ECEN 5813

Embedded Software Essentials

Course Syllabus

Embedded Systems Engineering Professional Master’s Program

Department of Electrical, Computer and Energy Engineering

College of Engineering and Applied Science, University of Colorado Boulder

# Specifics

**Instructor:** Kevin Gross [<kevin.gross@colorado.edu>](mailto:Kevin.Gross@Colorado.edu)

**Office hours:** M/W 3-345p, ECEE 1B61

**Student assistants:** Nikhil Divekar [<nikhil.divekar@colorado.edu>](mailto:nikhil.divecar@colorado.edu),   
Nagarjuna Reddy Kovuru [<nagarjunareddy.kovuru@colorado.edu>](mailto:nagarjunareddy.kovuru@colorado.edu)

**Class times:** M/W 4-515p

**Class location:** ECCS 1B14

**Zoom meeting ID:** 880-519-621 (<https://cuboulder.zoom.us/j/880519621>, +16699006833,,880519621# or +16465588656,,880519621#)

**Midterm exam:** 15 October, 4-515p, DLC 1B70

**Final exam:** 19 December, 730-10p

# Description

Introduces principles around embedded software elements and software development needed for the Embedded Systems Engineering core curriculum. Students will write C-program applications that employ efficient, high performance, and robust software design techniques. Topics include bare-metal firmware, C-programming and optimization, and introductions to underlying embedded architecture. Sound testing and debug practices will be instilled and utilized in several application projects.

# Prerequisites and rationale

This course requires that you have C-programming experience. Although not strict prerequisites, courses offered in the department where this experience can be obtained include:

* ECEN 1310 C-programming for ECE
* ECEN 3350 Programming of Digital Systems

This course is not an introductory software course. If you have programmed in different languages like C++ or Java, and you feel like you can quickly adjust to the syntax and changes with C programming, you can continue with the course. If you have no comprehensive experience in any software languages, you should not be taking this course.

There will be an early exam to test your competency with C. Students scoring below a C on this exam must review their results with the instructor team before continuing with the course.

Embedded systems are present everywhere you go. Your car contains numerous embedded computers, and your home likely contains many more. Modern medicine relies on embedded technology for research and clinical applications.

The requirements for each of these embedded computers varies greatly and the ESE program exposes students to diverse applications. Each course in the program, although different in content and implementation, shares a major common characteristic: embedded software. From one embedded architecture to the next, the fundamental software concepts are largely the same. It is therefore important that we provide a course to teach the concepts of embedded software design to reduce repetition of this content and provide a reference point that students may start their core ESE curriculum with momentum.

Many engineers coming into the program may already have a solid understanding of embedded software. Student with this background should be able to move on to the core courses of the program without taking this soft prerequisite.

# Communications

The professor and assistants may be contacted via email. Please use your colorado.edu email address when connecting the instruction team. The team may also be contacted through the course Canvas website <https://canvas.colorado.edu>. The Canvas site will also be used for instructional materials, assignments, grading and some quizzes. Students will need to regularly check their email and Canvas for communications from the instruction team.

# Textbooks

## Required

* Making Embedded Systems. Elecia White, O’Reilly ISBN-13: 978-1-449-30214-6

## Reference

* Brian Kernighan; Dennis Ritchie (1988). The C Programming Language (2nd ed.). Prentice Hall. ISBN 978-0131103627.
* Mike Banahan; Declan Brady; Mark Doran (1991). [The C Book.](http://publications.gbdirect.co.uk/c_book/) Addison Wesley.

# Development hardware

Development kits are built by microprocessor manufacturers or independent parties. These are simple and extensible platforms for project development. Most include a cross-development environment. Many also include provisions for an off-the-shelf operating system.

This course will use the following development kits for projects and assignments.

* [FRDM-KL25Z](https://www.nxp.com/support/developer-resources/evaluation-development-boards/freedom-development-boards/mcu-boards/freedom-development-platform-for-kinetis-kl14-kl15-kl24-kl25-mcus:FRDM-KL25Z)
* [BeagelBone Black](http://www.ti.com/tool/beaglebk?DCMP=PPC_Google_TI&k_clickid=b5af63ae-775b-4c5e-8918-5f41635797e1)

These development kits have a limited set of onboard peripherals. To make projects more interesting and realistic, external peripherals can be attached to the development kits. We will be using the following external peripherals.

* [Nordic nRF24L01+ 2.4 GHz transceiver module](https://www.amazon.com/Makerfire-Arduino-NRF24L01-Wireless-Transceiver/dp/B00O9O868G)

The above hardware may be checked out by students for the semester. Students are expected to replace any damaged equipment. Students may alternatively wish to purchase their own hardware from online sources.

# Content

This course will provide students, who have minimal embedded software experience, the foundational knowledge needed for the Embedded Systems Engineering core curriculum. The course will breakdown the software hardware interactions, study the implications of the C-programming language to the underlying architecture, provide C-programming applications, and instill efficient, high performance, and robust software design techniques. Testing and debug practices will be developed and need to be successful for assignments. Students will participate in several development projects throughout the semester to reinforce classroom topics.

1. Resource constraints and real-time performance requirements
2. Development environment including
   1. Version control
   2. Configuration management
   3. Development kits
   4. Cross compiling and debugging
3. Advanced C-programming
4. Software architecture, design and design documentation
5. Hardware interfaces and processor selection
6. Peripherals and device drivers
7. Memory and memory management
8. Scheduling, multitasking and multiprocessing
9. Data-driven systems
10. Security, maintenance and code updates
11. Performance optimization
12. Power optimization
13. Numerical programming

# Evaluation and grading

Grade-earning work in the course will be in the following categories and will contribute to the final grade in the proportions indicated.

