The Use of a Microcomputer in High-Powered Rocketry

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Abstract

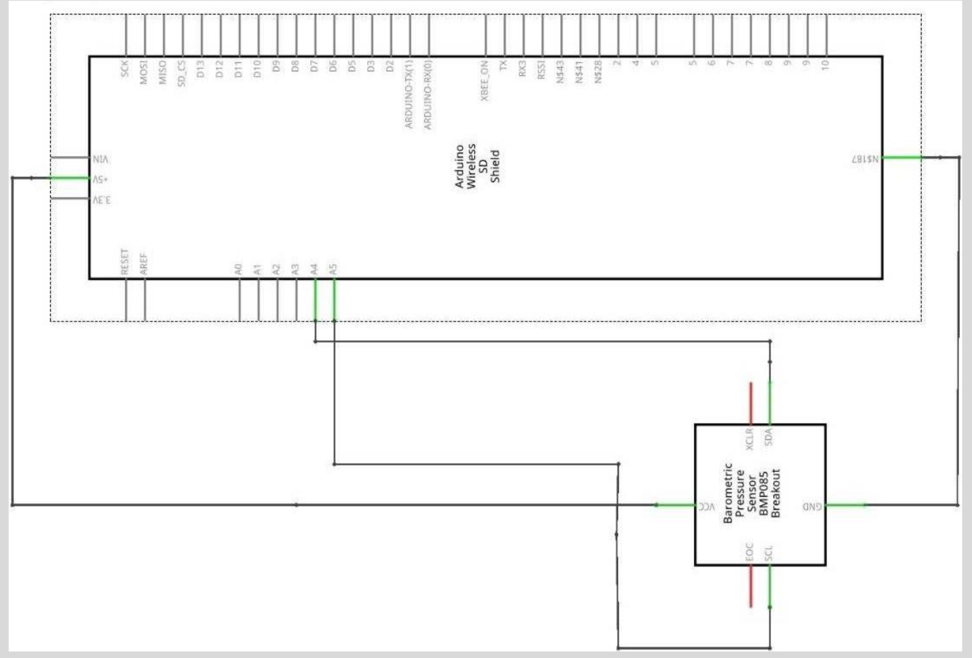
The main purpose of this project was to design, construct, and launch a rocket that included an Arduino Uno in the payload to record data during the flight. A BMP 085 and an SD shield were used with the Arduino to record temperature, atmospheric pressure, and altitude data. The whole process consisted of four main phases. The first phase was brainstorming the design of the rocket. The second phase was learning how to use an Arduino and programming it to record the correct data. The third step was to build the rocket. The last step was to launch the rocket and retrieve the data. The data recovered from the Arduino was proven reliable since the altitude calculated was similar to the altimeter placed in the rocket. The results indicate that the Arduino can be used as an affordable flight computer.

Introduction

A rocket was designed so that it would successfully be launched and recovered while carrying and protecting a payload designed to collect atmospheric data.

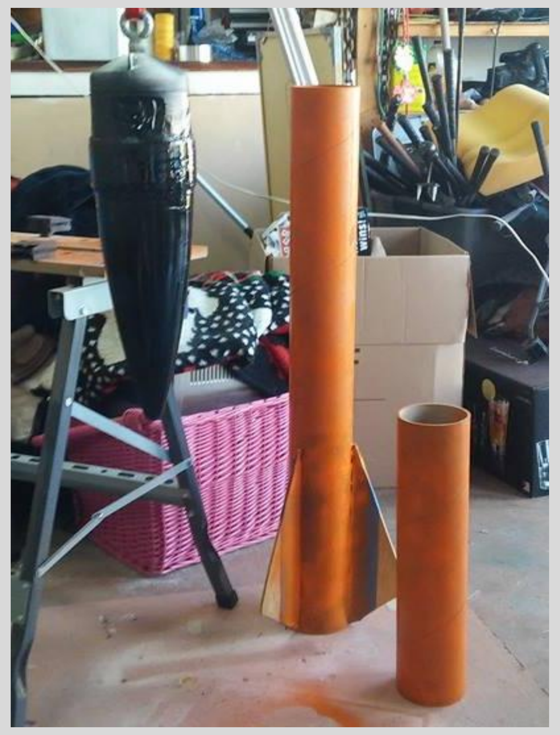
The payload was designed to hold electronic components in a way that they could withstand the forces during takeoff and impact upon landing. The electronic components include an Arduino Uno microcontroller, a microcontroller compatible Altimeter and an Arduino SD shield.

