Galileo's Ramp Lab

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1 Observations

Table 1: Height and Angle Data

Trial Number	Track Height (m)	Average Time (s)	Angle of Incline (°)
Height #1	0.13m	2.56s	5.07°
Height #2	0.20m	1.98s	7.66°
Height #3	0.27m	1.66s	10.07°
Height #4	0.34m	1.38s	12.98°
Height #5	0.41m	1.30s	15.68°

Length of Ramp ($\boldsymbol{\Delta d}$) = 1.50 metres

2 Analysis

1. Calculating Acceleration of the Ball:

Sample Calculation for Height #1:

$$\vec{a} = \frac{2\Delta d}{t^2}$$

$$\vec{a} = \frac{2(1.50)}{2.56^2}$$

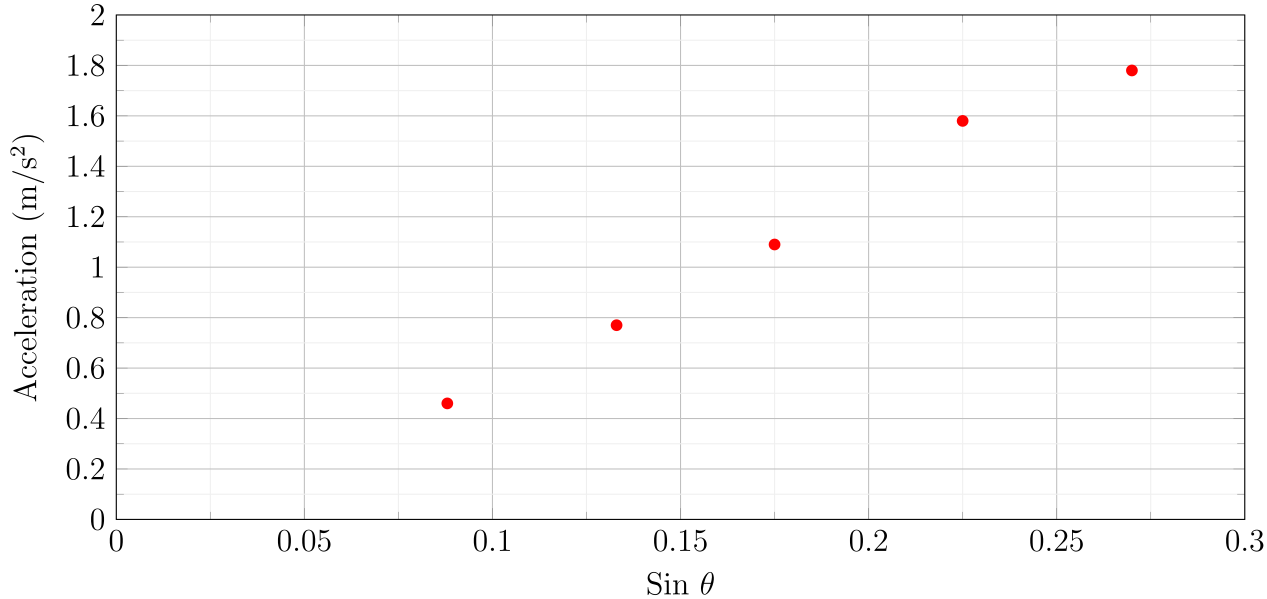
$$\vec{a} = 0.46 \text{ m/s}^2[\text{downhill}]$$

Table 2: Angles and Acceleration Data

Height (m)	Angle (°)	Sin θ	Acceleration (m/s^2)
Height #1: 0.13m	5.07°	0.09	0.46m/s^2
Height #2: 0.20m	7.66°	0.13	0.77m/s^2
Height #3: 0.27m	10.07°	0.18	1.09m/s^2
Height #4: 0.34m	12.98°	0.23	1.58m/s^2
Height #5: 0.41m	15.68°	0.27	1.78m/s^2

