Penny Drop Lab: Earth Edition

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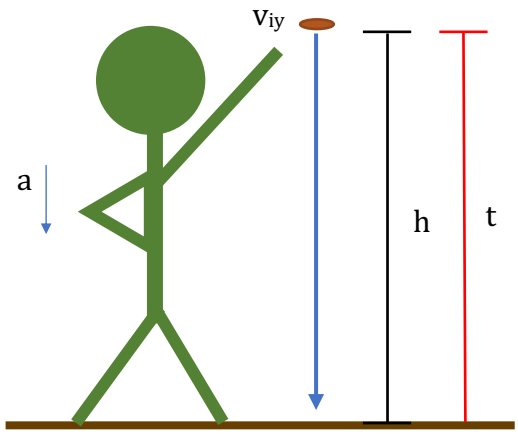
Introduction

The purpose of this lab was to design a scientific experiment using a stopwatch to determine the acceleration of gravity based on the curve of best fit from the graphed data. How does increasing the height above the ground, h, from which a penny is dropped affect the time, t, it takes for the penny to hit the ground? If the height from which a penny is dropped increases, then the time taken to hit the ground will also increase, where $t \propto \sqrt{h}$.

Procedure and Materials

Pieces of masking tape marked various drop heights on a wall. Sashank held a 1961 penny to the bottom of each piece of tape and dropped the penny horizontally. For every trial, Aaron said "3, 2, 1, go" while simultaneously starting a timer at "go." Sashank would also release the penny at "go." Aaron stopped the timer when he saw the penny hit the ground. Kiara recorded data all 10 trials at 5 heights in a notebook and notified the group when a drop was conspicuously late or out of sync.

Diagram



Constants and Equations

$v_{iy} = 0\ m/s$

$y_i = h\ (m)$

$y_f = 0\ m$

$a_T = -9.8\ m/s^2$

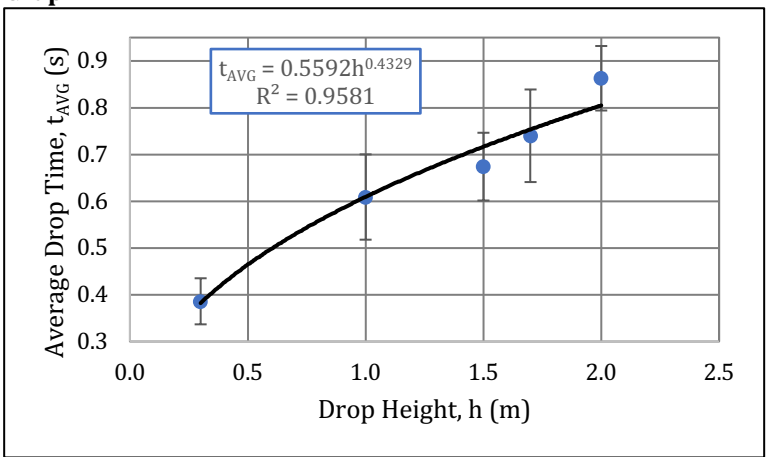
$y_f = \frac{1}{2}a_T t_T^2 + v_{iy} t_T + y_i$

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

Data Summary

height (m)	t_{AVG} (s)	STDEV (s)	%RSD of t_{AVG}	t_T (s)	|%err| of t
0.300	0.34	0.05	14.66	0.25	35.79
1.000	0.56	0.09	16.32	0.45	23.74
1.500	0.62	0.07	11.61	0.55	12.78
1.700	0.69	0.10	14.35	0.59	17.14
2.000	0.81	0.07	8.48	0.64	27.25
		AVG	13.08	AVG	23.34

Graph



Analysis

The average %RSD of 13.08 indicates low precision of the experiment. The average percent error between experimental t_{AVG} and theoretical t_T stipulates low accuracy for the overall experiment as well. However, the R^2 value of 0.9581 from the t_{AVG} vs. h graph indicates that the strength of the model is strong. Accordingly, the data will follow this same trend if more heights and drop time were measured. The t-intercept for this trend was 0 s, since at h = 0 m (on the ground), the drop time to reach the ground would also be 0 s. Using the equation of the power series line of best fit, the experimental acceleration of gravity was calculated to be -7.659 m/s². The power in the power series equation was 0.4329, which deviates from 0.5, the theoretical factor by which h is raised by. When using the linearized line of best fit for t_{AVG}^2 vs h (t_{AVG}^2 = 0.2946h + 0.0074), the experimental acceleration was determined to be -6.788 m/s². The limits were h > 0 m and t > 0s. The slope of each line represents the instantaneous velocity of the penny at a given drop height.

Conclusion

Some parts of the proposed hypothesis remain inconclusive; while it was observed that the time taken to reach the ground increased as the drop height increased, the direct proportionality of t to $\sqrt{h}$ was not supported since the experimental line of best fit yielded a power of 0.4329, deviating from the theoretical factor of 0.5. The experimental acceleration was calculated to be -7.659 m/s² and -6.682 m/s², which is inconsistent with the known acceleration of gravity on Earth (-9.8 m/s²). All the experimental recorded values are consistently higher than the theoretical values. A plausible source of error within this experiment is the discrepancy between when the penny was released and when the designated timer began the stopwatch, especially since these activities were performed by separate people. It is possible that the small reaction time it took for the person to release the penny after the designated timer began the stopwatch increased the recorded time values. In future experiments, the procedure may be redesigned to have the same person releasing the penny and timing, even though that may influence the ability to accurately stop the time, especially given low drop heights.