

## ASEN 4067/5067 Microavionics for Aerospace

### Syllabus, Fall 2020

Lecture: Zoom Mon and Wed 4:30 - 5:20 PM  
Lab: AERO N100 (COPILOT classroom) Thursday 12:50 - 2:40 PM\*  
Zoom link for lab and lecture: <https://cuboulder.zoom.us/j/91542795274>, password given on Canvas.  
Lecture zoom session will be recorded.

\*Students who wish to attend in person may do so biweekly to conform to new COVID occupancy limits, the remainder of the class may participate in Zoom lab sessions offered every week at the same lab time.

### Instructor

Trudy Schwartz  
Office: AERO 150B (Inside the Electronic Center AERO 150)  
You can reach me at [trudy.schwartz@colorado.edu](mailto:trudy.schwartz@colorado.edu) or by phone at 303-735-2986  
Office Hours: Office Hours: Tues 3 PM - 4 PM and Wed 9:30 AM – 10:30 AM  
Office Hours Zoom <https://cuboulder.zoom.us/my/trudyschwartz>

### Teaching Fellow

Email: [Lara.Lufkin@colorado.edu](mailto:Lara.Lufkin@colorado.edu)  
Office Hours: TBD based on Student Feedback, Location: Zoom

### Internet Information

Class website on Canvas ([canvas.colorado.edu](https://canvas.colorado.edu)) will be used to post announcements and submit assignments  
Piazza: Discussion board. Find our class signup link at: <https://piazza.com/colorado/fall2020/asen40675067>  
Email List: The course email list provided through Canvas will be utilized for the course email list. Make sure you enable email notifications from Canvas.

### Prerequisites

CSCI 1320 (or GEEN 1300) – basic programming or equivalent  
ASEN 3300 – basic digital and analog electronics or equivalent  
Some C programming experience is strongly recommended  
Some Matlab or other programming experience is necessary

### Required Texts

*Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC18 Microcontroller Family)* **1<sup>st</sup> Edition** by Ramesh S. Gaonkar, Thomson-DelMar, 2007. ISBN 1-4018-7914-4

### References

PIC18F87K22 Data Sheet: <http://ww1.microchip.com/downloads/en/DeviceDoc/39960d.pdf>  
PIC18F87K22 Errata Sheet: <http://ww1.microchip.com/downloads/en/DeviceDoc/80507c.pdf>  
*Embedded Design with the PIC18F452 Microcontroller*, John B. Peatman, Prentice-Hall.  
*Designing Embedded Systems with the PIC Microcontrollers: Principles and Applications*, Tim Wilshurst.  
*The Art of Electronics*, Horowitz and Hill, Cambridge University Press.

## Learning Goals

Basic microcontroller architecture and memory  
Assembly and C language microcontroller programming  
Analog to Digital Conversion, and Digital to Analog Conversion  
Basic sensors, microcontroller and sensor interfacing  
Interfacing to peripherals  
Interrupts and timing  
Developing hardware/software systems  
Embedded system debugging and troubleshooting

## Course Calendar

Refer to Schedule 2020 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 to supplement the Gaonkar book. The QwikFlash board had been used previously in this class for about 10 years, and contained outdated hardware – the PIC18F452 in particular. 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 PIC18F87K22 – but this solution was labor intensive to support our own PCB fabrication. The PIC18F87K22 is all around very capable in the PIC18 family as measured by program memory size, RAM size, number of peripherals and low power consumption. In 2017, 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 PIC18F87K22 that we had already been using! 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 a potential design to utilize for many different microcontroller needs. Students can start with the full EasyPIC PRO v7 as the microcontroller setup for initial development, then for other courses or projects design a custom-sized Base Board / Daughter Board later to satisfy particular design requirements to fit in a cubesat, rover, airplane, etc. or to add additional microcontroller capabilities. Each small PIC board (in many varieties) are available COTS for only ~\$20. Not only does this give a head start on the hardware (every year there is at least one senior or grad project that never gets their hardware working), it also gives a head start on the software and provides familiarity with the PIC microcontroller family. If they choose, students can also leverage the EasyPIC PRO v7 to prototype a piece of their Senior, Grad 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 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

responsible for fixing or replacing the hardware. ALWAYS place the hardware in the provided padded anti-static bag and laptop case when not in use, and do not expose 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, this semester each student will check out the coveted Analog Discovery 2, a USB powered oscilloscope and function generator.

