware.ncsu.edu/course/view.php?id=2805#section-2

Lecture: Tuesday / Thursday 3:00pm - 4:15pm,

Classroom 02124 EBIII August 20th – December 3rd

Laboratory: 1020 EBII

Instructor: Jim Carlson

Office: 2092 EBII

Office hours: Times TB

Email: jbcarlso@ncsu.edu

TA(s): Posted on the top of the main class Moodle web page along with their e-mail addresses.

TA Office Hours: This will also be posted at the top of the Moodle class web page.

The best way to get a question answered is to submit it to Discord – fellow students, the TA(s) and the instructor will see it right away.

This is the preferred method for interaction, as it allows other students to see the question and answer. You can email the TA(s) questions if they are not suitable for the message board. The TA(s) will be in the lab during their scheduled times to answer questions in person. Finally, if your question is not resolved with posting Discord or asking a TA, you can e-mail the instructor.

It is always acceptable to ask in class.

Prerequisite

Grade of C or better in ECE209 and ECE212. Lack of the prerequisite is grounds for cancellation of enrollment in the course.

Class Materials and Textbook

Class Required: In previous classes, the Purchase of an **Analog Discovery** was required. This course will also use the Analog Discovery. In addition, depending on the semester you took the pre-requisite courses, you will also need a **Digital Voltmeter**. You will need to be able to measure current that cannot be easily done with an Analog Discovery. The one I use is from Harbor Freight. Often the one listed below is advertised or offered for instore sales for around $7.

https://www.harborfreight.com/7-function-digital-multimeter-59434.html

Required: Each student is required to have a microcontroller evaluation board starter kit. Project assignments will be configured for the Texas Instruments MSP-EXP430FR2355 Experimenter Board. http://www.ti.com/tool/msp-exp430fr2355 The kits are available online from Texas Instruments for about $12.99 each. They are also available from various distributors for slight increase in price. A few tools and supplies are also required. The chart below gives suggested sources. While you may purchase like items from alternate locals, the list below can be ordered from one or two sources (Digikey or Mouser and Arrow or Symmetry) including the Experimenters Board.

YOU DO NOT NEED TO ORDER THE LIST OF PARTS FROM BOTH DIGIKEY AND MOUSER.

Highlighted items are optional. **Price listed were correct Last semester. They may have changed.**

https://www.ti.com/tool/MSP-EXP430FR2355#order-start-development Price $12.99 unknow availability

https://www.mouser.com/ProductDetail/Texas-Instruments/MSP-EXP430FR2355?qs=MLItCLRbWsy88WceFCoMsA%3D%3D $17.28 Currently 347 in stock

Digi-Key

Item	Digi-Key Part Number	Description	Unit Price
1	296-50211-ND	MSP430FR2355 LaunchPad Development Kit [47 in stock]	$15.59
2	EROP7SA-ND	TWEEZER POINTED MICRO 4.50"	$5.80
3	KE1808-ND	DISPENSING PEN FLUX .32OZ	$13.23
4	461-1010-ND	XKMRED MICRO-HOOK RED 0.025" SQ PINS	$3.47
5	461-1009-ND	XKMBLK MICRO-HOOK BLACK 0.025" SQ PINS	$3.59
6	80-1-5-ND	SOLDER-WICK ROSIN .030" 5'	$5.64
7	243-1184-ND	DESOLDERING PUMP METAL BODY	$8.91
8		**IOT Module [See Next Page]**	?
			$56.23

[Chose one source or mix just do not order duplicates unless you really want to.]

Alternate Source

Mouser

Item	Mouser Part Number	Description	Unit Price
1	595-MSP-EXP430FR2355	MSP430FR2355 LaunchPad Development Kit [718 in stock]	$17.27
2	578-EROP7SA	TWEEZER POINTED MICRO 4.50"	$5.80
3	5878-80-1-5	Solder Removal .03" WHITE	$5.64
4	533-2331	Soldering Flux OA WS Alcohol Flux	$10.42
5	119-17537	Solder Removal De-Soldering Pump	$9.09
6		**IOT Module [See Next Page]**	?
			$48.22

The IOT module is the ESP32-WROOM-32E part. Any of the following versions will work. You can search either Digikey or Mouser for supply.

