The purpose of this lab was to analyze the projectile motion of a ball using the displacement equation, and equations derived from it. The experiment performed was measuring the average range of the ball launcher shot the ball at a 0-degree angle on the short-range setting, then medium range, and calculating the initial velocity of both. This was done so that we could find the initial velocity of the ball for further experiments that we did not complete. With the data, we took the standard deviation of the range to analyze how consistently the launcher shot the same range. During our experiment, we did experience some errors caused by the launcher tipping further upward after each launch. This caused the angle being shot at to be greater than 0 causing measurements after the first trial to be slightly greater than they should have been. This caused errors in how v\_0x was calculated because the equation for time assumes that the angle is at 0 degrees.

Before starting the experiment we used a plumbob to find the zero point of our calculations, put a piece of paper down at the approximate range of the launcher to mark where the ball landed, then set up a measuring tape at the zero point to find the range that the ball shot. We then measured the height of the ground which came to be 1.165m so it could be plugged into the equation Delta y = v\_0y t + ½ (-g) (t^2), the displacement equation in kinematics. Using the Delta y equation assuming the launch angle was at 0 degrees (because sin 0 = 0, and v\_0y = v\_0 sin theta causing there to be no initial y velocity), the equation for time was derived as t = sqrt(2 Delta y/g). The reason this concept works is that if the initial velocity of y is 0 then the only acceleration acting on the ball in the y direction is gravity. Using this principle we can calculate the time it takes for gravity to pull the projectile down from height h, which will be the change in y when the ball lands. The equation for time would allow us to solve for v\_0x later in the lab. The main physics principles of the experiment were how time of flight and range relate to each other under projectile motion. Using the relationship between the two the initial velocity can be calculated.

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| **Short Range Table** | Trial 1 | Trial 2 | Trial 3 |
| Length (+/- .001 m) | 0.591 m | 0.612 m | 0.614 m |
| Initial velocity | 1.2126 m/s | 1.256 m/s | 1.315 m/s |

After the initial setup was done for the short-range we began the trials. The ball was shot at 0.591m for the first trial, 0.612m for the second, and 0.614m for the third, with an uncertainty of 0.001m. We then measured the from trial 1 to 3 that v\_x0 as approximately 1.21m/s, 1.26m/s, and 1.32m/s. The average initial velocity was 1.261m/s and the standard deviation was 0.0498m/s. This was done by solving for initial velocity x with the equation v\_0x = Delta x/t and then plugging in the equation for t derived from the Delta y equation. This means that the initial velocity of x on average had a 0.0498m deviation from the mean with the equation sqrt(Sigma (x\_n – x\_avg)^2). The average range was also calculated to be 0.606m.

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| **Medium Range Table** | Trial 1 | Trial 2 | Trial 3 |
| Length (+/- .001 m) | 0.956 m | 0.968 m | 0.969 m |
| Initial velocity | 1.962 m/s | 1.986 m/s | 1.988 m/s |

After completing all 3 trials for the short-range we performed the same setup for the medium range finding the displacement to be 0.956m, 0.968m, and 0.969 respectively with an uncertainty of 0.001m. Then using the same method for calculating the initial velocity in the short-range trials we calculated v\_0x as 1.962m/s, 1.986m/s, and 1.988m/s respectively, the average initial velocity x from the three trials was 1.979m/s and the standard deviation was 0.0145m/s. The average range was also calculated to be 0.964m from the 0 point. Then the standard deviation in initial velocity was calculated to be 0.0145m, some of which can be attributed to the cannon tipping after each trial.

In the end, this lab showed how range and time relate to each other under projectile motion. Using the range measured using the measuring tape and the equation for time derived from the change in y equation plugged into the velocity equation displacement/time we were able to calculate the initial velocity of x for each trial. It was found that the initial velocity was not entirely consistent. What was not expected was the difference in standard deviations in both trials which were 0.0498-0.0145=0.0353. This is unexpected because I assumed that the standard deviations should be similar but the medium-range trials were much smaller than the short-range because the standard deviation.