Lab IV: Projectile Motion Experimentation

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Abstract

In this experiment, the kinematic equations of motion in two dimension were used to calculate the behavior of an object with initial known velocity experiencing uniform acceleration in one dimension in order to test for uncertainty on the range measurement Δx_f by using the SDOM, the uncertainty of angle measurement $\Delta\theta$, the calculation of muzzle speed v_i and uncertainty in the muzzle speed Δv_i. In the first part of lab, a projectile steel ball was launched horizontally after applying the measurement of initial horizontal velocity v_{ix} and table height y_f to find the calculated range, R_A as an initial prediction. In the next section of lab, the launch angle θ and the range R_B were found in order to calculate muzzle velocities for three consecutive projectile motion trials launched from 45◦, 65◦ at two plunger clicks, and 80◦ at three plunger clicks. For each trial, fifteen trials were recorded, and the distance of the projectile was measured by taping down a strike sheet so the projectiles nominally landed in the middle of the sheet. For all the three different Mini Launcher configurations, Pasco Capstone was used to measure and record the steel ball's speeds. The value of R_A was calculated to be 0.297166m and the value of R_B was calculated to be 0.974582 m. Some sources of uncertainty in this lab include sampling error, due to the discrepancy on the velocity recorded for 45◦, 65◦, and 80◦. Typically, the velocity recorded was the same, except for a few times in each trial. With only fifteen trials recorded at each angle θ, it is hard to tell how the differences in the velocity come into effect. With a larger number of trials, it would be easier to tell how the velocity effects the final calculation for muzzle speed and the uncertainty in muzzle speed.

Data

Table 1: Projectile with an initial horizontal speed, v_{ix}

	Time (s)	Velocity (m/s)
Run 1	0.1452	0.6868
Run 2	0.148	0.6821
Run 3	0.144	0.6870
Run 4	0.145	0.6910
Run 5	0.1448	0.6915
Average	0.1454	0.68768

Table 2: Calculations for v_{ix}, y_f and R_A for a Projectile Launched Horizontally

Height of the table, y_f (m)	Initial horizontal speed v_{ix} (m/s)	Range of Projectile, R_A (m)
.915	0.68768	0.297166

Table 3: Projectile Motion Measured at θ=45◦

Velocity (m/s)	Distance (m)	Average Distance (m)	STDEV	SDOM
3.0984	1.076	1.080929	0.003385	0.000874
3.0984	1.076			
3.0984	1.078			
3.0984	1.079			
3.0984	1.08			
3.0984	1.08			
3.096	1.081			
3.0864	1.082			
3.0675	1.082			
3.0769	1.08			
3.0675	1.083			
3.0864	1.085			
3.0769	1.086			
3.0864	1.087			

Table 4: Projectile Motion Measured at θ=65◦ at 2 Plunger Clicks

Velocity (m/s)	Distance (m)	Average Distance (m)	STDEV	SDM
3.8911	1.36	1.373286	0.010291	0.002657
3.8911	1.358			
3.8911	1.361			
3.9901	1.366			
3.9901	1.369			
3.8911	1.37			
3.8911	1.37			
3.8911	1.38			
3.8911	1.386			
3.8911	1.38			
3.8911	1.39			
3.8911	1.387			
3.8911	1.374			
3.8911	1.375			

Table 5: Projectile Motion Measured at θ=80◦ at 3 Plunger Clicks

Velocity (m/s)	Distance (m)	Average Distance (m)	STDEV	SDM
5.1813	1.26	1.1405	0.037821	0.009765
5.1546	1.099			
5.1546	1.116			
5.1813	1.131			
5.1813	1.115			
5.1813	1.121			
5.1813	1.123			
5.1813	1.127			
5.1813	1.151			
5.1546	1.136			
5.1813	1.152			
5.1813	1.14			
5.1813	1.146			
5.1813	1.15			

Post-Lab Questions

1. In the first part of lab, the calculated range R_A was calculated by measuring the initial horizontal velocity v_{ix} and table height y_f. One possible source of error for the calculation of R_A could be because of the stability of the 25cm aluminum u-channel ramp. If the ramp became shifted or was unstable, then the calculation of R_A would be improperly calculated because the measurement of the table height would not be measured from the right area affecting measurement of table height y_f. Also, if the elevation of the ramp was not in the anticipated region of 2-4 cm and completely stable, the ball may not roll freely down the ramp or encounter unexpected friction from the sides of the ramp, thus making it roll down slower. This would affect the measurement of the initial horizontal velocity, and making the calculated range smaller. In order to calculate the initial horizontal speed v_{ix}, dual photogates were implemented so that after the steel ball rolled down the ramp, the ball rolls through the photogate plugged into channel 1 and then rolls through the photogate plugged into channel 2. A possible source of error could be the Pasco Capstones recognition of the photogate receptors in their proper order. If the photogate did not respond accurately to photogate one for example, the horizontal speed would be calculated as slower than expected. It is also important to recognize that calculation 10 assumes that air resistance is a negligible force because of the projectile motion. If air-resistance was to come into effect or play a role, the equation would no longer be completely accurate. For the first part of lab, I believe that the horizontal range R_A had the greatest effect on my results, because this was the measurement that was actually

used to anticipate the distance the ball would travel that was then tested for accuracy through direct experimentation.

