Syllabus, Fall 2023

Lecture:	AERO 114 (Classroom)	Tues and Thurs	11:30 AM - 12:45 PM
Lab:	AERO 141 (PILOT Laboratory)	Thursday	2:45 PM - 4:35 PM

Instructor

Trudy Schwartz, Teaching Professor
Office: AERO 150B (Inside the Electronics Lab AERO 150)
You can reach me on the ASEN 4/5067 class Slack or at trudy.schwartz@colorado.edu.
Office Hours: **25 min after lectures and during all lab hours. By appt for personal course issues.**

Teaching Fellow

Name: Carson Leppla
Email: Carson.Leppla@colorado.edu
Office Hours: **TBD, and during all lab hours**

Internet Information

Class website on Canvas (https://canvas.colorado.edu/) will be used to post official announcements and submit some assignments. Most assignments will be submitted through Gradescope.

Communication: The primary forms of communication will be during lectures, Canvas announcements and Slack discussions. The course email list provided through Canvas will be utilized if needed. Make sure you enable email notifications from Canvas and set up the Slack channel.

Prerequisites

CSCI 1320: Computer Science 1 – Basic C programming course. (Or GEEN 1300 or equivalent.)
ASEN 3300: Electronics and Communications – Digital and analog electronics, sensors, and measurements done in a laboratory. (Or equivalent. Contact instructor for equivalency questions.)
Programming experience is necessary to be successful in this course.
Some basic C programming experience is strongly recommended.

Text Resources

1. ***PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18.*** **2nd Edition by Muhammad Ali Mazidi, Danny Causey, Rolin McKinlay, MicroDigitalEd, August 16, 2016. ISBN 9780997925999 (Recommended if you can find a copy.)**

2. ***Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC18 Microcontroller Family)*** **1st Edition by Ramesh S. Gaonkar, Delmar Cengage Learning, 2007. ISBN 9781401879143 (Older, but alternative recommended text if you can find a copy.)**

3. *PIC18F87K22 Data Sheet: http://ww1.microchip.com/downloads/en/DeviceDoc/39960d.pdf*
4. *PIC18F87K22 Errata Sheet: http://ww1.microchip.com/downloads/en/DeviceDoc/80507c.pdf*
5. *MPLAB XC8 PIC Assembler User's Guide: https://ww1.microchip.com/downloads/en/DeviceDoc/MPLAB%20XC8%20PIC%20Assembler%20User%27s%20Guide%2050002974A.pdf*

References / Additional Text Resources

1. ***Embedded Design with the PIC18F452 Microcontroller,*** **John B. Peatman, Prentice-Hall. (Select chapters)**
2. *Designing Embedded Systems with the PIC Microcontrollers: Principles and Applications*, Tim Wilshurst.
3. *The Art of Electronics*, Horowitz and Hill, Cambridge University Press.

Learning Goals

Basic microcontroller architecture including various memory types and locations.

Decimal, hexadecimal, binary conversions and mathematics.
Assembly and C language microcontroller programming.
Interfacing with sensors, servos, and Liquid Crystal Display (LCD).
Interfacing to the wide variety of onboard peripherals (Counter/Timers, ADC, DAC, USART, SPI, I2C).
Analog to Digital Conversion (ADC), and Digital to Analog Conversion (DAC) and Signal Conditioning.
Various timing schemes and proper use of interrupt service routines and levels.
Developing hardware/software systems for aerospace applications.
Embedded system debugging and troubleshooting of hardware and software.

Course Calendar

Refer to the 2023 schedule document posted on Canvas (https://canvas.colorado.edu).

Required Hardware

This course was originally designed around the QwikFlash board that came as a kit students soldered themselves. In 2014, we moved to a custom in-house PCB design with a two-part setup, a PIC Board and a Base Board, which utilized the newer and more capable PIC18F87K22 – but this solution was labor intensive to support our own PCB fabrication at large scale. The PIC18F87K22 is all around very capable in the PIC18 family of 8-bit microcontrollers as measured by program memory size, RAM size, number of peripherals and low power consumption. To keep up with student demand, it was more cost effective to purchase a commercial-off-the-shelf (COTS) development board, the EasyPIC PRO V7 from MikroElektronika; which is readily available on Digikey or Mouser. The EasyPIC PRO V7 also consists of a main baseboard, and interchangeable PIC boards, where the default board is the one that we will use in this course, the PIC18F87K22. For more information, refer to the hardware documents and datasheets provided on Canvas.

The intent of the modular baseboard/PIC board setup is to provide students with a prototyping development board system applicable to many different microcontroller applications. Students will use the full EasyPIC PRO v7 and the PIC18F87K22 exclusively in this course as the basis for initial development. If desired for other courses or projects students can design a custom-sized Base Board (outside the scope of this course) to upgrade to additional microcontroller capabilities or to satisfy specific design requirements to fit into a specific Aerospace application such as a CubeSat, rover, airplane, UAV, etc. Each small PIC board (in many varieties) is also available COTS for only ~$20. This EasyPIC development board provides a head start on the hardware (every year many senior or grad projects never gets their hardware working), it also gives a head start on the software and provides familiarity with microcontrollers and the PIC18 family as a basis. If they choose, students can also leverage the EasyPIC PRO v7/PIC18F87K22 to prototype a portion of their Senior, Graduate, or research project as their final project in this Microavionics class.