ESP32-WROOM-32E-N8 8 MB (Quad SPI)

ESP32-WROOM-32E-N16 16 MB (Quad SPI)

ESP32-WROOM-32E-H4 4 MB (Quad SPI)

ESP32-WROOM-32E-H8 8 MB (Quad SPI)

Price range is from $2.50 to $7.00

You should expect to spend an additional **$30 - $40** in parts [Batteries / Wheels / Caster] associated with the projects. Some specific additional items will be identified as the class progresses.

Most student assignments must be submitted through TA demonstrations, but some will be submitted via either Wolfware or Moodle. Past assignments are maintained for 1 week and then shredded. Test answer sheets are available at the next class after the test, then shredded. You will not get the test questions returned after the test. If you want to go over specific questions missed, that will occur during the next class following the test or by appointment.

Required Text: None.

Required Reading: There are relevant articles posted on the class website that supports topics discussed.

Highly Suggested Text: Brian Kernighan and Dennis Ritchie, **The C Programming Language**. ISBN: 0131103628. This is a useful reference for programming in C. This book will serve you for many years. I still use the copy I purchased back when I was in school.

Optional Text: Yale N. Patt and Sanjay J. Patel, **Introduction to Computing Systems: From Bits & Gates To C & Beyond**. McGraw-Hill. ISBN 0-07-237690-2. This is the same textbook as is used in ECE 206, so you should already have it. Either the first or second edition can be used as a reference for this class.

Catalog Description

Introduction to designing microcontroller-based embedded computer systems using assembly and C programs to control input/output peripherals. Use of embedded operating system.

Purpose of Course

In this course students will:

- Install a development environment.
- Recognize and identify the constraints facing embedded system designers and determine how to assess them.
- Program a modern microcontroller in assembly language, C, and operate its peripheral devices.
- Interpret how the assembly code generated by a compiler relates to the original C code.
- Practice thread-based program design with a real-time operating system.
- Develop programs controlling embedded systems using quick and efficient methods.
- Predict, measure, and manipulate a program's execution time.
- Create / Document an Embedded System project.

Projects

The projects are an integral part of the course and are intended to provide experience in the application of the design techniques discussed in lecture. These projects will utilize the embedded systems board required for the class. All projects are to be done individually. You may discuss coding strategy but not share code directly. The Team structure is for discussion, not copying. Sharing of diagrams or sudo coding is okay. Sudo coding is not actual C code!

There will be ten project exercises assigned. These projects are cumulative.

Project 1	Power System	Individual
Project 2	LCD	Individual
Project 3	Vehicle Assembled and Moves	Individual
Project 4	Motor Control Forward	Individual
Project 5	Motor Control Forward / Reverse	Individual
Project 6	Black Line Detection	Individual
Project 7	Black Line Navigation	Individual
Project 8	Serial Port Communication	Individual
Project 9	IOT	Individual
Project 10	Navigate a Course	Individual

Project 10 Demo in class Last week of Class

The class will be broken into teams of students. While the projects are worked on in teams all team members must complete the project. Individual Bonus will be given for early demonstrations. It is expected with all projects are individual assignments and that each team will support each other. Each team member must perform their own work.

Projects can be completed in the Embedded Systems Teaching Lab (1020 EB2) or on your own home PC/ Laptop. Significant soldering assembly will be required. The lab will be open when a TA is present; these times will be listed on the web. When the TA leaves, he/she will close the lab. This is to protect the PCs and equipment from vandalism, which has unfortunately occurred in the past, forcing this policy. If possible, additional access may be granted.

Teams will be assigned Lab duty to keep the lab organized and clean. Moving soldering irons is strictly prohibited. The TA's will grade each teams cleaning participation throughout the semester and will be a factor in the final project grade.

