# Introduction

A **projectile** is an object which is projected (thrown, flicked, blown, kicked, shot, ion-thrust, etc.) and then left alone to be acted on only by gravity. On earth, the movement of a projectile can be described by a quadratic function – a projectile’s current height depends on its starting height and the time that has elapsed since it began moving. (Assuming no air resistance or other complex physical considerations, like the Coriolis effect!)

*e.g.*, A rock which is dropped (not thrown) off a cliff which is 70 meters tall has a height function  which gives the rock’s height (in meters) depending on time  seconds after it is dropped:



The time  represents the instant that the rock is dropped, so the rock’s height at this moment is given by  meters. After  seconds in the air, the rock is at a height of  meters above the ground.

Note that the height function  only makes sense when both  and  are positive. Before the rock is dropped, its height is constant at 70 (maybe there is a crowd gathering to watch this rock fall, and a clock counting down to the time that it is released). After the rock hits the ground (when it has a height of 0) then it no longer makes sense to use this function  to get the height of the rock. For times after the rock hits the ground, the function  no longer gives the height, since it outputs negative values (as if the rock would burrow into the ground forever!). So the domain of this function begins with the  -value  and ends with the  -value when the rock hits the ground.

To find the last input for the function, we set  equal to 0 and solve for .

 

Note that because we introduced the square root into the problem, we should get seconds, but the function  doesn’t give the height if  is negative (remember the crowd waiting around while the rock stayed at a height of 70?). So we throw this negative -value out because the domain starts at 0.

The positive -value is the last time that makes sense, so the domain of  is .

## Note

This introduction is meant to serve as a model for the style of your report, especially with regards to the amount of explanation and the way calculations are interspersed with the explanations. Your actual problem is slightly harder.

# Assignment

Your group will submit one copy of your report, **including each group member’s birthday** (in the format MM/DD, like 11/05 for November 5th). The birthdays will be used to make your problem unique to your group. **You cannot start this problem until three members’ birthdays are known!** If you don’t want to share your real birthday, then use some other random day (i.e., make up a birthday so yours stays private).

## Report

Your assignment is to **fully describe, in paragraph form,** the path of a human cannonball, MAJ, who was shot from a cannon at the top of a tower. The cannonball was shot completely vertical (and the tower was moved out of the way to reveal a very safe pool to land in). You will examine MAJ’s height above the ground, which is modeled by



where is in feet, and  is in seconds since the cannon was shot. Note that the first coefficient is . The coefficients and  will be different for each group, generated in the following manner:

1.  is 33 plus the sum of **just three** of the days your birthdays (the DD parts).
2.  is 17 plus the product of **just two** of your birth months (you choose which two).

In the project include each group member’s birthday and the ones selected to form the function used in the project. In your report, **you must use an equation editor to show/explain your work**. You must have a written explanation of the mathematics behind each question below. You will essentially be writing an essay with embedded, detailed, algebraic explanations, like the example in the Introduction (except yours is harder).

**Do not** turn in handwritten work. **Your report will be typed, using an equation editor.  
Do not** use a graph to answer these questions**. Answers should use exact values.  
Do not** list/number your responses**. Your report will be in paragraph form.**

### Questions

1. How high above the ground is the tower?
2. When does MAJ hit the ground?
3. What is the domain of the model?
4. When is MAJ higher than 30 feet?
5. When does MAJ hit his highest height?
6. What is MAJ’s highest height?
7. What is a better way to write the function  so that the answers to #5 and #6 could be simply read off of its form, instead of calculated?

### Graph (included in report for reference)

Your report will also include a graph (probably from Desmos) of (for the times in the domain of ).

Your graph should satisfying all of the following:

* 1. Appropriate scale on axes
     1. Graph should take up most of the viewing window
     2. The whole graph should fit
  2. Axes have quantity and units labeled correctly
  3. Correct domain restriction on function, based on the real world limitations of the model
     1. Tip: In Desmos use braces { and } with an inequality on the input variable, like 
  4. All the important points on the graph are labeled to at least 2 decimal places (see questions 1-6).
     1. Tip: In Desmos, you can just enter  and it will draw a point there