The Arduino microcontroller is in essence the core component of the payload bay as it acts as a small computer with designated code looping endlessly during its operations. The microcontroller runs on an integrated C++ language and can have any program running upon command. The altimeter is an atmospheric sensor that collects pressure, temperature, and altitude data from ground level. The altimeter was chosen so that it could be connected to, and powered by the Arduino Uno, who main role was to save the readings of the altimeter. The Arduino without any extensions is only capable of storing kilobytes of information which is only a few lines of information. To increase this potential, an Arduino SD shield was attached to allow saving the information onto a portable SD card.
The circuit schematics is shown below.

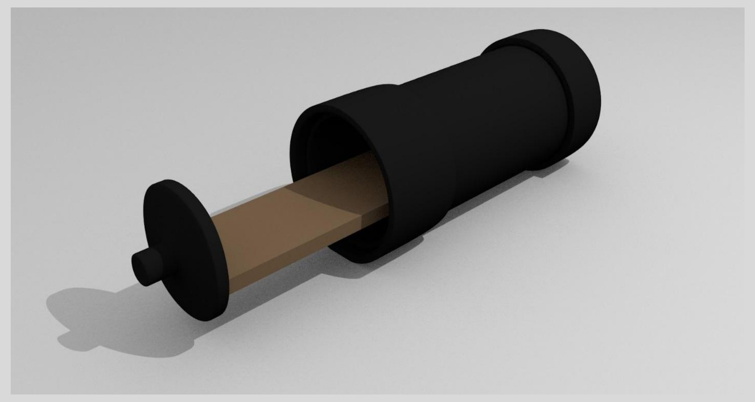


Experimental Methods

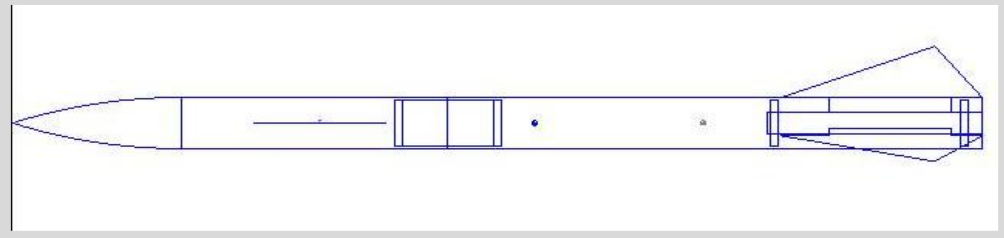
Rocket Construction



The body tube of the rocket was constructed using recycled materials. Plywood was used to construct the fins, bulk plate, and electronics bed. The data collection hardware, which included the Arduino, BMP sensor, and recovery altimeter (RRC2+), was housed on the hardware bay within the payload section.

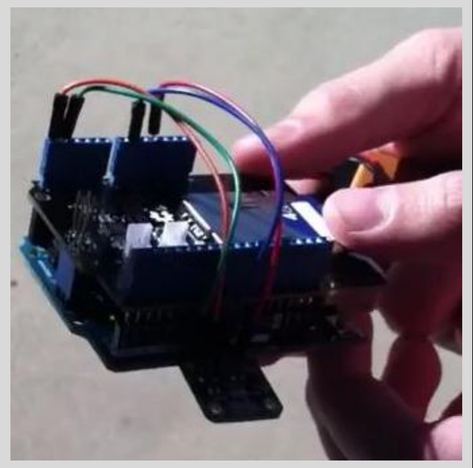


To secure this section of the rocket and prevent damage to the hardware, the payload bay was constructed using polyvinyl chloride (PVC), a rigid plastic. In addition, the Arduino and altimeter were secured to the electronics bed using plastic screws. The hardware bay was mounted within the payload tube, which also served as the coupler tube seen in the diagram below.



