CprE 288 – Introduction to Embedded Systems

Department of Electrical & Computer Engineering
Iowa State University

Spring 2018

Course Information

Catalog Description: Cr. 4 (3-2). Embedded C programming. Interrupt handling. Memory mapped I/O in the context of an application. Elementary embedded design flow/methodology. Timers, scheduling, resource allocation, optimization, state machine based controllers, real time constraints within the context of an application. Applications laboratory exercises with embedded devices.

Prerequisites: CprE 281, ComS 207 or ComS 227 or EE285

Textbook (required): Practical Microcontroller Engineering with ARM Technology, by Ying Bai, 2016

C Programming Books (optional; may find these or similar books useful)**:**

- The C Programming Language, Brian W. Kernighan and Dennis M. Ritchie, 2nd edition, Prentice Hall, 1988. This is a famous book (the second author is the original designer of the C language).
- C: A Reference Manual, Harbison and Steele, Morgan Kaufmann, 1998. This is a standard reference; better as a reference than as an expository text.
- Expert C Programming: Deep C Secrets, Peter Van Der Linden, Prentice Hall, 1994. This explains many of the more confusing aspects of C; helpful for even experienced C programmers.

Why C?

This course covers low-level features in computers and programming, so we use a low-level programming language to emphasize this. Everything in C can be implemented on typical processors in a fairly straightforward manner, and it is thus often considered a high-level assembly language. Similarly, it exposes some details of the underlying machine, e.g., how data are stored in memory. It is important to get experience in a variety of programming paradigms and languages. To emphasize the importance of code documentation, good code must be written so others can understand it, and this requires extensive documentation.

Website: The course will use Canvas and CyBox. Prior semester course materials may be browsed at http://class.ece.iastate.edu/cpre288/ (current course materials will NOT be placed at this website).

Class Schedule: There are two lecture sections that meet on Tuesdays and Thursdays.
      Morning section: Tuesday & Thursday, 9:30 – 10:50 am, in Sukup 0022.
      Afternoon section: Tuesday & Thursday, 2:10 – 3:30 pm, in 1414 Mol-Bio.

All laboratory sections meet in Coover 2041. Labs begin in Week 2 of the semester. Refer to the Schedule of Classes or Canvas course site for the lab section schedule.

Instructional Staff:

Instructor
      Diane Rover, 333 Durham, 515-294-2819, drover@iastate.edu,
      www.eng.iastate.edu/~drover/
      Office Hours: Tuesday & Thursday, 11 am – noon, 1 – 2 pm, and by appointment

Teaching Assistants
      Refer to the Canvas course site for the list of teaching assistants.
      Office Hours: TBD and by appointment

Course Learning Objectives

Students will:
- Learn to interface microcontrollers with the real world
- Learn to enable others to interface microcontrollers with the real world
- Learn system-level debugging
- Learn the computing and data storage structure of microcontrollers
- Improve systematic learning
- Become familiar with professional roles and responsibilities within embedded systems careers
- Understand how societal and human factors affect their engineering work and solutions
- Gain an awareness of design thinking methods and understand how they relate to engineering work

At the completion of the course, each student should be able to:
- Program and design applications for embedded systems
- Read datasheets/manuals in order to develop practical applications
- Perform basic hardware and software debugging
- Program in C for the ARM Cortex M4 based microcontroller
- Understand basic computing concepts such as interrupts, interrupt service routines (ISR), memory-mapped input/output (I/O), simplified processor architecture, registers, program and data memory structure
- Generate and interpret signals interacting with the environment
  - UART serial communication

- o Analog to digital conversion (ADC)
- o Input capture
- o Pulse width modulation (PWM)
- Convert C code into assembly and binary code
- Better identify the extent to which the embedded systems field aligns with career interests

Course Schedule

A complete course schedule is provided as a separate document.

