Penny Drop Lab

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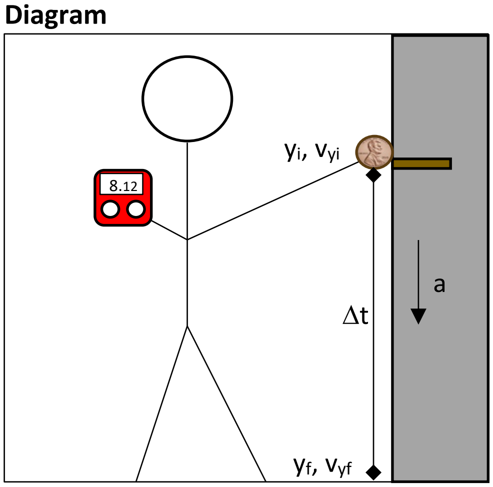
Introduction

The purpose of this lab was to design an experiment using a penny and stopwatch to determine the acceleration of gravity based the curve of best fit from the graphed data. The researchable question was: how does increasing the height above ground (h) from which a penny at rest is dropped affect the time it takes to fall that distance (t)? If the height above the ground increases, then the time it takes for it to reach the ground increases, where $\sqrt{h} \propto t$.

Procedure and Materials

Raheel measured the height, put down tape and marked the height. Daniel held the 1979 penny to the wall using his fingernail, the bottom of the penny being at the marking, and counted "3,2,1, go" in his head. He dropped the penny on go while starting the timer. Once he saw and heard the penny hit the ground he stopped the timer, and Ryan and Smita recorded the times. This was done at 5 different heights with 10 trials at each height.

Diagram



Constants and Equations

v_{yi}=0m/s
y_f = 0m
y_i = h
a_y=-9.81 m/s^2

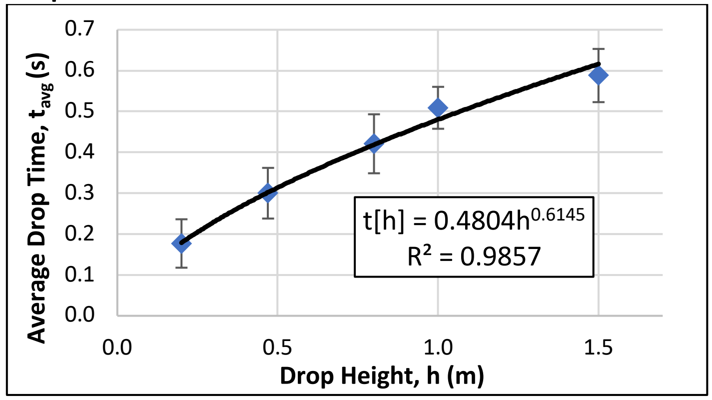
$$y_f = \frac{1}{2}a\Delta t^2 + v_{iy}\Delta t + y_i$$

$$\Delta t = \sqrt{\frac{-2\Delta y}{a_y}}$$

Data Summary

h	t_{avg}	SD	%RSD	t_T	|%err|
(m)	(s)	(s)	of t_{avg}	(s)	of t
0.200	0.18	0.06	33.48	0.20	12.34
0.470	0.30	0.06	20.67	0.31	3.08
0.800	0.42	0.07	17.14	0.40	4.25
1.000	0.51	0.05	10.08	0.45	12.73
1.500	0.59	0.07	11.07	0.55	6.33
		Avg	18.49	Avg	7.75

Graph



Analysis

The precision of the measurement was low, especially for the lower heights, as the average %RSD was 18.49%. The percent error from calculated theoretical times was 7.75%, making the collected data moderately accurate. The mathematical model was strong, as the R^2 value was 0.9857. The equations of best fit, for both raw and linearized data, allowed acceleration to be derived using kinematic equations. The coefficient in the power function as well as the exponent were 0.4804 and 0.6145 respectively, and using this acceleration is calculated to be -6.59m/s^2. The y-intercept is 0 for this power equation correctly signifying the 0s fall time at y_i=0m . The percent error was 33% for the non-linearized acceleration, which makes the accuracy of the acceleration low. Using the linearized line of fit, where the slope is equal to $2/g$, gravity was found to be -7.96m/s^2, which has a percent error of 19%. This value is closer to -9.81m/s^2, but still has significant deviation from the actual value, and the equation itself did not have a y-intercept of 0 due to the *b* value being 0.0187.

Conclusions

The results do somewhat support the hypothesis that the square root of the height is directly proportional because the exponential value of the power function is 0.6145, which is near 0.5, however, as the deviation in the exponent is 22.9%, the hypothesis is not fully supported, and is somewhat disproven. This conclusion is supported by the 33% deviation in acceleration, which if they were directly proportional would have been 0%. Outside of humans, sources of error include air resistance, as well as lag in the electrical timing of stopping the stopwatch. There is also the delay of human reaction time, and this results in slightly increased times for some y_i values. Future extensions could include accounting for air resistance and using a light-gate sensor to record the time, which would allow for a more accurate acceleration to be calculated.