## 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 a decision based about a future action. The collection and processing of these data is often made by a 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 both sensors and actuators. While the course does tend towards sensors that are useful in aerospace engineering the concepts are applicable to all disciplines of engineering. The goal of this course is to learn how to interface sensors to a microcontroller, collect input, make decisions and take an action in real-time.

To gain a full appreciation about how microcontrollers work 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**” conducting lab assignments and a semester final project using the PIC18F87K22. This will include programming in assembly language and then C to collect data from external sources such as a serial terminal, temperature or rotary sensors, etc. and outputting results to a liquid crystal display (LCD), or an actuator such as a servo.

## Class Format

This class is a senior/grad level Aerospace Engineering Sciences elective designed to provide students with some background and experience working with microcontrollers in specific Aerospace applications. The course meets three times each week for a total of 3.5 hours. This includes two 50-minute lecture periods and one 1-hour 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 of the labs prior to the assigned lab period. All of the labs will take more that the allotted lab period, 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/TF and to help

troubleshoot and debug. In addition to the lab assignments, your grade for this course will also include two exams, and a final project at the end of the semester. 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 problem and not spend a lot of time on concepts that can be self-taught.

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 questions and complete more in-depth tasks on your lab assignments and develop a graduate caliber final project. The 4000 and 5000 level students will be graded separately to insure fairness in the evaluation of performance.

## Logistics

1. Lectures slides will be posted at least 24 hrs in advance – it is expected that you read those lecture slides and then attend lecture online every MW 4:30-5:20pm at this link:  
<https://cuboulder.zoom.us/j/91542795274> - Zoom sessions will be recorded.  
Use the password “micro” to get in.
2. Lab attendance (unless enrolled as a distance student) is mandatory in some form. You may always choose to attend lab Thursdays 12:50 – 2:40pm over zoom with the course Instructor. Same link as lectures above, same password.  
In-person lab attendance is optional, if you prefer to have an in-person experience and help with the lab and your hardware in person with the TF. Room AERO N100 has a capacity of 19 + the TF. This allows each student enrolled to attend lab biweekly if they choose. Attendance will be assigned to half of the class using Sign Up Genius. Please remove your name if you will not be attending and other students may sign up to fill that opened slot in the lab.
3. **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.
4. **INDIVIDUAL** Lab reports are due by 11:59 PM on the specified due date. These labs must be submitted electronically through Canvas. **Late labs will be assessed a 5% penalty for up to 1 hour late, and then a 15% penalty for that day and each additional day late and will not be accepted after 4 days.**
5. 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, good documentation practice, good modular coding implementation and coding style. The labs will be graded on whether your solution meets the assigned requirements, code is well documented/commented and has good programming techniques i.e. using efficient loops and functions where appropriate.
6. Under **NO circumstances** should get code solutions somewhere or provide your code to another student. Luckily, this has only occasionally been a problem. If you work or speak with another student about your

ideas, you should provide a reference in your code or report. We will use Turnitin, code checking software and the grading meetings to help determine if your work is original and if you understand what you wrote.

7. If you are ill and will not be able to complete an assignment or attend an exam, you must contact the instructor via email as soon as possible to make specific arrangements. Late lab policy is covered above. Make ups for exams are extremely difficult to accommodate. There will be no unexcused exam makeups provided. If you miss an exam, the course instructor will evaluate each case on an individual basis based on the context and information available to decide if a makeup exam will be provided. 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).
8. There will be 2 in-lecture Exams and one Final Presentation/Demo for the course. **Exams may be cumulative.** Copying, collaborating, or discussing material during an exam constitutes **cheating and will result in an F for the exam** and will be reported to the University Honor Code. The following dates and times are **mandatory**.