Experimental Setup

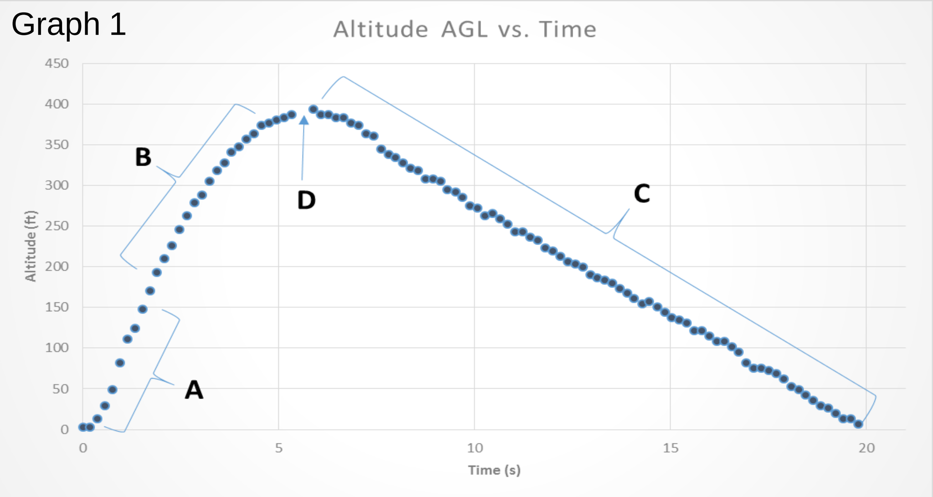
In order to collect data, the Arduino and BMP sensor were programmed using Arduino software. To ensure proper setup, the electronics were tested before flight by exposing the sensor and altimeter to changes in temperature and altitude (**scan the QR code at the bottom of the poster to see testing videos**).



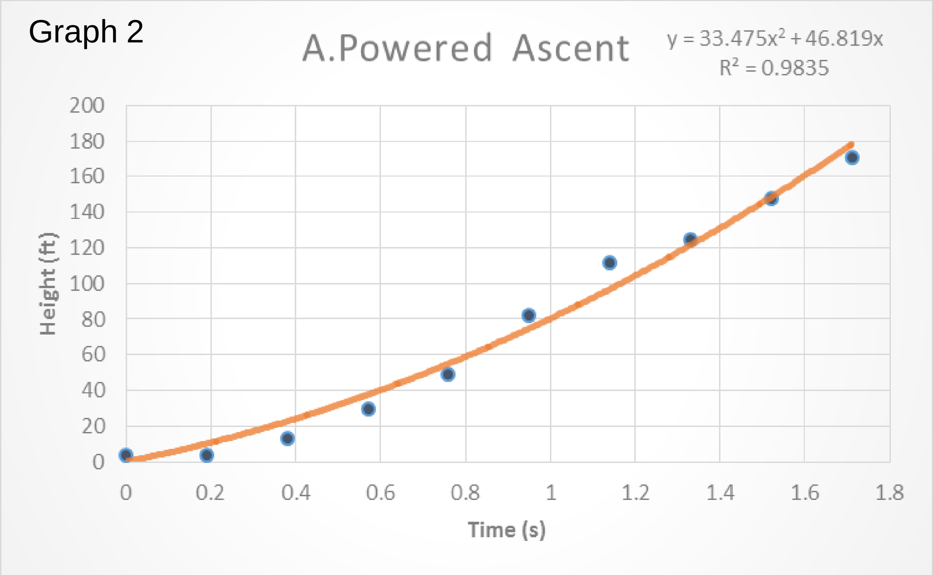
A match is used (right) to briefly increase temperature near the BMP sensor. An SD card (left) is used to collect pressure, temperature, and altitude data from the Arduino.

