Zoe Butzke, Section S

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Lab Partners: Charlotte Cain, Robin Warner

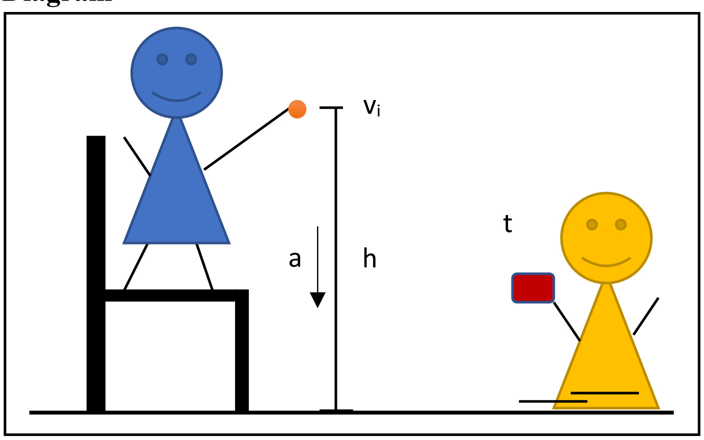
Introduction

The purpose of this lab was to design an experiment to determine the acceleration due to gravity using a penny and stopwatch based on the curve of best fit from the graphed data. How does increasing the initial drop height of a penny affect the time it takes the penny to hit the ground after being dropped? The hypothesis is that if the drop height of the penny is increased, the time it takes the penny to fall to the ground after release will also increase, where $t \propto \sqrt{h}$.

Procedure and Materials

Zoe held a penny pinched vertically with two fingers. The bottom of the penny was placed to be in line with a pre-measured marker line, and the penny was held a half-inch away from the lip of the door. The markers were made by measuring heights with a meterstick and marking them with lines on tape. Zoe counted down from 3, not including 0, with a "Go" at the end. Robin started the timer and Zoe released the penny on "Go." Robin would then stop the timer when she heard the penny hit the floor. Charlotte recorded the time from Robin. 5 drop heights were pre-measured, with time being recorded 10 times for each height. For the experiment, Zoe was standing on a chair and Robin was seated on the floor

Diagram



Constants and Equations

$$v_i = 0$$
$$y_i = h$$
$$y_f = 0$$
$$a_T = -9.8\, m/s^2$$

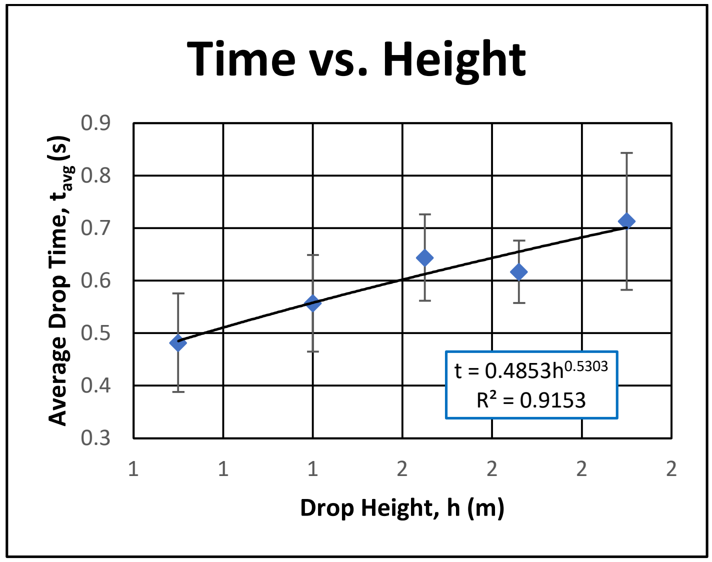
$$h_f = \frac{1}{2}at^2 + v_i + y_i$$

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

Data Summary

Height (m)	t_{avg} (s)	SD (s)	%RSD of t_{avg}	t_T (s)	|%err| of t
1.00	0.48	0.09	19.51	0.45	6.70
1.30	0.56	0.09	16.48	0.52	8.14
1.55	0.64	0.08	12.75	0.56	14.50
1.76	0.62	0.06	9.61	0.60	2.95
2.00	0.71	0.13	18.28	0.64	11.60
		Avg	**15.32**	Avg	**8.78**

Graph



Analysis

The average %RSD of the data was 15.32%, which means the data had low precision. However, the average percent error of the data was 8.79%, so the data has moderate accuracy. With an R^2 of 0.9153, it can be seen that the strength of the model is moderate. In the equation of best fit for the graph above, the coefficient of h can be used to determine the experimental acceleration due to gravity. For the original data, this value is -7.8186 m/s^2. For the linearized model, the acceleration is -7.837 m/s^2. The acceleration from the linearized data is closer to the theorized acceleration due to gravity, so it can be concluded that this model is more accurate. The limit is 0 for both height and time. Theoretically, the line of best fit should pass through the origin, meaning that at zero height the time should also be zero. This is true for the graph above, however, for the linearized data the line of fit has a time -0.0191s at 0 height. The error bars are similar in size, which means there was consistent variation in the data. The power of h (0.5658) is close to 0.5. This means that t is close to being proportional to $\sqrt{h}$.

Conclusions

As stated before, from the data it can be seen that t is close to being proportional to $\sqrt{h}$. This means that the hypothesis is correct. Apart from a human source, error was likely made from air resistance and sound speed. Human error could have happened due to separate drop and time starts, visual measurement of penny and marker alignment, and reaction time. Both human and the other sources of error discussed would cause greater experimental time values than expected. Greater experimental time values would cause a lower expected experimental acceleration than theoretical. Since both of these trends are seen in the data, it can be concluded that the potential sources of error did affect our data. Future experiments may want to include non-human drop mechanisms or automatic timing. Using a ramp and marble is an example of a possible extension.