In the second part of lab, a possible source of error could be the force applied to the launch string for each of the three consecutive trials. For instance at 45° for the short-range launch, only a gentle tug should have been applied as a form of force. In only a few trials, the velocity was larger than the nominal value, which is a source of sampling error that could affect the overall calculated muzzle speed on Mathematica. A greater force applied also in turn led to a source of error for the calculation of x_f of the steel ball, as a greater force led to a larger distance traveled by the small steel ball in the experiment. A larger distance traveled by the ball would affect the overall calculation of Δx_f by using SDOM. Another possible source of error in the uncertainty in the angle measurement of θ, that contributed to the overall calculation of Muzzle Speed v_i and Uncertainty in the Muzzle Speed Δv_i. The exact measurement of θ could have been off by a few degrees for the calculations if it was not perfectly stabilized on the table, affecting the overall results calculated in the experiment. For this experiment, I believe the muzzle velocity v_i held the greatest effect on the results, because it was affected by the range measurements and angle measurements. The muzzle velocity was affected by these sources that contained uncertainty in them, and was calculated along with the uncertainty in the muzzle speed.

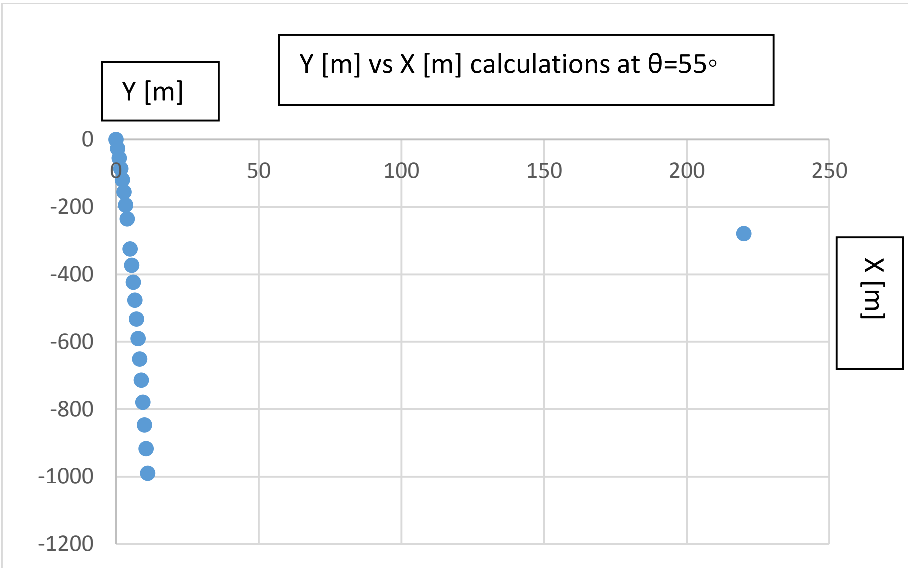
2.

Table 1: Solving for x [m] and y [m] when $\theta=55^\circ$ and $v_i=50$ m/s

v_i [m/s]	Theta [deg]	v_ix [m/s]	v_iy [m/s]
50	55	1.106338	-49.9878
time [s]	x [m]	y [m]	
0	0	0	
0.5	0.553169	-26.2189	
1	1.106338	-54.8878	
1.5	1.659507	-86.0066	
2	2.212676	-119.576	
2.5	2.765845	-155.594	
3	3.319013	-194.063	
3.5	3.872182	-234.982	
4	220	-278.351	
4.5	4.97852	-324.17	
5	5.531689	-372.439	
5.5	6.084858	-423.158	
6	6.638027	-476.327	
6.5	7.191196	-531.945	
7	7.744365	-590.014	
7.5	8.297534	-650.533	
8	8.850703	-713.502	

8.5	9.403871	-778.921
9	9.95704	-846.79
9.5	10.51021	-917.109
10	11.06338	-989.878

Chart 1: Plotting Y [m] and X [m]



This chart plots the y [m] and x [m] data for the data displayed in Table 1 when θ=55◦ and v_i=50 m/s.