Lab Report 2: Investigating the relationship between horizontal displacement and falling distance in projectile motion.

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September 17, 2024

1 Raw data

Diameter of the ball $d' = 1.580 \pm 0.005cm$

Trial	**Photogate passing time** $t(ms)$	**Height** $h(cm)$	**Horizontal displacement** $d(cm)$	
1	17.13 ± 0.01	77.7 ± 0.5	33.7 ± 0.5	33.4 ± 0.5
2	17.80 ± 0.01	40.2 ± 0.5	23.2 ± 0.5	23.3 ± 0.5
3	17.17 ± 0.01	31.8 ± 0.5	20.2 ± 0.5	20.6 ± 0.5
4		28.6 ± 0.5	19.6 ± 0.5	19.1 ± 0.5
5		26.3 ± 0.5	19.3 ± 0.5	19.6 ± 0.5

Table 1: Raw data

2 Processed data

Average photogate passing time $\bar{t} = 17.37(\pm 1.93\%)ms$.

Initial velocity $v = \frac{1.580}{17.37} = 0.091cm/ms = 0.91m/s$.

Velocity error $\Delta v = \pm(1.93\% + 0.32\%)v = \pm 0.02m/s$.

Trial	**Avg. horizontal disp.** $\bar{d}(cm)$	**Error** $\Delta\bar{d}(\%)$	**Height squared** $d^2(cm^2)$	**Error** $\Delta d^2(cm^2)$
1	33.55	0.44	1125.6025	10.065
2	23.25	0.21	540.5625	2.325
3	20.5	0.48	420.25	4.1
4	19.35	1.29	374.4225	9.675
5	19.45	0.77	378.3025	5.835

Table 2: Processed data

3 Sample working

Take the wroking process of trial 1 data as an example. We can find

$$\begin{aligned}
&\bar{d} = \frac{d_1 + d_2}{2} = \frac{33.7cm + 33.4cm}{2} = 33.55cm \\
&\Delta\bar{d} = \pm\frac{|d_1 - d_2|}{2} = \pm\frac{33.7cm - 33.4cm}{2} = \pm 0.15cm \\
&\%\Delta\bar{d} = \frac{\Delta\bar{d}}{\bar{d}} = \pm 0.44\% \\
&\bar{d}^2 = 1125.6025cm \\
&\%\Delta(\bar{d}^2) = 2\%\Delta\bar{d} = \pm 0.88\% \\
&\Delta(\bar{d}^2) = 0.88\% \times \bar{d}^2 = \pm 10.065cm
\end{aligned} \tag{1}$$

Where $\bar{d}$ is the average value of d, $\%\Delta$ refers to the percentage uncertainty of the following variable and Δ refers to the absolute uncertainty of the following value.

4 Diagram

$\bar{d}^2$ alongside with its error is plotted against h, the graph plotted is shown in Figure 1.

Linear fit is used to find the relationship between d^2 and h. A linear fit of $15.00h - 46.06 = d^2$ is found.

5 Analysis and conclusion

We can find in our previous hypothesis that

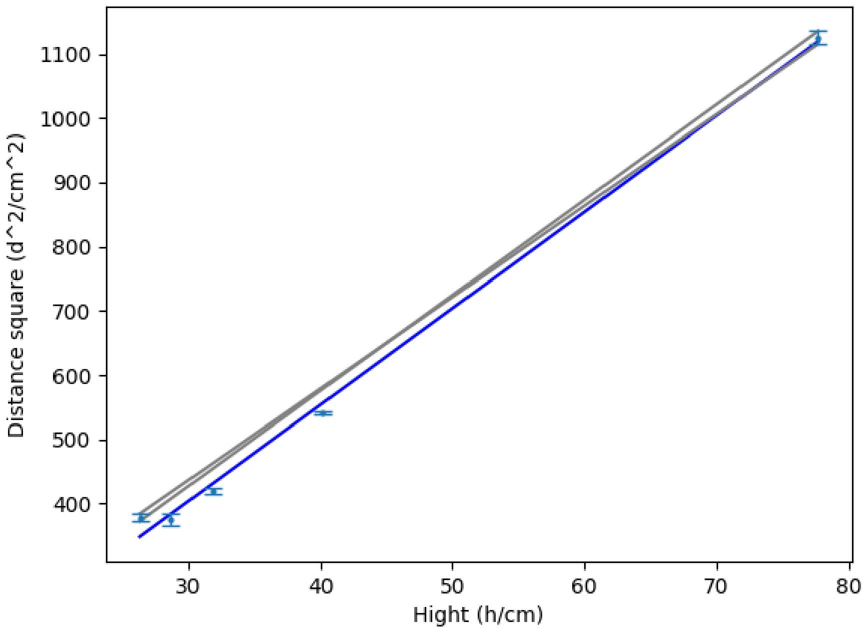

Figure 1: $d^2 - h$ graph

$$d^2 = \frac{2v_0^2}{g}h \tag{2}$$

as d and h are in centimeter, $\frac{2v_0^2}{g}$ should be $0.1500m$.

According to our measurement of d', the measured $\frac{2v_0^2}{g}$ is $0.169 \pm 0.008m$.

The calculated value shows a percentage error of $\frac{|0.15-0.161|}{0.161} = 6.83\%$. This is an error within a reasonable range.