DUTCHESS
COMMUNITY COLLEGE

Lab Report 5: Projectile Motion

PHY121

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Purpose

The purpose of this lab was to measure the distance of a metal ball shot from a spring loaded horizontally aligned "gun" before it hit the ground. We then used that distance to the calculate the ball's initial velocity and predict its distance when shot from the gun tilted at an angle.

Theory

Procedure

Horizontal Gun

1. Measured height of the gun above ground using a **meter stick**.
2. Fired gun, then measured distance travelled.
3. Marked where the ball landed on the ground with tape.
4. Repeaated steps 1-3, five times to calculate average distance.
5. With the average distance and height of the gun above the ground, used equations a & b to calculate the ball's time in the air and initial velocity.

Inclined Gun

6. Guessed where the ball would land, marking our expectations with tape.
7. Inclined gun to 40°.
8. Measured new height of the gun above ground.
9. Calculated expected time in the air and horizontal distance using the initial velocity found in step 5.
10. Marked expected distance on the ground with tape.
11. Shot ball from the angled gun five times.
12. Calculated average distance and standard deviation of trials in step 4.
13. Repeated steps 6-12 at a different angle.

Calculations & Graphs

Average Value Formula

$$\overline{a} = \frac{sum\,of\,values}{total\,\#\,of\,values}$$

Sample Calculation

average acceleration of free fall trials

$$\begin{aligned}\overline{a} &= \frac{9.751 + 9.758 + 9.749 + 9.620 + 9.769 + 9.837}{6} \\ &= \boxed{9.747\,m/s^2}\end{aligned}$$

Standard Deviation Formula

$$\begin{aligned}\sigma &= \sqrt{\frac{\Sigma(x_i - \overline{a})^2}{N}} \\ &= \sqrt{\frac{SS}{N}}\end{aligned}$$

N : Total number of values
$\overline{\mathbf{a}}$: Average value
$\mathbf{x_i}$: Each value from the data set
SS : Sum of squares

Sample Calculation

std of free fall trials

$$\begin{aligned}\sigma &= \sqrt{\frac{(9.751 - \overline{a})^2 + ... + (9.837 - \overline{a})^2}{6}} \\ &= \sqrt{\frac{0.024865333}{6}} \\ &= \boxed{0.06439\,m/s^2}\end{aligned}$$

Relative Error Formula

$$RE = \left| \frac{V_A - V_E}{V_E} \right| \text{ x } 100\%$$

$\boldsymbol{V_A}$: Actual value observed
$\boldsymbol{V_E}$: Expected value

Sample Calculation

acceleration of free fall trial 1

$$RE = \left| \frac{9.751 - 9.80}{9.80} \right| \text{ x } 100\%$$
$$= \boxed{0.4917\%}$$

Free Fall

Trial 1

Time(s)	**Velocity(m/s)**
0.0532	1.199
0.08952	1.553
0.1189	1.841
0.1444	2.087
0.1671	2.31
0.1878	2.513
Average Acceleration (m/s^2)	9.751