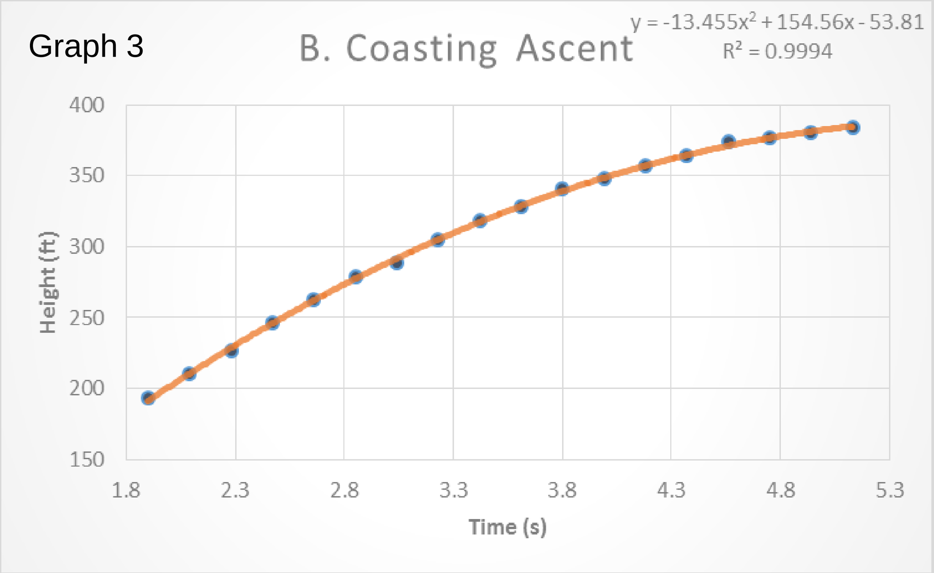
Results

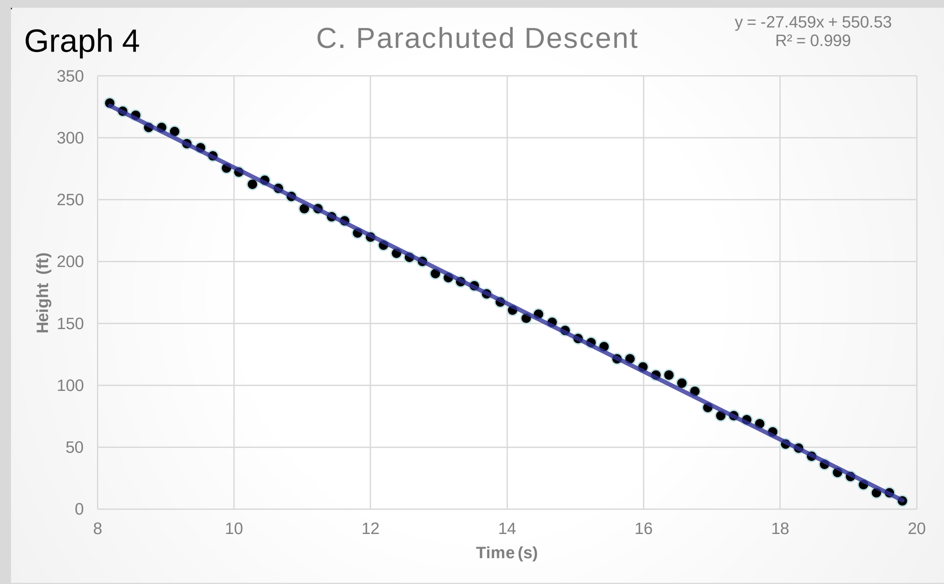
The altitude and time data collected by the Arduino and BMP sensor allowed for a detailed understanding of the rocket's flight. The rocket was in the air for 19.79 seconds, with apogee occurring at 5.89 seconds. The rocket's recovery altimeter, a RRC2+ recorded the maximum altitude of the rocket as 388 feet. The Arduino and BMP sensor recorded the same height which indicates the microcomputer and sensor are precise.



