

# Phy 420 – High Altitude Ballooning

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## 1 Logistics

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Office Hours: MW 1:00 - 2:00 and by appointment. However, you will have access to the lab at other times as well.

## 2 Overview

The goal of this project is to design, build, test, and launch a weather balloon that will travel to an altitude of 100,000 ft (30 km) above the Earth's surface. These types of balloons are flown regularly by the National Weather Service, as well as many other groups of amateur scientists. We will break into groups of 3 – 4 students to do this, and the balloon will be launched at the end of the semester, travel upwards for roughly 1 – 3 hours, burst, and then descend. You will then recover it.

The main scientific purpose of the project is to make measurements of atmospheric pressure, temperature, humidity, and wind speed from the ground to 100,000 ft, and take pictures of the atmosphere from altitude. Your balloon should be able to transmit the data to a ground station during the flight and will also be stored onboard. You will have to retrieve the payload. Your instrument payload will need to be less than approximately 2 kg, and the cross-sectional size roughly 10cm (not including insulation).

For the most part, class will meet in the electronics laboratory. I expect students to show up during class times to work with their fellow teammates. Your final grade will be determined in part by peer evaluation (see below). We will have some formal classes during which we discuss a few things that relate to the project, as well as what I expect from you from your documentation.

## 3 Course Schedule

- January 5: First week, Introduction
- January 12: Abstracts due, Heritage Study due, Begin intro to Arduino
- January 19: Proposals due (including preliminary design), Continue Arduino Intro (sensors)
- January 26: Parts List Due, Orders Placed, **Design approved**, Subsystems build
- February 2: Subsystems build

- February 9: Subsystems build
- February 16: Subsystems build, PCB Design
- February 23: Winter Break, stop slacking- get your HAM license!
- March 2: **Subsystems built with breadboards**, PCB layout complete and ordered, Systems integration
- March 9: Integration/Testing
- March 16: Testing
- March 23: Symposium practice (Symposium is March 27), Final Test Results Due, Launch Plan Due / Launch Window Opens
- March 30: Launch Window
- April 6: Launch Window
- April 13: Final Report Writing
- April 22: (11:00): Final time, Final Presentations, all documents due, lab clean up completed

The final week of March and the first 2 weeks of April will be the launch window (starting March 23). **You must be ready to launch on 3/30!** Each day that you are not ready after 3/30 you will lose 3 points off of the launch portion of your grade.

## 4 Amateur Radio License

In addition to requiring a callsign for GPS tracking purposes, FAA regulations require balloonists to have a HAM license prior to launch. For our purposes, at least 3 people in each group must have their HAM license, though I recommend everyone gets it. This can be done by taking the HAM license Technician Class exam. It is possible to prepare for the exam on your own, and as you are physics students, much of the material on the exam will be familiar to you. However, the exam does cover material regarding operation and policies, therefore you may wish to take a course prior to the exam. These are offered regularly. See <http://www.w8pgw.org/services/classes/> for more information.

**You are required to have your HAM technicians license (at minimum) by March 8.**

## 5 Grading

Your final course grade will be determined based on:

- **Team Feedback (10%):** Since you are required to attend class, I will have the ability to observe how each team member is performing. Further, there will be team and individual review sessions approximately every two weeks so that I can evaluate progress on the project in a formal setting and ensure that any issues with team members can be discussed. Therefore, I expect to not have any surprises on team feedback at the end of the semester. Still, 10% of your grade will be based on end-of-term peer evaluations.
- **Documentation (30%):** In addition to proper documentation being necessary for any scientific project, this course serves as your writing intensive experience for the major. Throughout the semester, you will have to provide several documents to me, including an abstract for your symposium talk, the heritage study, the project proposal document, the parts list, and the final report. Each of these will be due on certain days. Some of these will be individual reports, some will be team reports. If they are turned in late, 10% will be reduced from that specific document for each day it is late. You must also maintain a team lab notebook throughout the project that I will look at periodically.
- **Hardware Testing (25%):** Testing your systems in the anticipated flight environment is a necessary step before actually flying your balloon. There are several sets of tests that must be completed before I will sign off on the balloon being launched. You will document each test on a website or blog that you create and maintain.
- **Launch (20%):** While a successful launch is highly desired, it is not necessary in order to receive maximum points here. I am looking for teams to be ready to launch at the beginning of the window, a detailed launch plan, to see if you are well prepared on launch day, that all of your tests are completed, a specification of your launch location, landing location, and todo check-list, and that the FAA has been notified. Aside from transportation of certain materials, you are responsible for handling all aspects of the launch smoothly, with minimal prompting from me.
- **Lab Stewardship (10%):** All teams must act responsibly in the lab. It is expected that teams keep their areas organized at all times, respect all of the equipment, and clean up their area when they are done with the semester.
- **Other (5%):** There are several deadlines for certain deliverables during the course, including 1) A Preliminary design, 2) HAM License Testing, and 3) Placing a PCB order. Failure to meet the deadlines for these things will result in points being deducted from your grade and possibly affect your ability to launch. In designing your PCB, we will order through [www.4pcb.com](http://www.4pcb.com). They use PCB layout software called **PCB Artist**. You will need to learn how to use this software. Additionally, if you do not order your PCB on the order date, you will be given a PCB that was designed by me.

## 6 Keys to a successful project

1. A complete record of the flight path, including latitude, longitude, and altitude will be recorded onboard.
2. A complete record of the temperature inside and outside of the package, the pressure, and the three-axis acceleration will be recorded on-board as well as transmitted to the ground station during the flight. Wind speed will be calculated from position measurements. All measurements should have a temporal resolution of 10 seconds or better.
3. Horizontal and vertical pictures recorded at least twice per minute. The cameras should be contained within the structure if at all possible.
4. Knowledge of the balloon's location maintained at least 80% of the time.
5. The balloon reaches an altitude of 100,000 ft.
6. The package is successfully recovered.