Penny Drop Lab

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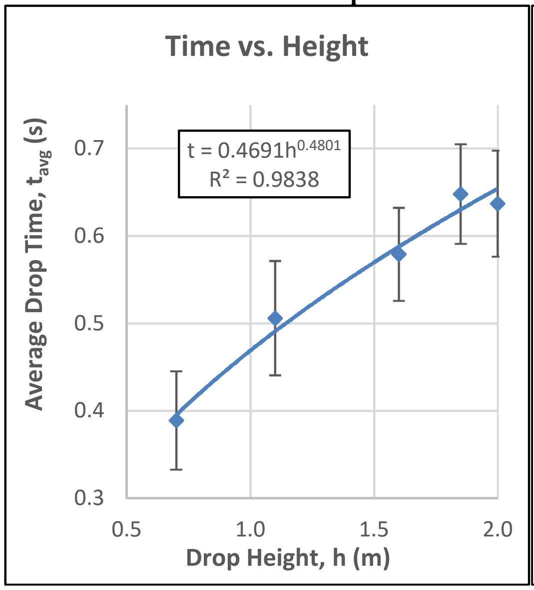
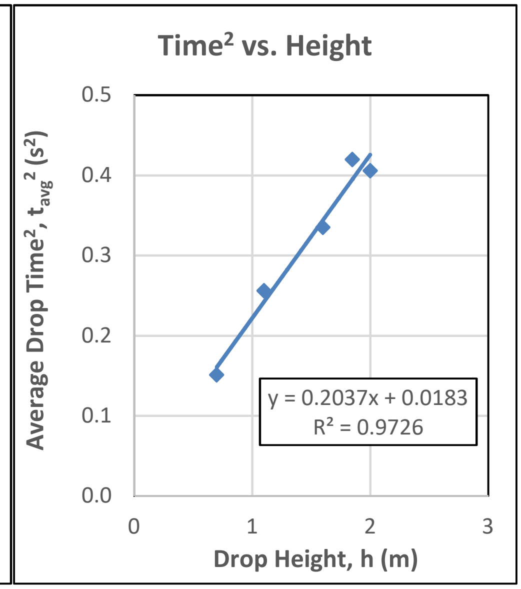
Introduction

The purpose of this lab was to design an experiment using a penny and stopwatch to determine the acceleration of gravity based on the curve of best fit from the graphed data. The researchable question was: how does increasing the height, above a surface, from which the bottom of a vertically oriented penny is dropped, affect the time it takes for the penny to reach the surface? The hypothesis was that if the height at which the bottom of the penny was dropped increases, then the time it takes for the penny to reach the ground will increase, where $t^2 \propto h$.

Graph

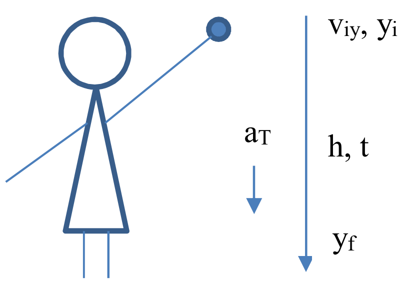




Procedure and Materials

A wall was marked at various increments between 0.70 m and 2.00 m with a pencil line drawn on masking tape. Then Zoie held the penny between the tips of her fingers; her fingers were perpendicular to the wall and parallel to the floor, and the face of the penny was parallel to the wall. The bottom of the penny was aligned with the mark on the tape when testing for each trial. In her other hand, she held the stopwatch. Arav counted down "3," "2," "1," "go." When he said "go," Zoie dropped the penny and immediately started the stop watch. She stopped the stopwatch when she heard the penny hit the tile floor. Divya recorded the time of each drop and Daniel retrieved the penny and gave it to Zoie for the next drop. There were 10 trials for each setting; after completing all 10 trials, the group moved on to the next height.

Diagram



Constants and Equations

$m_p = 2.48\ (\pm 0.01)$ g
$v_{iy} = 0$ m/s
$y_i = h$
$y_f = 0$ m
$a_T = -\ 9.807$ m/s^2

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

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

Data Summary

h	t_{avg}	SD	%RSD	t_T	|%err|	t_{avg}^2
(m)	(s)	(s)	of t_{avg}	(s)	of t	(s^2)
0.700	0.39	0.06	14.46	0.38	2.92	0.15
1.100	0.51	0.07	12.92	0.47	6.80	0.26
1.600	0.58	0.05	9.19	0.57	1.33	0.34
1.850	0.65	0.06	8.78	0.61	5.46	0.42
2.000	0.64	0.06	9.51	0.64	0.29	0.41
		Avg	**10.97**	Avg	**3.36**	

Analysis

The lab produced the data and graphs above, and the trends in the data are as shown. The second graph is a linearized version of the first, which makes the direct relationship between t^2 and h clearly visible. The first graph gives a gravitational acceleration of 9.677 m/s^2, while the second gives a gravitational acceleration of 9.818 m/s^2. The percent error for gravity ranged between 1.32% and 0.184%, so there was high accuracy overall. However, the average percent error for the time was 3.36, which gives high accuracy for the timing. The %RSD was on average 10.97, which gives low precision for the timing. For the first graph, the R^2 value was 0.9838 and for the second 0.9726, thus both models were a strong fit. The first graph had the intercept at (0,0), which means the first model implies that at height 0 the penny will not have any drop time. The second graph has a non-zero intercept, which implies that a penny dropped from height 0 would take time to reach the ground, which is inaccurate.

Conclusions

The lab demonstrated that the time it took for a penny to drop did (usually) increase when the height increased, almost according to the relationship $t^2 \propto h$ (though the data gave the relationship $t^{2.083} \propto h$), so the results support the hypothesis. There was one data point which contradicts this model, though it was caused by a high time measurement during one of the trials due to an early start on the timer.

Some sources of error included air resistance and the time it takes for the sound of the penny dropping to reach the ear, and these would both increase the experimental time, which explains why in this lab the experimental time was sometimes higher than expected. However, some trials had lower times than theoretically expected. The buttons on the stopwatch took time to press, which meant that the time readings did not factor in press time, and this could have contributed to making the times less precise.

To make this lab more precise, a better timing method should be explored. The use of a high-speed camera would allow for more exact measurements and thus more precision. The penny could also drop between two lasers which could precisely measure when the penny passes through them. The lab could also be made more precise if the penny was dropped with a steady, mechanical hand.