Table 1: Velocity vs Time — Free Fall Trial 1

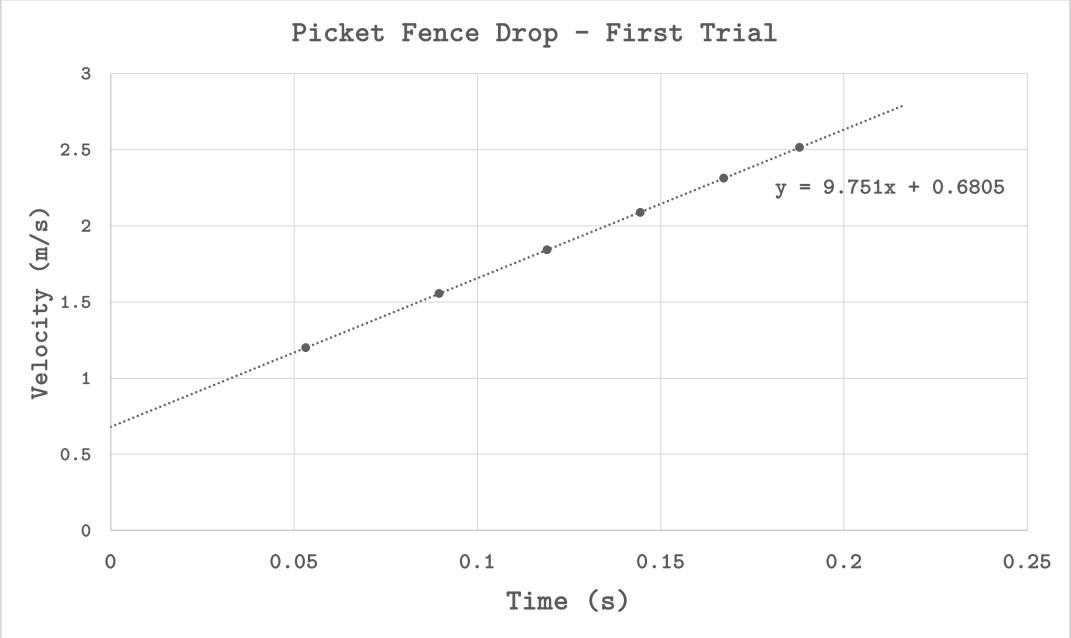

Figure 1: Velocity vs Time Graph — Free Fall Trial 1

Trials 1-6

Trials	Acceleration	Relative Error (%)
1	9.751	0.4917
2	9.758	0.4271
3	9.749	0.5108
4	9.62	1.829
5	9.769	0.3135
6	9.837	0.3877
Average (m/s^2)	9.747	
Standard Deviation (m/s^2)	0.06439	