We have decided to invest *significantly* in this set of EasyPIC PRO v7 development boards in the hopes that they will continue to last for many years to come and therefore they are the property of the department that will be on ***loan*** to you. We will also provide a protective padded static bag, static strap, laptop case and all the accessories. This also means ***you are responsible*** for treating all the hardware appropriately and will be held accountable for fixing or replacing any damaged hardware. ALWAYS place the hardware in the provided padded anti-static bag and laptop case when not in use, and do not expose these to excessive heat. (i.e., do not leave in your car!) We will also provide the PicKit-3 In-Circuit Debugger for use as a programmer and

debugger for the microcontroller as well as a kit of accessories and testing components to complete the labs. In addition, each student will check out the expensive Analog Discovery 2 - a USB powered oscilloscope, function generator, logic analyzer.

Overview

The world of aerospace engineering is growing quickly and becomes more interdisciplinary every year. The major aerospace products such as aircraft and satellites are becoming more complex and intelligent in part due to the explosion of information technology. This increase in capabilities requires more detailed information about the system state, provided by sensors and processed in real-time, to make an informed decision on future action. The collection and/or processing of this data is often done by a single or distributed network of inexpensive processors called microcontrollers.

This course has been developed to provide engineers with a ***basic understanding*** about the fundamental architecture of a microcontroller and how it operates and interfaces with various inputs (sensors, communication, etc.) and outputs (actuators, displays, communication, etc.). This course focuses on sensors and actuators and strict timing requirements that are especially important in aerospace engineering, such as servos for example. The goal of this course is to learn how to *properly* interface inputs to a microcontroller and program it to collect/store/convert that input, make decisions, and take action in real-time.

To gain a full appreciation of how microcontrollers really work on the inside you will develop your own software code using MPLAB X to program the development board hardware. This board uses the Microchip PIC18F87K22 microcontroller and will be the foundation of the course. In this course you will "**learn by doing**" through lab assignments and a semester final project using the PIC18F87K22. This will include mostly programming in assembly language first to appreciate hardware specifics and then progress to C programming for more advanced programming at the end of the course and for the final project.

Class Format

This class is a demanding and fulfilling senior/graduate level Aerospace Engineering Sciences elective designed to provide students with a solid background and some experience working with microcontrollers with specific Aerospace applications in mind. The course meets three times each week for a total of 3.5 hours. This includes two 50-minute lectures and one 1-hour and 50-minute lab period. Lectures are generally much more productive for students if you are ready to ask questions. **This lecture format expects students to come prepared!** Being prepared means doing the required reading ***before*** lecture and attempting all the labs prior to the lab periods. All the labs will take much more time than the allotted lab period, and as a result you should attempt the labs on your own ***before*** the lab session. The lab periods should be used to receive assistance from the instructor and teaching fellow and to help troubleshoot and debug. In addition to the lab assignments, your grade for this course will also include quizzes and a final project. The relative weighting for each is provided below. The idea is to have a dynamic and interactive lecture where we can focus on the material that is giving students the most problems and not spend a lot of time on concepts that can be self-taught from the book, online resources, and working through the labs.

This class is cross listed as both a 4000 and 5000 level course. If you are taking this course for graduate credit (5000 level) then you will be expected to answer additional/more difficult questions, complete more in-depth tasks on your lab assignments, and develop a graduate caliber final project as determined be the teaching team in the project proposal. The 4000 and 5000 level students will be graded separately to ensure fairness in the evaluation of performance.

Logistics

1. Lecture slides will be posted at least 24 hrs. in advance – it is expected that you read those lecture slides before attending lectures to make them most productive.

2. The course teaching team reserves the right to make changes to the weekly course schedule based on occurring events that require different dispositions. Sufficient advance notice (preferably 24 hrs) will be given through announcements in class and posting on the web. Changes to this syllabus and schedule may be announced at any time during class periods. We will post the current syllabus and schedule on the Canvas course website.

3. Slack will be the main form for communication amongst the class. Please post your questions to the appropriate channel for each assignment. Students are highly encouraged to use this platform to answer questions of others as a form of collaboration and peer learning. The teaching team will respond to questions usually within 24 hours during business hours, i.e., Monday through Friday, 8:00 am – 5:00 pm. Questions sent over email will be redirected to use the appropriate Slack channel. Questions that are 24 hours or less of the lab due date may not receive a response in time from the teaching team. Please utilize the office hours and the lecture time effectively.

4. In-person lab attendance is expected. The PILOT AERO 140 computers have the necessary software installed. It is highly recommended that you use a personal computer or laptop installed with the necessary free software downloads so you can work on the labs from home in addition to on campus.

