# Projectile Motion-The Lab!

Russell Aguilar

## Purpose:
The purpose of this lab is to study projectile motion, starring Sean Prentiss' arm the projectile launcher, a tennis ball as the projectile, and a Macbook equipped with a digital video camera and Logger Pro installed. We filmed and analyzed the motion of a thrown projectile with the video (see below).

## Background:
A projectile is an object propelled through the air. Here we studied the motion of a projectile, specifically a tennis ball. Projectiles move in parabolas, forced upward at first by whatever propels it and then downward by gravity, all the while going away from where it was launched.

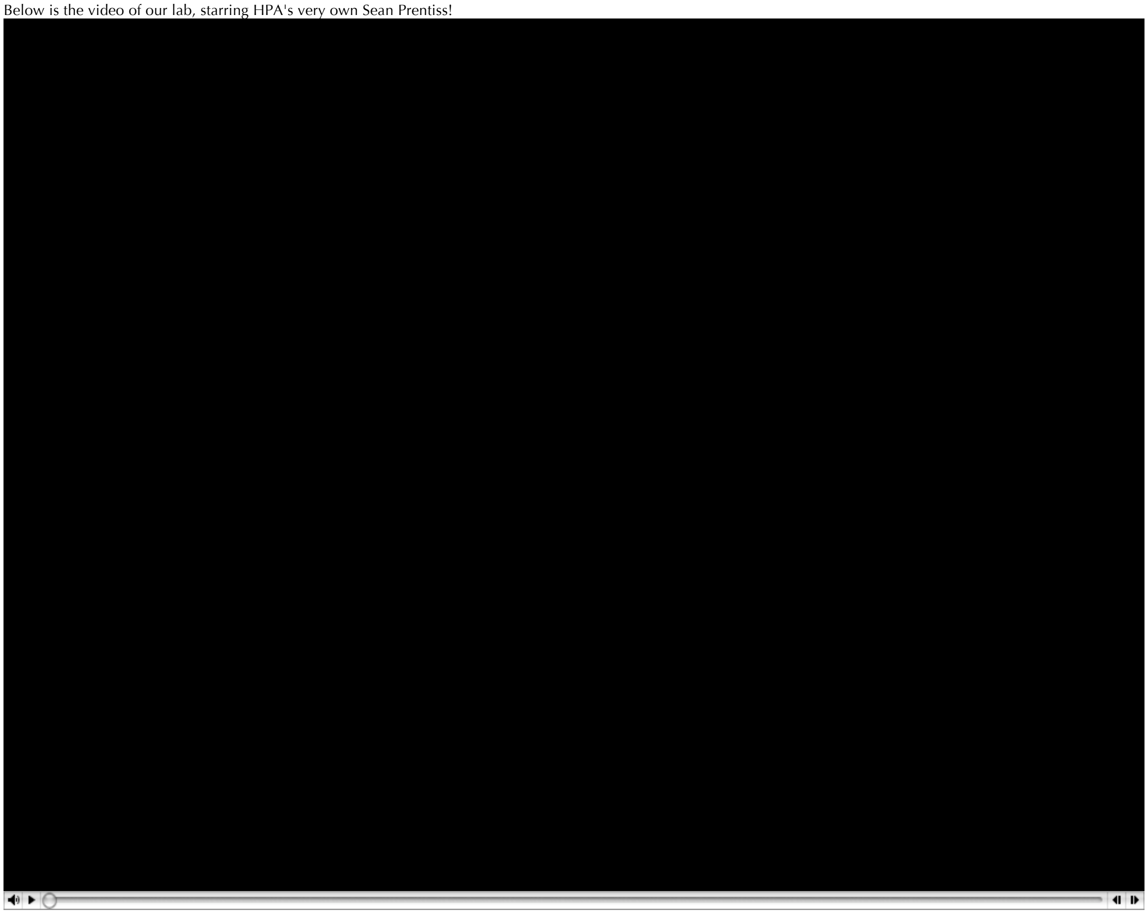
## Formulas And Constants:
The most important formula for projectiles is range=(original velocity]/gravity)*sine(2ø). Here on Earth, the value for gravity is always -9.8 meters per second.

## Materials:
One Macbook with a working built in camera with the application Logger Pro installed.
One tennis ball.
One meter stick.
Two physicists.