Key dates:
- First day of class: Tuesday, January 9
- Spring Break week (no class): March 12-16
- Final exams:
  - o Morning section: Wednesday, May 2, 9:45 – 11:45 am, Sukup 0022
  - o Afternoon section: Thursday, May 3, 7:30 – 9:30 am, 1414 Mol-Bio

Policies and Procedures

General
1. You are required to access the Canvas course site for relevant and timely information throughout the semester.
2. Email is an effective way to communicate with the instructor and teaching assistants.
3. You should regularly check your Iowa State email.
4. Class attendance is expected and contributes to your class participation grade.
5. Lab attendance is mandatory. Refer to the lab policies below.
6. Read all assigned material.
7. Complete all work in a timely manner.
8. Actively participate in class discussions.
9. Participate fully in group discussions.
10. Treat all classmates in a respectful manner.
11. Communicate with the instructor and teaching assistants and visit during office hours as needed.
12. There will be opportunities for feedback as a means of continuously improving the course and your learning during the semester.
13. If you have special learning needs, please contact the instructor to make suitable arrangements.
14. Students are responsible for being familiar with the University's student rules and policies. Visit the ISU Policy Library website (http://www.policy.iastate.edu/)

Overall Goals for Every Student
- Take advantage of the opportunity to learn and meet your responsibilities.

- Think critically about topics to gain insights.
- Understand how to apply modern tools and techniques.
- Take responsibility for your own learning, learn with others and learn by doing, and be active in the course.
- Improve skills for working effectively with others.
  - Describe what you know to others.
  - Ask others to share their knowledge and insights with you (and listen to them).
- Actively reflect on your learning in the course and the overall functioning of the course.
- Actively process the group work.

Grading

Both individual and group work are graded to evaluate your performance in the course. You are expected to participate fully in informal and formal group work.

Academic dishonesty on course work will be dealt with strictly following university policy, will at a minimum result in a 0 on an assignment, and may result in a 0.0 for the course.

The following grading scheme will be used:
  - Exams: 30%
    - Exam 1: Week 7 (Thursday)
    - Exam 2: Week 12 (Thursday)
    - Exam 3 (Final Exam): See final exam schedule.
  - Assignments and Class Participation (Homework, Reflections, Quizzes, In-class Exercises): 25%
  - Laboratory Exercises: 30%
  - Laboratory Project: 15%
  - TOTAL: 100%

Note: Lab work is group work (either with a partner or team). Other work will be submitted as individual work. If your average score on the individual work, including the final exam, is a passing grade, i.e., 55% or above, you will receive full credit for your lab work. However, if your individual work is not at a passing level, you may receive only partial credit for your lab work.

Course letter grades will be assigned based on a straight scale. There will not be any curving of final grades to obtain a predetermined distribution of A, B, C, etc. letter grades. The grading scale is shown below:

Weighted Average %	≥90	87-89.9	84-86.9	78-83.9	75-77.9	72-74.9	67-71.9	64-66.9	61-63.9	58-60.9	55-57.9	<55
Letter Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F

Exam Policies
If you require exam accommodations, contact the instructor to make the necessary arrangements. Absences approved by the university must be brought to the instructor's attention and documentation provided in advance. All other absences will be dealt with individually and determined by the instructor to be excused or unexcused. If you miss the final exam without a valid excuse, a zero will be averaged into your grade.

Lab Policies
Lab attendance is mandatory. If you will be absent, you must notify the lab instructor (TA) by email *before* the absence for it to be decided if it is an excused absence. An unexcused absence will result in a zero for the corresponding lab, and missing several labs is sufficient cause for a zero lab score for the semester, and in turn, a 0.0 (failing) grade for the course.

Students work with partners or groups on lab work. Lab partner roles will be rotated during the term to give students different learning experiences. The same score will be awarded on group work unless there is evidence to support different scores for individuals.

A lab should be worked on during its corresponding lab period. If the lab is not completed during the lab period, it should be finished during any other unscheduled/open lab time *before* the next regular lab. **The lab must be demonstrated to your lab instructor no later than the beginning of the *next* regular scheduled lab.** The lab must be ready to demonstrate; students may not work on Lab *i* during the period for Lab (*i+1*).

While it is highly discouraged, a lab may be demonstrated up to 1 week late with a late penalty of 20%.

All code must be commented.

Homework Policies
Homework must be typed and uploaded through Canvas in PDF or WORD format (other formats are not accepted). It is due in Canvas by the due date. We would like you to complete all homework assignments even if they are turned in late. You can submit homework up to two days late at a penalty of 10% per day.