If there is a problem with any of the equipment or tools, notify a TA immediately. DO NOT TRY TO FIX IT YOURSELF. THE SOLDERING IRONS USE SPECIAL POLARIZING TIPS. THEY ARE NOT CIRCULAR.

Note that the lab (1020 EBII) is shared with other classes. Access during those times is not permitted unless by prior arrangement.

Each student will sign up for a demonstration time to show their project hardware / software.

All Team members must be prepared to answer questions about hardware and software. While there will be collaboration on Software, each team member must author their own solutions and be able to answer technical questions about the code on their project.

The lab times will be posted on the course home page. The TA's must be scheduled on the method they choose [Google calendar last semester] for demonstrations. Some class time has been allocated for final demonstration / competition.

There are blocks of time for each TA. You will select a 2 block of time each week that you are expected in lab to work on assignments and have the TA present to help with problems. These are not structured Labs; you will use the time to complete the Projects and have the TA present to obtain help.

Please note that the teaching assistants will be present in the lab at the open times listed on the class website for office hours as well as lab demonstrations. You can meet them to ask questions in person. Demos take precedent over questions.

Because almost all of us learn by doing, the laboratory will probably be the most effective method for learning the material and will help you on homework and exams. Also, ask yourself questions while completing the project and during the lab time. Take advantage of access to the TA. Do not just passively and monotonously expect the homework and projects to be a + b = c process. To learn, you need to do it and you need to creatively think about what you are doing! Homework and Project grades will be based on individual assignments and demonstrated functionality of problem requirements. If you do not understand what to do, you need to ask questions in class!

In general, the assignment grade will be determined according to:

- **Technical Content:** Technical Content refers to the answers you provide to sections of the write-up. Make sure you understand the required material before embarking on your write up as your effort will be graded for correctness. Students often lose points for not having good figures or a reasonable write-up, neglecting to add sub sections or cover all the required parts of the project or leaving out required figures or tables.
- **Presentation:** Presentation refers to the overall "look and feel" of the write-up and demo, which includes such items as format and content. You shouldn't be embarrassed by your write up or by the operation of your vehicle.
- **"What if" Question:** For certain homework and projects, a portion of your grade may be determined by your answer to a question from the TA. The goal of this question is to test your understanding of the code. You are responsible for understanding the behavior of all the code in your system, even if you obtained assistance to get it working and /or if your project partner wrote it.
- **Code Review:** For certain homework and projects, a portion of your grade may be determined code review and analysis. Note, it is easy to identify code from previous semesters. ***Using code from previous semesters will result in a zero for the assignment.***

- **Demo:** The Projects and Homework's include some portion of Demonstration. The assignment outlines what must be demonstrated.
- **Peer Review:** For certain projects, a portion of your grade will be peer review. A form will be provided to rate your teammates involvement.

Late project demonstrations will be accepted up to a week after the due date. There is a 5-point penalty per day late. For example, if you demo on Wednesday instead of the due date of the previous Monday, the penalty will be -5 (Tuesday) + -5(Wednesday) = -10 points. Weekends are not counted. You are limited to demonstrating during times when the TAs are present in the lab. **You must complete each project in order as they are cumulative except Project 8.** Bonus points will be offered for early demonstration.

A demo grade of 0 will be entered for any project not demoed after the time the next project is due. Demos are allowed on the same day of the next demo.

Bonuses are granted for early Project demonstrations. Demos are on Mondays. If demoing on the previous Friday, then it is +1, Thursday is +3, Wednesday is +5. The bonus is individually assigned. Bonus is applied to **Demo portion of Project only**.

Demonstration times will be assigned using the methods identified by the TA's. Class size is large and optimum signup times will go rapidly. Variances from this policy are only granted in rare occasions and must be approved by the instructor. Issues with personal computers is not a qualifier for project problems. The machines in the lab contain the IAR Compiler and can be used for all but the first assignment.

