Penny Drop Lab

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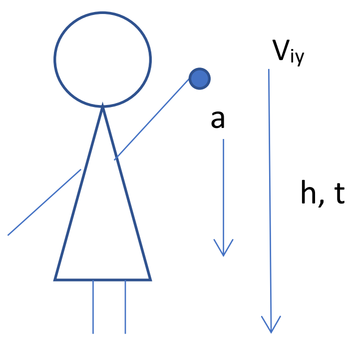
Introduction

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. How does increasing the height above ground a penny is dropped affect the time the penny takes to reach the ground? The hypothesis for this experiment was if drop height increases then time taken for the penny to hit the floor will also increase; $t \propto \sqrt{h}$.

Procedure and Materials

Saaya Daga dropped a 2005 penny, held horizontally, from varying heights to the ground. A piece of paper was placed on the ground to help Jessica Taubert both see and hear the time at which the penny hit the ground to increase the level of precision of data. Karisma Lavana would count down from three and on the word one, Saaya Daga would drop the penny and Jessica Taubert would start the timer. When Jessica Taubert would hear the penny hit the ground, she would stop the timer and Karisma Lavana would record the data in her notebook. These trials were repeated 10 times per height for 5 different heights marked with tape. The heights were measured using a meter stick.

Diagram



Constants and Equations

$m_p = 2.47$ g
$v_{iy} = 0.00$ m/s
$y_i = h$
$y_f = 0.00$ m
$a_T = -9.80$ m/s^2

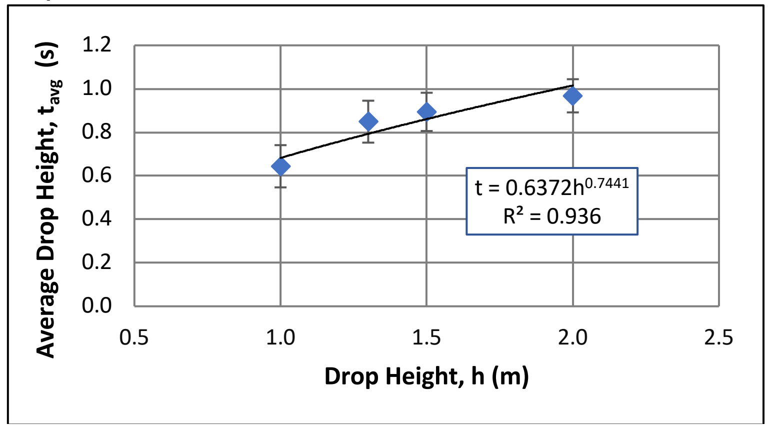
$$y_f = \frac{1}{2}at^2 + v_{iy}t + y_i$$

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

Data Summary

h (m)	t_{avg} (s)	STDEV (s)	|%RSD| of t_{avg}	t_T (s)	|%err| of t
0.500	0.37	0.05	13.51	0.32	14.26
1.000	0.64	0.10	15.63	0.45	42.56
1.300	0.85	0.10	11.76	0.52	64.83
1.500	0.89	0.09	10.11	0.55	61.58
2.000	0.97	0.08	8.25	0.64	51.52
		Avg	**11.85**	Avg	**46.95**

Graph



Analysis

The acceleration due to gravity was found to be -3.663 m/s^2 using the slope of the graph depicted above. The data depicted low precision because the average |%RSD| value of the graph was 11.85%. It had low accuracy with an average % error of 46.95%. The R^2 value was moderately strong at 0.936 and was indicative of the fact that the line of best fit above did not explain over 6% of the data. The curve of best fit approximately equals ½ times the square root of the height which, in the data depicted above, refers to the equation $t = 0.6372h^{0.7441}$. The exponent value of 0.7441 was theoretically anticipated to have a value of 0.5. The slope of the linearized data represents -2 divided by acceleration. As the y-intercept was set at 0, this means that h = 0.00 m and t = 0.00 s. The model does not predict a maximum height or time meaning that time will continue to be proportional to the square root of the height for an infinite number of heights. Additionally, gravity will act on the penny with the same acceleration for any given height. All time averages were larger than theoretical times by a difference ranging from 0.05 s – 0.34 s. This model was additionally linearized with a t^2 vs. height graph. This graph was used to calculate an acceleration due to gravity of -3.552 m/s^2.

Conclusions

The conclusion reached after conducting this experiment was that time increased as $\sqrt{h}$ increased on average. However, this data is not perfectly proportional. Meaningful sources of error included from where the penny was dropped, adhesion between the penny and a finger, and human error. As the penny was dropped from a starting point against a wall, friction between the penny and wall could have impacted time to ground. Additionally, the penny might have hit the wall, giving it velocity in the x-direction. Another source of error could have been the penny sticking to Saaya Daga's finger as she dropped it. Finally, the biggest source of error is human error as reaction time could have varied between trials, impacting time. The recorded times were higher than time theoretical by a difference ranging from 0.05 s – 0.34 s. Additionally, the value found for the acceleration due to gravity was significantly different than the expected value of -9.8 m/s^2. Extensions could be measuring velocity at different points during the penny's fall or looking at projectile motion.