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

- |   |   |
|---|---|
| – Exam #1                                 | <b>Wednesday Oct 21<sup>st</sup> (Online 4:30-5:20pm MST)</b>   |
| – Exam #2                                 | <b>Monday Nov 16<sup>th</sup> (Online 4:30-5:20pm MST)</b>      |
| – Final Presentation Slides/Report/Videos | <b>Saturday Dec 12<sup>th</sup> 11:59 PM (submitted online)</b> |
| – Final Peer Reviews                      | <b>Sunday Dec 13<sup>th</sup> 11:59 PM (submitted online)</b>   |

9. Review quizzes will be given – but are not for credit but rather to test yourself on the course content and if you are retaining the necessary information.
10. The course instructor reserves the right to make changes to the weekly course schedule based on occurring events that require different dispositions. Sufficient advance notice 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.
11. Emailed questions will be responded to during normal business hours, i.e. Monday through Friday, 8:00 am – 5:00 pm. Extra questions outside of class and office hours directed to the TF or Instructor that are 24 hours or less of the lab due date or exam date may not receive a timely response. Please utilize the exam reviews given in the lecture prior to exams and office hours effectively.

## Course Grading

60% 6 Lab Assignments (10% each)  
 20% 2 Exams (10% each)  
 20% Final Project

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100% Final Grade

## Grading Meetings

You will sign up for a 15 time slot to meet with the Teaching Fellow after each lab submission to demonstrate your code is working on the 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 lab, exam, or project has been graded incorrectly you must submit your complaint in writing via email to the instructor. All complaints must be filed within 1 week after the assignment has been returned to the class. Your written request must clearly state your complaint. Be aware the *entire* assignment will be re-graded during the re-assessment process and the new grade may increase or decrease.

## Classroom Behavior

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Whether you will be attending in person or from home, you should treat the remote meeting environment just as professional as the in-person classroom—this includes expectations for your conduct, attire, and 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. For more information, see the policies on [classroom behavior](#) and the [Student Code of Conduct](#).

## Requirements for COVID-19

As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements, and public health orders in place to reduce the risk of spreading infectious disease. Required safety measures at CU Boulder relevant to the classroom setting include:

- maintain 6-foot distancing when possible,
- wear a face covering in public indoor spaces and outdoors while on campus consistent with state and county health orders,
- clean local work area,
- practice hand hygiene,
- follow public health orders, and
- if sick and you live off campus, do not come onto campus (unless instructed by a CU Healthcare professional), or if you live on-campus, please alert [CU Boulder Medical Services](#).

Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to [Student Conduct and Conflict Resolution](#). For more information, see the policies on [COVID-19 Health and Safety](#) and [classroom behavior](#) and the [Student Code of Conduct](#). If you require accommodation because a disability prevents you

from fulfilling these safety measures, please see the “Accommodation for Disabilities” statement on this syllabus.

Before returning to campus, all students must complete the [COVID-19 Student Health and Expectations Course](#). Before coming on to campus each day, all students are required to complete a [Daily Health Form](#). *For the in person lab time, you may be reminded of the responsibility to complete the [Daily Health Form](#) and given time during lab to complete it.*

Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home and complete the [Health Questionnaire and Illness Reporting Form](#) remotely. In this class, if you are sick or quarantined, **you must email the instructor and TF: [Trudy.Schwartz@colorado.edu](mailto:Trudy.Schwartz@colorado.edu), [Lara.Lufkin@colorado.edu](mailto:Lara.Lufkin@colorado.edu)**. Under FERPA you do not need to tell us why you are sick, but we do need to be notified of your absence. We also ask that you remove yourself from the Sign Up Genius (link provided on Canvas) to give an opportunity for other students who wish to come in person the ability to use a spot in the classroom for Thursday labs.

## 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](#). Contact Disability Services at 303-492-8671 or [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu) for further assistance. If you have a temporary medical condition, see [Temporary Medical Conditions](#) on the Disability Services website.

*This course requires the use of MPLAB X, Realterm and Waveforms software as well as the EasyPIC PRO v7 hardware which has not yet been reviewed fully for accessibility. This course also uses Piazza 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](tel:303-492-8671) or by e-mail at [dsinfo@colorado.edu](mailto: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 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](mailto:honor@colorado.edu)); 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic 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](#).

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

The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or 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](mailto:cureport@colorado.edu). Information about the OIEC, university policies, [anonymous reporting](#), and the campus resources can be found on the [OIEC website](#).

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

## **Religious Observance**

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 [Trudy.Schwartz@colorado.edu](mailto:Trudy.Schwartz@colorado.edu) 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.