Homework

Homework is another example of learning by doing. Although not as exciting as the projects, homework is essential to learning the concepts in this course. Homework will be in the form of reading assignments and problem sets, configuration associated with the embedded hardware with a due date 1-2 lectures after it is assigned.

- **No late homework will be accepted.**
- **No make-up homework will be provided.**
- **Your homework must be done individually.**

Homework 4 is required. No points will be granted if turned in late. Projects will not be accepted until Homework 4 is submitted.

If you have a dispute with how an assignment is graded, you should follow this procedure:

1. Get the solution to the assignment from the TA or the class web site and examine it. You may have just worked the problem incorrectly.
2. If you really believe that your answer is correct (matches the answer given in the solution), contact the TA and discuss it with him or her. He / She will listen to your concern, and act on it, at his / her discretion.

3. If you are still not satisfied with the resolution, you may bring the homework to me for review. I will not review homework that has not been seen by the TA.

The lowest homework score will be dropped, with no questions asked. This is to accommodate illnesses, dead car batteries, missed buses, etc. Use this freedom wisely – save it for when you will need it.

Grade Sheet

You will need to maintain a grade sheet. Many assignments are checked by demo, and grades entered later. To insure there is a record of the grade, keep up with a grade sheet. A scan copy of your grade sheet can be submitted each weekend via Moodle.

DO NOT DEMO WITHOUT GETTING YOUR GRADE SHEET SIGNED! Have it when you arrive to demo.

Regular Grades Sheet submissions are provided on Moodle.

Grade Sheets

MUST BE SUBMITTED

Every time a sign-off is obtained.

ON MOODLE.

Emailed copies will not be accepted.

A scan copy of your grade sheet must be submitted weekly on Moodle.

Tests

There will be three tests throughout the semester and no final exam; Test 3 carries more weight. Tests will be closed-book and closed-notes. Tests will include material from the lecture, reading material, homework, and projects. Knowledge in this class is cumulative with information learned early on being on any of the tests.

Test dates:

- Test 1: In class Tuesday, September 24th
- Test 2: In class Thursday, October 24th
- Test 3: In class Tuesday, November 26th

Dates may change due to Weather

Missed exams: Attendance at all tests is mandatory. Only legal or debilitating medical excuses will be accepted if they are accompanied by the appropriate official documentation. Makeup tests maybe more difficult than the tests they replace. Failure to satisfy these criteria will result in a zero grade for the tests.

Registration for those who qualify for DSO services, must plan and schedule test to occur the same day as the test is scheduled. The ending time of the arranged scheduled test should occur coincident with normal class time.

Missing Class/Assignments

Throughout the semester, a student may miss classes/assignments/exams due to many reasons. Most of the reasons ***will not*** be accepted as an "excused" absence. That is why one of the homework's is dropped when determining your final grade. For example:

- ECE or other class test review sessions: All ECE 306 class and test times take precedence over any review sessions.
- University sponsored activity: All ECE 306 class and test times take precedence over any University-sponsored activity.
- Business trips: If you miss an ECE 306 assignment because you were on a business trip, you miss out on the assignment points.
- Illness: If you miss an ECE 306 assignment because of illness; medical excuses will be accepted with doctor's note.

Course Lectures

We will use PowerPoint slides to teach this class. You can download PDF versions of them and print them from the web. See the web for the course lecture outline. While these will provide a guide to what is lectured on, I do not just read from the slides. Classes are taught based on the information to be covered not based on reading from slides. The slides should be treated as the text book for the class.

Grading Percentages and Grade distribution

Homework assignments		**10%**	
Project assignments			
Project 1	Power System	**2.5%**	
Project 2	LCD	**2.5%**	
Project 3	Vehicle Created	**2.5%**	
Project 4	Motor Control Forward	**2.5%**	
Project 5	Motor Control Forward / Reverse	**5%**	
Project 6	Black Line Detection	**2.5%**	**[40%]**
Project 7	Black Line Navigation	**5%**	
Project 8	Serial Port Communication	**2.5%**	
Project 9	IOT	**5%**	
Project 10	Navigate a Course	**10%**	
Test 1		**15%**	
Test 2		**15%**	
Test 3		**20%**	
Total		**100%**	

The letter grade distribution for this class.