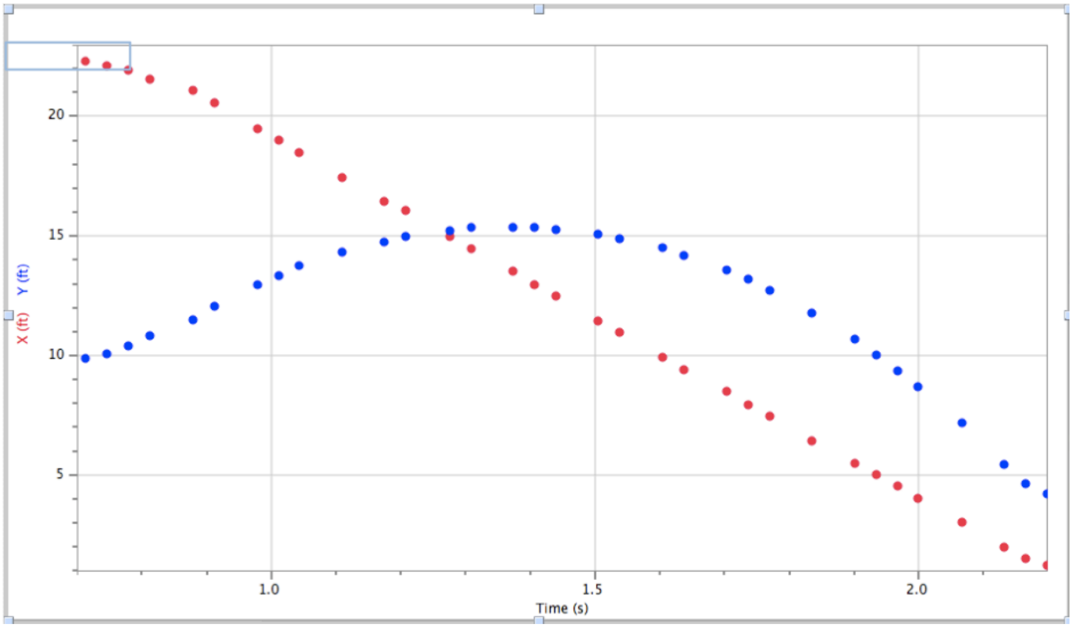
## Procedure:
Step One: Power up the Macbook and open Logger Pro. Go to the "Insert" tab and click "Video Capture". You should see yourself displayed on the screen, from your built in camera, and there should a button on the sides that says "Start Capture".
Step Two: Find an open space in which to film your capture of projectile motion.
Step Three: Go out into the range of the camera and place the meter stick on the ground so you can see its full length on the camera display.
Step Four: Press the "Start Capture" button and have one of your physicists take the tennis ball and throw it in an arc so as that it both starts and hits the ground within the frame of the camera. Once the ball has hit the ground, press "Stop Capture", which will have taken the place of the "Start Capture" button.
Step Five: Once you have an appropriate video capture of the projectile motion, take it into the lab and graph the motion of the ball with dots in Logger Pro.
Step Six: Analyze your data.

## Data:

Below is the video of our lab, starring HPA's very own Sean Prentiss!



Below is the graph of the projectile's movement. The series of red dots represent acceleration, while the blue dots represent distance, or height in meters.

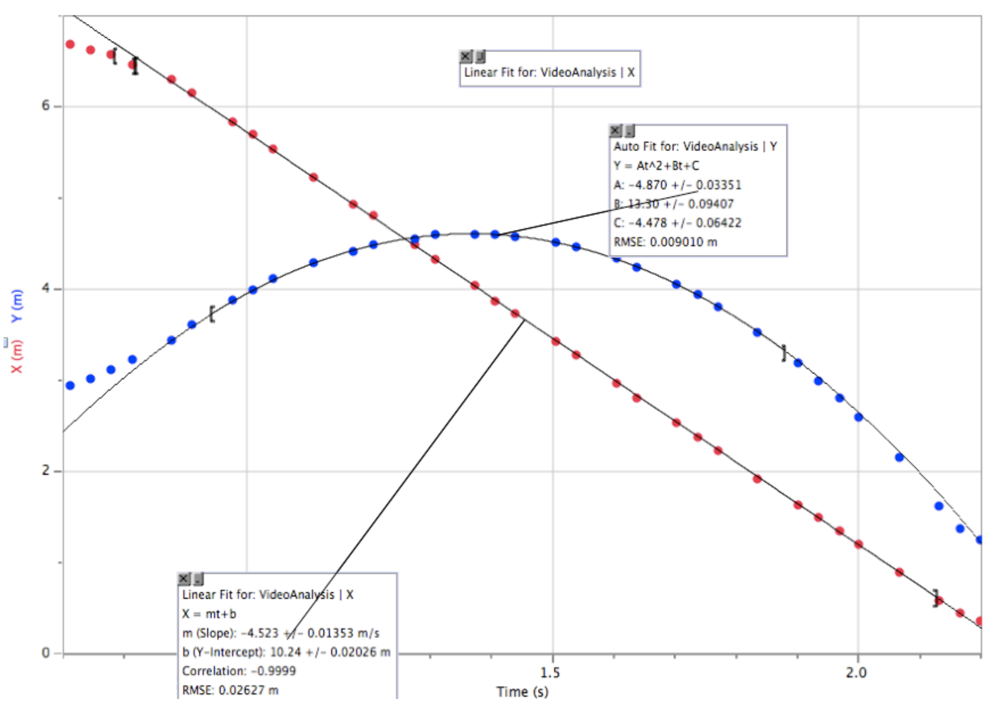



Below is our data table.