Table 2: Free Fall Acceleration — Trials 1-6

Inclined Plane

Plane Angle

$$sin\theta = \frac{\Delta h}{D}$$

$\boldsymbol{\Delta h}$: height of the track at two points = $\boxed{.01870\,m}$

D : distance along the track between two points = $\boxed{.3\,m}$

$sin\theta = 0.0623 = \boxed{3.57^\circ}$

Acceleration Vector on Incline Plane

$$a = gsin\theta$$

g : Acceleration due to gravity on Earth = $\boxed{9.80\,m/s^2}$

sinθ : Angle of track

$$a = gsin\theta = \boxed{-.6105\,m/s^2}$$

Starting From The Top - Trial 1

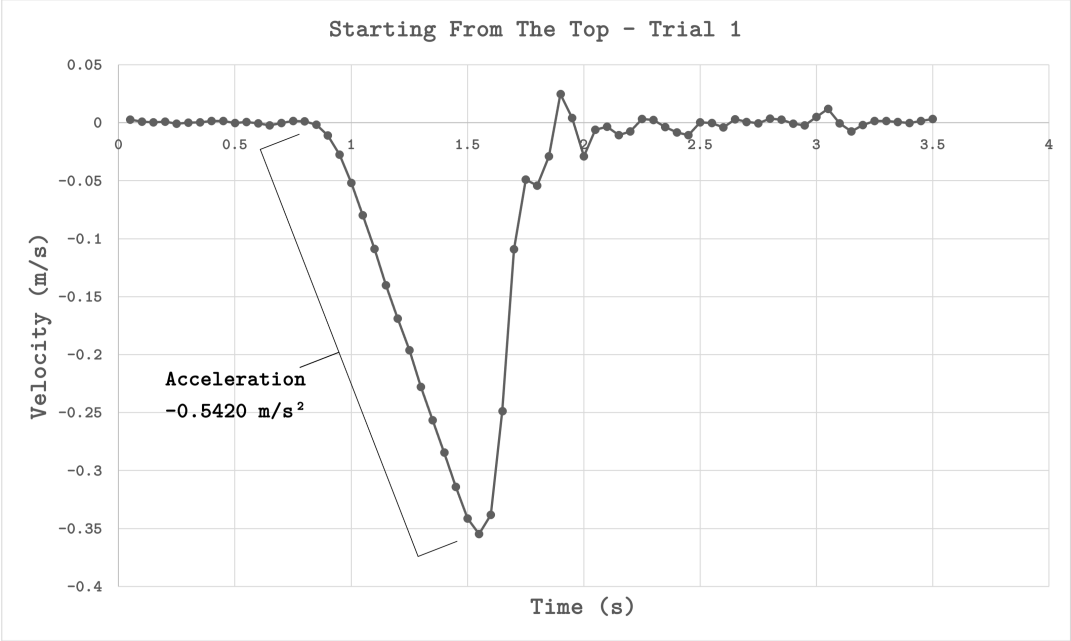

Figure 2: Starting From The Top Graph — Trial 1

Starting From The Top - Trials 1 - 4

Trials	Acceleration	Relative Error (%)
1	-0.542	11.22
2	-0.5315	12.94
3	-0.529	13.34
4	-0.5244	14.1
Average (m/s^2)	-0.5317	
Standard Deviation (m/s^2)	0.006455	

Table 3: Starting From The Top — Trials 1-4

Starting From The Bottom - Trial 1

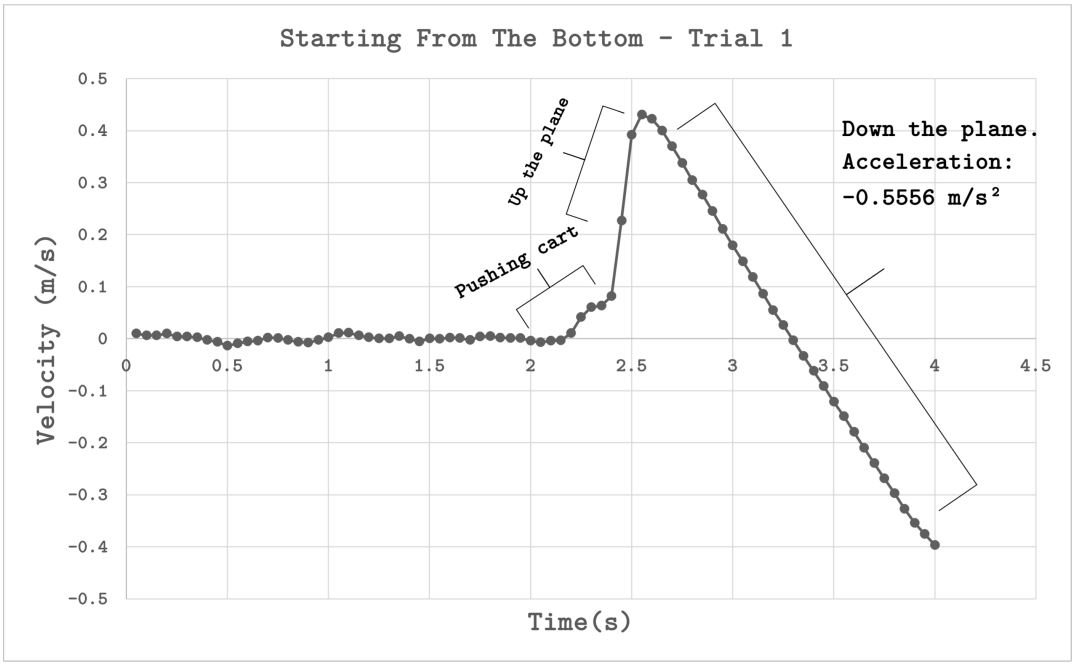

Figure 3: Starting From The Bottom Graph — Trial 1

Starting From The Bottom - Trials 1 - 4

Trials	Acceleration	Relative Error (%)
1	-0.5556	8.992
2	-0.5755	5.733
3	-0.5622	7.911
4	-0.5639	7.633
Average (m/s^2)	-0.5643	
Standard Deviation (m/s^2)	0.007171	

Table 4: Starting From The Bottom — Trials 1-4

Incline Plane Averages - Relative Error

	Acceleration (m/s^2)	Relative Error (%)
SFTT	-0.5317	12.9
SFTB	-0.5643	7.567

Table 5: Inclined Plane Averages — Relative Error

Conclusion