Penny Drop Lab Report

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Introduction

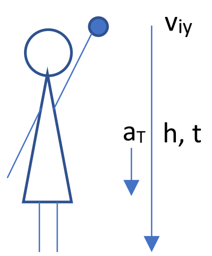
The purpose of this lab was to design an experiment using a penny and stopwatch to determine the acceleration of gravity based on the curve of best fit from the graphed data.

Researchable Question: How does the initial height of a penny from the ground affect the time the penny takes to free fall from that height to the ground? If initial height of the penny increases then time taken to free fall to the ground will increase, where time is proportional to the square-root of height.

Procedure and Materials

The specified heights of 0.500, 1.000, 1.500, 2.000 and 2.355 m were measured with a meterstick held against the surface perpendicular to the floor and marked with a line drawn on a piece of tape. Jacky held a US penny minted in 2000 against the wooden pole with one finger so that the lowest point of the penny was tangent to a line. He counted off, "3, 2, 1, go". On "go", he moved his finger away from the surface. The designated timer, Anaya, began to start the timer when Jacky said "1", to account for reaction time, and stopped the timer when she heard the penny hit the ground. Neil recorded the values after each trial. If the penny hit the wall during its fall, the trial was thrown out.

Diagram



Constants and Equations

$m_p = 2.50$ g
$v_{iy} = 0$ m/s
$y_i = h$
$y_f = 0$ m
$a_T = -9.81$ m/s^2

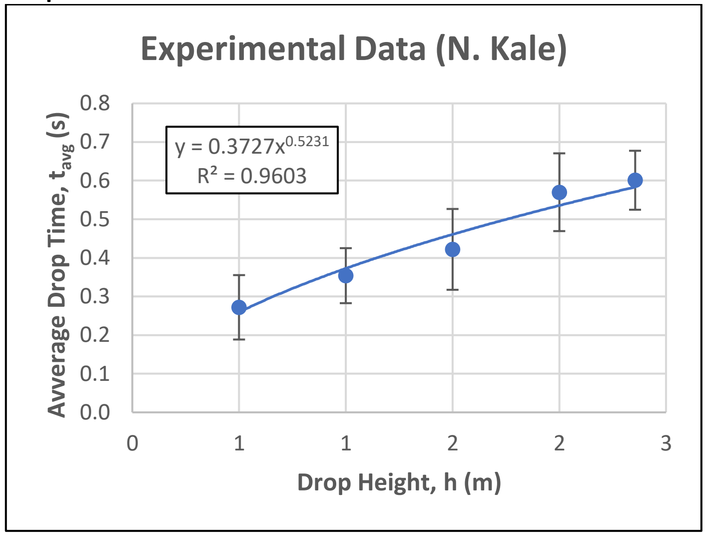
$$y_f = \frac{1}{2}at^2 + v_{iy}t + y_i$$

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

Data Summary

h (m)	t_{avg} (s)	STDEV (s)	|%RSD| of t_{avg}	t_T (s)	|%err| of t	t_{avg}^2 (s^2)
0.500	0.27	0.08	30.65	0.32	14.81	0.07
1.000	0.35	0.07	20.12	0.45	21.60	0.13
1.500	0.42	0.10	24.80	0.55	23.69	0.18
2.000	0.57	0.10	17.66	0.64	10.74	0.32
2.355	0.60	0.08	12.71	0.69	13.26	0.36
		Avg	**21.19**	Avg	**16.82**	

Graph



Analysis

The data has low precision; the average |%RSD| is 21.19%. The average % error is 16.82%, hence the accuracy is low. The R^2 is 0.9603, so the mathematical model is strong. The curve of best fit is $t_{avg}=0.3727*h^{0.5231}$. The slope of the curve (s/m) decreases as h increases, suggesting that the difference in drop time per unit height is greater at low values of h. The curve has no limit. Drop-time is always increasing directly proportional to $h^{0.5231}$. The calculated acceleration due to gravity, g, from this model is 3.3516 m/s^2. The linearized curve, $t_{avg}^2 = 0.1641h - 0.0287$ has a y-intercept of -0.0287 s. This suggests that if the penny were released from a height of 0 m, the timer would record -0.0287 s. This is nonphysical because the timer can't stop before it starts. The slope is 0.1641 s^2/m; for every one meter increase in height, the time increases by $0.1641^{1/2}$ s. The calculated acceleration due to gravity, g, from the linearized model was 3.047 m/s^2.

Conclusions

The hypothesis was supported by this experiment. Friction from the penny's contact with the wall introduced error by increasing measured time, which decreased calculated acceleration. Penny initial height varying slightly above or below the listed value either increased or decreased the calculated acceleration. Air resistance also increased measured time, thus decreasing calculated acceleration due to gravity. The calculated values of 3.047 m/s^2 and 3.3516 m/s^2 are both less than the accepted value of 9.81 m/s^2, hence these sources of error account for the difference. One future extension to this lab could determine the effect of the mass of object on drop time and calculated acceleration due to gravity. Another could explore whether the trends observed in this lab continue at heights over 100 m when air resistance becomes significant.