| | Time (s) | X (ft) | Y (ft) | Vx (ft/s) | Vy (ft/s) |
|---|---|---|---|---|---|
| 1 | 0.7133 | 22.30 | 9.855 | -5.788 | 7.622 |
| 2 | 0.7467 | 22.12 | 10.08 | -6.434 | 8.949 |
| 3 | 0.7800 | 21.94 | 10.40 | -8.098 | 10.658 |
| 4 | 0.8133 | 21.57 | 10.81 | -9.407 | 11.528 |
| 5 | 0.8783 | 21.06 | 11.50 | -11.276 | 12.677 |
| 6 | 0.9117 | 20.55 | 12.05 | -14.336 | 13.667 |
| 7 | 0.9783 | 19.49 | 12.97 | -15.167 | 12.884 |
| 8 | 1.012 | 19.01 | 13.33 | -15.403 | 11.551 |
| 9 | 1.043 | 18.50 | 13.73 | -15.662 | 9.705 |
| 10 | 1.110 | 17.44 | 14.32 | -15.319 | 7.934 |
| 11 | 1.175 | 16.45 | 14.76 | -14.680 | 6.584 |
| 12 | 1.208 | 16.05 | 14.98 | -14.879 | 4.748 |
| 13 | 1.275 | 14.99 | 15.20 | -15.545 | 3.471 |
| 14 | 1.308 | 14.44 | 15.34 | -15.350 | 1.929 |
| 15 | 1.373 | 13.49 | 15.38 | -15.305 | 0.395 |
| 16 | 1.407 | 12.94 | 15.38 | -15.303 | -1.442 |
| 17 | 1.440 | 12.47 | 15.27 | -15.264 | -2.922 |
| 18 | 1.505 | 11.45 | 15.09 | -15.296 | -4.095 |
| 19 | 1.538 | 10.97 | 14.90 | -15.344 | -5.799 |
| 20 | 1.605 | 9.911 | 14.50 | -15.383 | -7.412 |
| 21 | 1.638 | 9.399 | 14.17 | -14.855 | -9.222 |
| 22 | 1.703 | 8.485 | 13.55 | -14.930 | -10.412 |
| 23 | 1.737 | 7.937 | 13.18 | -15.181 | -12.561 |
| 24 | 1.770 | 7.461 | 12.71 | -15.124 | -14.455 |
| 25 | 1.835 | 6.438 | 11.76 | -14.895 | -15.752 |
| 26 | 1.902 | 5.487 | 10.66 | -14.520 | -17.224 |
| 27 | 1.935 | 5.012 | 10.00 | -14.509 | -18.915 |
| 28 | 1.968 | 4.537 | 9.380 | -15.120 | -20.708 |
| 29 | 2.000 | 4.025 | 8.685 | -15.472 | -22.733 |
| 30 | 2.067 | 3.001 | 7.185 | -15.323 | -24.107 |
| 31 | 2.132 | 1.978 | 5.429 | -14.763 | -24.349 |
| 32 | 2.165 | 1.503 | 4.624 | -12.658 | -20.705 |
| 33 | 2.198 | 1.210 | 4.185 | -10.493 | -16.602 |

Below is a still from the video showing the path of the projectile from our dot plotting.

Below is the graph of our data with lines of best fit: linear or quadratic equations that match the data as closely as possible.




## Observations:

The ball performed as we expected it to, it followed a parabolic arc. The acceleration, fastest at the beginning, is linear, as acceleration decreases the further the projectile gets from where the it was launched.

## Analysis:

The data you see here is fairly pure and representative of typical projectile motion. However, there is another story untold, a story of setbacks; glitches, and technological errors that would boggle the mind of the common man. One problem was finding an area with the proper conditions for doing the video capture: somewhere not too light to prevent glare, somewhere with a place to put the computer down high enough off the ground so we could keep it steady and capture the projectile motion from the right angle, and somewhere with enough space to throw the projectile. We eventually found a good spot, but then we were plagued with the problem of getting the right shot, with the projectile all-too-often flying out of the frame of the camera, or bouncing too short to provide meaningful results. Once we got all of this figured out, however, the computer ceased cooperating, giving us errors after an otherwise successful video capture and deleting our captures arbitrarily and with malice. After hours fixing these problems (and much gnashing of teeth), we finally got the capture you see above. Thankfully, there was little wind, and the sun was in a favorable position for our capture. Furthermore, there is a margin of error in this test, on account of the imperfection of man. It's impossible for whomever is graphing the dots to be exactly on target, so the graph and the data will be skewed every so slightly. Also, the frame rate of the camera left some to be desired, meaning there were gaps from which we could get no data. Lastly, there was air resistance in our test, of course, since it was not in a vacuum. Air resistance is not a factor in the equations, so there is a certain amount of difference there.

## Conclusion:

I conclude that despite many a mishap, we were able to demonstrate the motion of a projectile with a fair amount of accuracy. The results followed the formula fairly well, but not perfectly. There are quite a few things you could do to make this test more accurate. Using a camera with a much faster frame rate would help quite a bit, as you could track the projectile more accurately. You could do the test in a vacuum in order to remove the affects of air resistance and get purer data. Outside of a vacuum, anything you can do to minimize wind would help. Lastly, a program that automatically plotted the dots and graphed the motion of the projectile would make the data considerably more accurate. This would minimize human error if it worked correctly.