Collaboration is encouraged for the purpose of better learning course material. If you form a study group to work on a homework assignment, then you must cite/list all collaborators on your homework submission and state specifically how you collaborated with each. Note the following stipulations:

- Not identifying your collaborators is considered academic misconduct and will be treated as such.
- Collaborating with others does not mean copying others. If you are found copying others' work (from this semester or previous semesters), as opposed to working with them to better understand the material, this is also considered academic misconduct.

- To avoid misconduct situations, consider working through problems on your own, before collaborating with a study group.

Other Policies

Instructor Commitment
You can expect me to be respectful, punctual, organized, and prepared for course activities; to answer questions clearly and constructively; to be available during office hours or to notify you beforehand if I am unable to keep them; to make appropriate arrangements when I am traveling on university business; and to grade uniformly and consistently according to the written guidelines. I encourage you to contact me whenever you have questions or concerns related to the course.

Communication
Discussion boards are available for various course activities and questions. The instructor and/or teaching assistants will check for new posts in these forums approximately once per day. Use email to communicate with the instructor/TAs when issues are more specific or time-sensitive (such as notifying about an absence). Please put CPRE 288 in the subject line to give course-related messages priority.

Here is a helpful blog for guidelines about writing professional emails: http://mleddy.blogspot.com/2005/01/how-to-e-mail-professor.html

Mutual Respect and Professionalism
You are expected to treat your instructor and all other participants in the course with courtesy and respect. Your comments to others should be factual, constructive, and free from harassing statements. You are encouraged to disagree with other students, but such disagreements need to be based upon facts and documentation (rather than prejudices and personalities). It is the instructor's goal to promote an atmosphere of mutual respect in the classroom. Please contact the instructor if you have suggestions for improving the classroom environment. It is preferable if students discuss issues directly with the instructor, however, students may also leave a note in the instructor's mailbox.

Students are to treat all their classmates in a respectful manner. The following code of classroom conduct explains what this means in further detail: https://www.abe.iastate.edu/abe-code-of-classroom-conduct/ (under development for the ECE department).

Academic Integrity and Misconduct
Academic integrity, based on the values of honesty, trust, fairness, respect, and responsibility, is a fundamental principle of scholarship in higher education. You are expected to practice academic integrity in every aspect of this course and all other courses. Familiarize yourself with the ISU Student Disciplinary Regulations (Student

Conduct Code), especially the section on academic misconduct, at
http://www.policy.iastate.edu/policy/SDR. Students who engage in academic
misconduct are subject to university disciplinary procedures, as well as consequences
with regard to this course.

Disability Accomodation
Iowa State University is committed to assuring that all educational activities are free from
discrimination and harassment based on disability status. All students requesting
accommodations are required to meet with staff in Student Disability Resources (SDR) to
establish eligibility. A Notification Letter form will be provided to eligible students. The
provision of reasonable accommodations in this course will be arranged after timely delivery of
the Notification Letter to the instructor. Students are encouraged to deliver Notification Letters
as early in the semester as possible. See Student Disability Resources website
(https://www.sdr.dso.iastate.edu/).

Dead Week
This class follows the Iowa State University Dead Week policy as noted in section 10.6.4 of the
Faculty Handbook and in the ISU Policy Library; see the ISU Policy Library website
(http://www.policy.iastate.edu/) for policy wording.

Harassment and Discrimination
Iowa State University strives to maintain our campus as a place of work and study for faculty,
staff, and students that is free of all forms of prohibited discrimination and harassment based
upon race, ethnicity, sex (including sexual assault), pregnancy, color, religion, national origin,
physical or mental disability, age, marital status, sexual orientation, gender identity, genetic
information, or status as a U.S. veteran. Any student who has concerns about such behavior
should contact the instructor, Student Assistance at 515-294-1020 or email dso-
sas@iastate.edu, or the Office of Equal Opportunity and Compliance at 515-294-7612.

Religious Accommodation
Iowa State University attempts to reasonably accommodate students whose sincerely held
religious beliefs or creed conflict with academic requirements. The process for requesting an
accommodation is interactive and the process must be initiated by the individual seeking the
accommodation. For optimal consideration, students should inform instructors as soon as
possible in the semester of any future conflict. It is recommended that the student and
instructor discuss the request in person and then document the resolution in an email format.

The instructor reserves the right to revise the course and syllabus as needed and will inform
students about changes in a timely manner.