Graph 1 shows the altitude of the rocket for the complete flight, including the powered ascent (A), coasting ascent (B), apogee (D), and the parachuted descent (C). AGL is an acronym for above ground level.





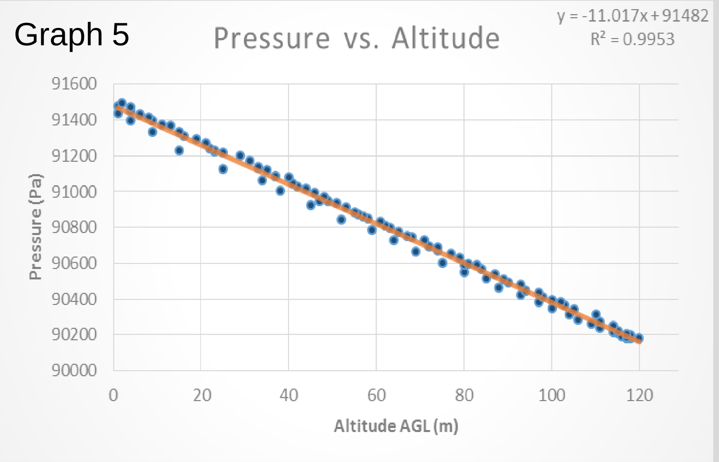


Graphs 2, 3, & 4 give a closer looks at each part of the rocket's flight. Both parts of the ascent could be modeled by parabolic equations while the parachutes descent is fitted by a linear equation.

In Graph 2, powered ascent of the rocket (via burning motor), there is a large increase in height over a short period of time. Graphically, the slope of the tangent line is the velocity, which increases over time, and the upward concavity further establishes that there is positive acceleration. The motion is represented by the quadratic function $y = 33.475x^2 + 46.819x$. The first derivative, $y' = 66.95x + 46.19$, represents the velocity function, and the second derivative, $y'' = 66.95$, represents the acceleration function.

In Graph 3, coasting ascent, the increase in altitude is similar to that of the powered ascent; however, the time over which this occurs is much greater. Graphically, the slope of the tangent line decreases over time, and the downward concavity indicates that there is negative acceleration. The motion is represented by the function $y = -13.455x^2 + 154.56x - 53.81$. The first derivative, $y' = -26.91x + 154.56$, is the velocity function, and the second derivative, $y'' = -26.91$, is the acceleration function. The rocket's velocity continues to decrease until it reaches zero, the rocket's apogee.

Graph 4 highlights the fact the parachute caused the rocket to descend at a constant velocity. The linear function fitted to this motion is $y = -27.459x + 550.53$ which puts the rocket's velocity at 27.459 ft/s vertically downward.



Graph 5 demonstrates the inverse relationship between altitude and atmospheric pressure. AGL stands for above ground level.

The BMP sensor also measured the pressure, and since the electronics bay was vented to the outside, it was determining the atmospheric pressure. As expected, there was an inverse relationship between the atmospheric pressure and altitude.

Conclusion

The Arduino Uno is an affordable replacement to commercial altimeters and flight computers for high powered rocketry. Generally, systems in the same price range as the Arduino Uno are only capable of deploying the parachutes and relaying the height at apogee.
The Arduino Uno and sensors used in this experiment provided data for the entire flight. The Arduino is capable of being the sole flight computer which can be customized with various shields and sensors needed for the mission.

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