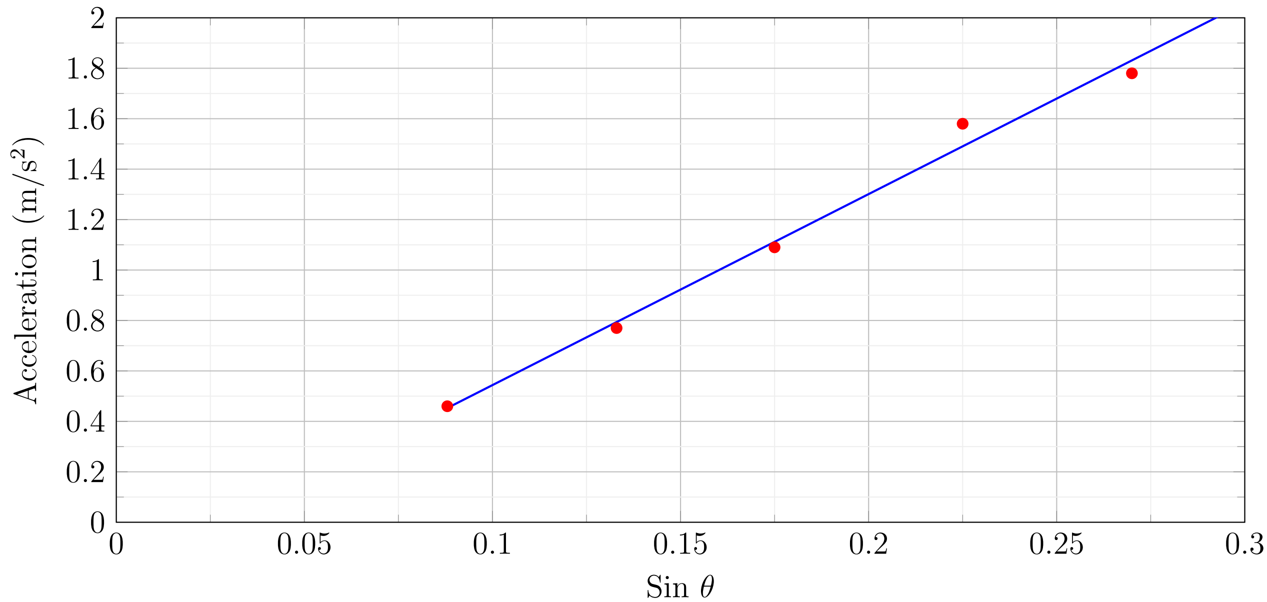
2. Acceleration Vs. Sin θ Graph Without Trendline:

Figure 1: Acceleration Vs. Sin θ



3. Acceleration Vs. Sin θ Graph With Trendline:

Figure 2: Acceleration Vs. Sin θ



a) Relation between Acceleration and Sin θ:

There is a linear relationship between acceleration and sin θ, which represents the acceleration due to gravity.

b) Calculating Slope of Trendline:

$$\boldsymbol{m = \frac{y_2 - y_1}{x_2 - x_1}}$$
$$\boldsymbol{m = \frac{1.09 - 0.46}{0.175 - 0.088}}$$
$$\boldsymbol{m = 7.24}$$

$\therefore$ The slope of the trendline is 7.24.

c) Equation of the Line:

Equation based on Excel trendline: $\boldsymbol{y = 7.5727x - 0.2135}$ *

Equation from calculations: $\boldsymbol{y = 7.24x - 0.177}$ *

$\star$ *Where x truly represents* $\sin x$

d) Acceleration of the Ball if $\boldsymbol{\theta = 90°}$:

Calculated using equation from calculations:

$$\boldsymbol{y = 7.24 \sin x - 0.177}$$
$$\boldsymbol{y = 7.24 \sin 90° - 0.177}$$
$$\boldsymbol{y = 7.24 - 0.177}$$
$$\boldsymbol{y = 7.06}$$

$\therefore$ The calculated acceleration of the ball at 90° would be 7.06 m/s^2.

e) Calculating the Percentage Error:

$$\boldsymbol{\delta = \left| \frac{\mathcal{V}_A - \mathcal{V}_E}{\mathcal{V}_E} \right| \cdot 100\%}$$
$$\boldsymbol{\delta = \left| \frac{9.8 - 7.06}{7.06} \right| \cdot 100\%}$$
$$\boldsymbol{\delta = 39\%}$$

$\therefore$ The calculated percentage error is 39%.

f) Discussing Two (2) Sources of Error:

1) Since the ball is travelling on a surface, there are other forces acting on it, which slow down the ball's motion such as friction between the ball and surface as well as air resistance. These two forces oppose the ball's motion, preventing it from reaching the target 9.8 m/s^2 acceleration. The material of the bouncy ball was rubber and was against semi rough plastic, which would result in a high force of friction that would affect the ball as "rolling friction" which we cannot account for currently.

2) In addition, due to the poor design of the ramp we used, the rubber ball kept hitting the sides of the ramp as it rolled down, which would decrease its speed and have external forces act upon it. This would increase in time and therefore, introduce a higher % error in our calculations.

4. After performing his experiments using inclined ramps and balls of different masses, Galileo concluded that the acceleration of various balls down a ramp was independent of mass.

a) Modifying The Experiment to Test Galileo's Conclusion:

The experiment could be modified by using multiple balls of varying masses with the same five angles and creating acceleration vs sin θ graphs for all of them. The graphs should roughly all look the same or only have slight differences due to experimental errors.

b) Explaining Why the Feather and Bowling Ball Result does not Contradict Galileo's Result:

The result does not contradict Galileo's conclusion because when the objects are dropped, other forces act on them; primarily air resistance, which is not independent of mass. As a result the feather experiences more air resistance than the bowling ball. If the two objects were placed in a complete vacuum, both objects would reach the ground at the same time, as gravity is the only force acting on the objects, displaying that acceleration is independent of mass.