Homework, quizzes and participation - 20%

Projects - 40%

Midterm exam - 20%

Final exam - 20%

Based on the percentage of available points received, a final letter grade is assigned as follows:

A 94% or above, A- 90%, B+ 87%, B 83%, B- 80%, C+ 77%, C 73%, C- 70%, D+ 67%, D 63%, D- 60%, F below 60%

Any issues with grading need to be raised with the professor within one week of posting on the course Canvas website.

# Academic Integrity

Any suspected violations of the Honor Code will be submitted to our Honor Code Office. **Students found responsible for any violation by our faculty and the Honor Code Office will earn an automatic F in the course.** We take these issues seriously and have a responsibility to all students who uphold the Honor Code, and to the highest industry standards for which we are preparing students. If you have any questions whatsoever regarding what collaboration is permissible in the course, consult your instructor directly before proceeding. By default, you are expected to turn in your own original work and cite any and all portions you did not create. All aspects of the Honor Code apply.

# General Attendance

Students are expected to participate in class discussions of course topics on course Canvas site. In addition, students are expected to assist other students in understanding course material and assignments.

Going forward, the following will be in effect for ESE program courses, as reported by ESE course instructors:

1. Students enrolled but not engaging in an ESE course for the first week will be moved to the end of any existing waitlist.
2. Students enrolled but not engaging in an ESE course for the first two weeks will be administratively dropped from the course.

# Work and study expectations

Beyond the time required to attend each class meeting, students enrolled in this course should expect to spend at least an additional 10-15 hours per week of their own time in course-related activities, including reading required materials, completing assignments, preparing for exams, etc.

Course materials include textbooks, papers, lecture slides, project guides, and other online materials. Lecture slides will show related reading material and homework assignments may specify specific reading material. Students will be required to read the associated material and be expected to answer questions regarding that material.

Expect homework assignments covering material from the course. Students may collaborate together on homework, but each student must turn an individual paper with problem solutions with their own work. Any online sources must be cited on assignments. Plagiarism will not be tolerated and can result in an honor code violation.

All homework and reports must be legibly written or typed. Assignments must be submitted to the course Canvas website, by the due dates and times announced on assignments. Do not deliver homework directly to the instruction team via email or other means as we may not accurately record receipt through these channels.

## Projects

There will be multiple projects which will require creation of programs that run on the development kits. Projects also involve deliverables including a written project report detailing results, data collected, and project files.

You can work on the projects with project partners. The professor will post a forum on the Canvas site for you to look for a partner. Groups can have a maximum of 2 members. Students are encouraged to help other students and teams solve problems. Since significant learning can result from such activities, such sharing is highly encouraged. However, each student or team is expected to independently create and implement their own project files and other deliverables.

Students may find that they are able to leverage firmware designs from books, magazines, the Internet, or their work environments; however, in these cases, students are expected and required to credit the source of the information clearly and completely. Plagiarism will not be tolerated and can result in an honor code violation.

All programming code must adhere to the ECE program’s [C-programming style guide](https://canvas.colorado.edu/courses/20519/pages/coding-guitelines). Code and comment quality will be evaluated as part of each assignments grading.

# Video and teleconferencing

Students in the on-campus section of the course are expected to attend regularly scheduled lectures in the classroom.

This course features a section of remote students who attend via Zoom teleconference or watch a recorded version of lectures as their schedule allows. The connection details for the Zoom teleconferences are as follows.

Meeting ID: 880-519-621

Connection options:

Join via web browser: https://cuboulder.zoom.us/j/880519621

Join via Zoom app (using meeting ID)

Join via telephone: US: +1-669-900-6833 or +1-646-558-8656

Join via iPhone one-tap: US: +16699006833,,880519621# or +16465588656,,880519621#

(Note: for higher quality, dial a number based on your current location)

The Zoom conferencing tool, is currently not accessible to users using assistive technology. If you use assistive technology to access the course material, please contact your faculty member immediately to discuss.

Lecture videos will be accessible as links from the course Canvas site usually a couple hours after the lecture is given.

# Accommodation for Disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the [Disability Services website](http://www.colorado.edu/disabilityservices/students). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see [Temporary Medical Conditions](http://www.colorado.edu/disabilityservices/students/temporary-medical-conditions) under the Students tab on the Disability Services website.

# Classroom Behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on [classroom behavior](http://www.colorado.edu/policies/student-classroom-and-course-related-behavior) and the [Student Code of Conduct](http://www.colorado.edu/osccr/).

# Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu); 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to non academic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the [Honor Code Office website](https://www.colorado.edu/osccr/honor-code).

# Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

The University of Colorado Boulder (CU Boulder) is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (including sexual assault, exploitation, harassment, dating or domestic violence, and stalking), discrimination, and harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, [anonymous reporting](https://cuboulder.qualtrics.com/jfe/form/SV_0PnqVK4kkIJIZnf), and the campus resources can be found on the [OIEC website](http://www.colorado.edu/institutionalequity/).

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

# Religious Holidays

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, Please contact the professor to make any necessary arrangements.

See the [campus policy regarding religious observances](http://www.colorado.edu/policies/observance-religious-holidays-and-absences-classes-andor-exams) for full details.