Penny Drop Lab Report – Planet Earth

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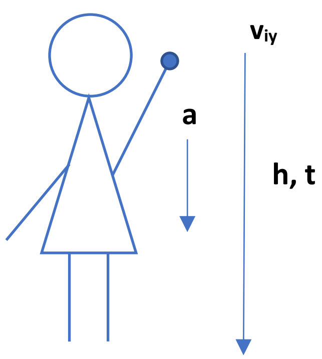
Introduction

The purpose of this lab is to design an experiment using a penny and stopwatch to determine a constant for the acceleration of gravity from the curve of best fit of the graphical data. The researchable question was, how does changing the height from which a penny falls affect the duration of the fall? The hypothesis is that as the vertical distance between the penny and the floor increases, the time at which it takes to hit the floor will increase, where t is proportional to the $\sqrt{h}$.

Procedure and Materials

Using a meter stick, tape was used to mark six different heights, spanning vertically, alongst a doorframe. At each height, between 0.25 and 1.75 meters, Stephen dropped a 3.13g penny at rest. The penny was dropped parallel to the floor, without any surface contact between it and the doorframe. To minimize error, Stephen simultaneously initiated a handheld timer as he dropped the penny in his other hand. The moment Stephen saw and heard the penny come into contact with ground, he paused then timer. The timer was reset, and this procedure was carried out ten times for every height while the data was annunciated and recorded by the other group members.

Diagram



Constants and Equations

$m_p = 3.13$ g
$v_{iy} = 0$ m/s
$y_i = h$
$y_f = 0$ m
$a_T = -9.8$ m/s^2

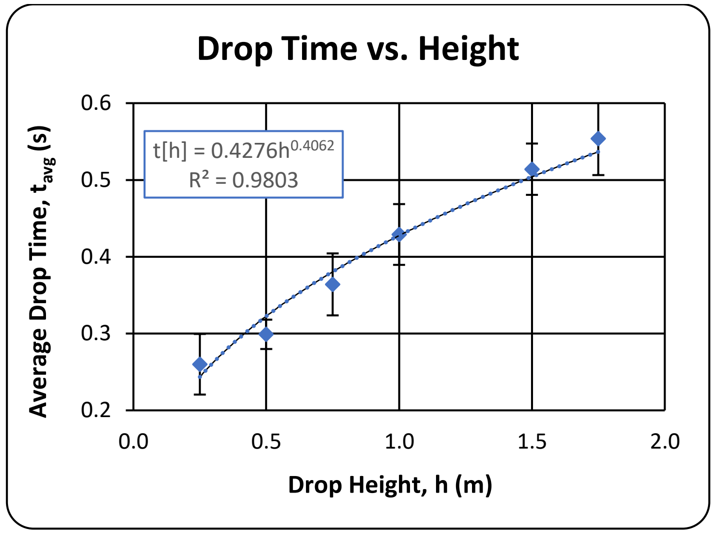
$$y_f = \tfrac{1}{2}at^2 + v_{iy}t + y_i$$

$$t_T[h] = \sqrt{\frac{-2h}{a_T}}$$

Data Summary

h (m)	t_{avg} (s)	STDEV (s)	%RSD of t_{avg}	t_T (s)	|%err| of t
0.250	0.26	0.04	15.17	0.23	15.11
0.500	0.30	0.02	6.39	0.32	6.40
0.750	0.36	0.04	11.08	0.39	6.96
1.000	0.43	0.04	9.22	0.45	5.04
1.500	0.51	0.03	6.50	0.55	7.10
1.750	0.55	0.05	8.60	0.60	7.30
		Avg	**9.49**	Avg	**7.99**

Graph



Analysis

The higher average relative standard deviation is 9.49%, indicates that the precision of the recorded times is low. In addition, the average percent error between the theoretical and average times is 7.99%, which shows that the accuracy is also low. However, the R^2 value of 0.9803 for the power function of the graphical data indicates the model is strong. The model can be used to derive a value for the acceleration based on the actual equation for $t_T[h]$ and the coefficient/slope 0.4276 in the function, which equals $(2/a)^{0.4062}$. The acceleration is -16.19 m/s^2, its magnitude is 6.9 m/s^2 greater than the actual acceleration of gravity. In addition, the x and y intercepts of the graph equate to 0 since a penny on the floor takes zero seconds to get there. There is no maximum in the model, increasing the height will always increase the time that it takes the penny to hit the floor. The greatest %RSD (15.17) and %error (15.11) was at the lowest recorded height of 0.250 meters due to the smaller theoretical time, which required more accuracy.

Conclusions

The hypothesis was affirmed by the model and the data- increasing the height of the penny does increase the amount of time it takes for the penny to reach the ground. The exponent 0.4062 n the model is close to the predicted exponent of 0.5, for $\sqrt{h}$. Nonetheless, it supports the hypothesized trend. A source of error within the data collection includes the small range in height. This would've maximized the effect of human and experimental errors due to the need for greater accuracy, and thus influenced the theoretical acceleration -16.19 m/s^2, which is a result of the lower average times compared to the actual theoretical ones. Another non-human source of error is drag from air resistance, however this would increase the percent error, since the theoretical time is already greater than the average recorded times. As a follow up to this lab, future extensions that use data from greater heights or examine the effects with initial velocities could be carried out.