5. ***Students are expected to work independently on all assignments!!*** All work submitted ***must be your own***, you may only discuss higher-level concepts and approaches with your classmates. **You may not share or tell someone else exactly how to complete the assignment.** We will check your assignments for similarities and penalize you accordingly. The ***only*** way to learn in this class is to do the programming yourself. It is very unlikely that you could pass the lab code reviews if you don't write the code from scratch yourself. Copying online resources for any assignment is strictly not allowed for lab assignments and only allowed in small portions of the final project if properly cited and with prior instructor approval. The policy on using ChatGPT is in the Honor Code section below.

6. **INDIVIDUAL** lab reports are due by 11:59 PM on the specified due date. These labs must be submitted electronically. **Late labs will be assessed a penalty each day and will not be accepted after 4 days.**

7. These are **INDIVIDUAL** lab assignments that make up a significant portion of your final grade. While having code that meets the assigned requirements is important, this is not the only criterion by which the labs are graded. As part of this course, you are expected to learn good coding practices, such as reasonable variable names that anyone can understand, good documentation practice using comments, good modular coding implementation and coding style and efficiency. The labs will be graded on whether your solution meets the assigned requirements when programmed on the teaching team development board and the code is well documented/commented using good programming techniques i.e., using efficient loops and functions where appropriate.

8. If you are ill and will not be able to complete an assignment or attend, you must contact the instructor via email as soon as possible to make specific arrangements. Late lab policy is covered above. Students are encouraged to provide as much documentation as possible to enable an informed decision. If necessary, the instructor may choose to use your existing grades to cover your missed grade(s).

9. There will be a Final Presentation/Demo for the course.

   Mandatory - All students must be available these days/times, please *plan your schedule* accordingly:

   - **Final Presentation Slides and Video due** **Tuesday Dec 19, 2023 @ 12:00 PM (NOON)**
   - **Final Project EXPO (Final Exam Time)** **Tuesday Dec 19, 2023 1:30 PM- 4:00 PM**
   - **Final Peer Reviews due** **Tuesday Dec 19, 2023 @ 4:00 PM**

10. Review quizzes will be given to test yourself on the course content and if you are retaining the necessary information from the readings, lectures, and labs. The lowest quiz score will be dropped.

Course Grading

60%	**6 Lab Assignments (10% each)**
20%	**Quizzes**
20%	**Final Project**
100%	**Final Grade**

Grading Meetings

You will *sign up for a time slot* to meet with the Teaching Fellow (TF) after each of labs 2-6 to demonstrate your code is working on the TFs hardware and **your knowledge** and **understanding** of the code ***you have*** written as part of the grade for each lab assignment.

Grading Disputes

If you feel that a graded assignment had a human error you must submit your regrade request via Gradescope (if available for that assignment). All requests must be filed within 1 week after the grading is completed. Your request must clearly state what error was made. Partial credit is not negotiable. In a regrade request, the *entire* assignment will be re-graded during the reassessment process and the new grade may increase or decrease.

Classroom Behavior

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure 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.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

Requirements for Infectious Diseases

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all public health orders to reduce the risk of spreading infectious diseases.

The CU Boulder campus is currently mask optional. However, if masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class. Students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct & Conflict Resolution. Students who require accommodation because a disability prevents them from fulfilling safety measures related to infectious disease will be asked to follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

For those who feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the further guidance of the Public Health Office. For those who have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

Disability Services determines accommodations based on documented disabilities in the academic environment. If you qualify for accommodations because of a disability, submit your accommodation letter from Disability Services to your faculty member in a timely manner so your needs can be addressed. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance.

If you have a temporary medical condition or required medical isolation for which you require accommodation which requires that you miss a lab or lecture, you don't need to notify the teaching team, since this course is up to you to pace your workload and makeup for any missed content. If this temporary medical condition affects the in person grading assignments, you must email the teaching team. It is up to the instructor's discretion whether that deliverable will be rescheduled, or your grade based on the remaining assignments.

This course requires the use of MPLAB X, (Realterm or Putty) and Waveforms software as well as the EasyPIC PRO v7 hardware which has not yet been reviewed fully for accessibility. This course also uses Slack for class discussions, which may not be fully accessible to users using assistive technology. If you use assistive technology to access the course material, please contact your faculty member immediately to discuss.
If you use assistive technology to access the course material, please contact the Instructor and Disability Services at 303-492-8671 *or by e-mail at* dsinfo@colorado.edu *as soon as possible to discuss other effective means for providing equal alternate access.*

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

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 Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), 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.

In this course you are not allowed to use ChatGPT for any portion of your lab coding assignments or quizzes. You may use ChatGPT only for portions of your final project and only if you give written request and approval from the instructor before the due date.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: honor@colorado.edu, 303-492-5550. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment,

exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and support resources can be found on the OIEC website.
Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive an outreach from OIEC about their options for addressing a concern and the support resources available. To learn more about reporting and support resources for a variety of issues, visit Don't Ignore It.

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, you need to email the instructor with as much advance notice as possible if you have any conflicts due to religious observance.

See the campus policy regarding religious observances for full details.

Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.