A+	97-100,	B+	87-89.9,
A	93-96.9,	B	83-86.9,
A-	90-92.9,	B-	80-82.9,
C+	77-79.0,	D+	67-69.9,
C	73-76.9,	D	63-66.9,
C-	70-72.9,	D-	60-62.9,
F	<59.9		

Rounding is not used. The grade you receive is the grade you earned.

To get an "S" grade, students taking the course for credit only must do all the coursework (homework, labs, quizzes, tests) and make the equivalent of a C-.

Auditing ECE 306 is not allowed.

Students with Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653.

http://www.ncsu.edu/provost/offices/affirm_action/dss/

For more information on NC State's policy on working with students with disabilities, please see http://www.ncsu.edu/provost/hat/current/appendix/appen_k.html

Academic Dishonesty

All the provisions of the http://www.ncsu.edu/provost/academic_policies/integrity/reg.htm code of academic integrity apply to this course. In addition, it is my understanding and expectation that your signature on any test or assignment means that you neither gave nor received unauthorized aid.

Please read the discourse on cheating and ECE 306 on the web page. For homework and laboratory projects, while collaboration is allowed, direct copying is not and students must turn in individual submissions. Realize that mastery of the material in the homework and lab assignments will be essential for a good performance on the tests!

Important Semester Dates

Refer to the NCSU Academic calendar for all relevant dates.

Due to the Coronavirus pandemic, public health measures have been implemented across campus. Students should stay current with these practices and expectations through the Protect the Pack website (https://www.ncsu.edu/coronavirus/). The sections below provide expectations and conduct related to COVID-19 issues.

Associate Deans of Academic Affairs and Registrar's office

Health and Participation in Class

We are most concerned about your health and the health of your classmates and instructors/TAs.

- If you test positive for COVID-19, or are told by a healthcare provider that you are presumed positive for the virus, please work with your instructor on health accommodations and follow other university guidelines, including self-reporting: https://healthypack.dasa.ncsu.edu/coronavirus/. Self-reporting is not only to help provide support to you, but also to assist in contact tracing for containing the spread of the virus.
- If you feel unwell, even if you have not been knowingly exposed to COVID-19, please do not come to class.
- If you are in quarantine, have been notified that you may have been exposed to COVID-19, or have a personal or family situation related to COVID-19 that prevents you from attending this course in person (or synchronously), please connect with your instructor to discuss the situation and make alternative plans, as necessary.
- If you need to make a request for an academic consideration related to COVID-19, such as a discussion about possible options for remote learning, please talk with your instructor for the appropriate process to make a COVID-19 request.

Health and Well-Being Resources

These are difficult times, and academic and personal stress is a natural result. Everyone is encouraged to take care of themselves and their peers. If you need additional support, there are many resources on campus to help you:

- Counseling Center (https://counseling.dasa.ncsu.edu/)
- Health Center (https://healthypack.dasa.ncsu.edu/)
- If the personal behavior of a classmate concerns or worries you, either for the classmate's well-being or yours, we encourage you to report this behavior to the NC State CARES team:

  (https://advising.dasa.ncsu.edu/resources-for-advisors/advisors-toolkit/cares/)
- If you or someone you know are experiencing food, housing or financial insecurity, please see the Pack Essentials Program (https://dasa.ncsu.edu/pack-essentials/).

Community Standards related to COVID-19

We are all responsible for protecting ourselves and our community. Please see the community expectations and Rule 04.21.01 regarding Personal Safety Requirements Related to COVID-19 https://policies.ncsu.edu/rule/rul-04-21-01/

Course Expectations Related to COVID-19:

Please refer to NCSU published guidelines as it pertains to Covid requirements.