Velocity and Acceleration

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1 Goal

The goal of the experiment is to determine the acceleration of an object sliding along frictionless incline.

2 Theory

When an object slides down a frictionless incline, its acceleration is given by

$$a = g \sin\theta \ , \tag{1}$$

where θ is the angle between the incline and the horizontal, and g is the gravitational acceleration, 9.8 $\frac{\mathrm{m}}{\mathrm{s}^2}$. For a motion with a constant acceleration, the function for the velocity of an object is given by:

$$v = v_o + a \triangle t \ . \tag{2}$$

3 Experimental Settings

In order to measure the acceleration, we used an airtrack with an air pump (to minimize friction), a glider with a picket fence, and a photogate connected to a computer. We used various cylinders as spacers to incline the track. For a given height of a spacer h, the angle of the incline was calculated as:

$$\sin\theta = \frac{h}{L} \ ,$$

where $L = 100$ cm was the length along the track between the track's two supports, as shown on the digram in Fig. 1.

The procedure was as follows:

1. We leveled the track first, by adjusting its supports and adding additional sheets of paper if necessary.

2. We put one cylinder under one of the air track supports. The height of the cylinder, h was used to determine our theoretical acceleration,

$$a_{\text{ th}} = g \sin(\theta) = g \frac{h}{L} \ ,$$

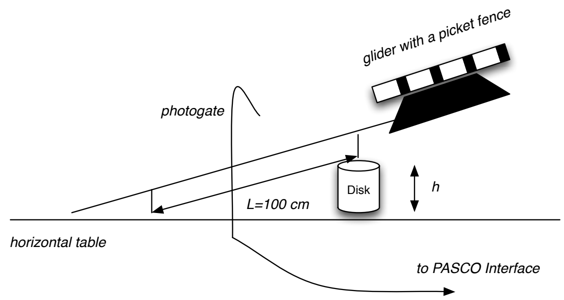

Figure 1: Air Track

where $L = 100$ cm.

3. We adjusted the photogate's height to ensure that it will "blink" every time a marked section of the picket fence passed through it.

4. The photogate was connected to a computer through PASCO interface. We used the Data Studio program to analyze the signals from the photogate.

5. In the Data Studio, we plotted the graph "velocity vs. time" and recorded the slope of that graph. That was our "measured" acceleration.

4 Data and Results

h [cm]	m [g]	$\sin\theta$	a_{th} $[\frac{\mathrm{m}}{\mathrm{s}^2}]$	a_{meas} $[\frac{\mathrm{m}}{\mathrm{s}^2}]$	$\frac{\|a_{\mathrm{meas}}-a_{\mathrm{th}}\|}{a_{\mathrm{th}}}$
1.28 ± 0.01	194.735 ± 0.001	0.0128	0.12544	0.120 ± 0.003	4%

Table 1: Data and Results

Our data and results are given in the table above. The last column gives the relative (percent) difference between the two values for the acceleration, a_{th} and a_{meas}. The uncertainty of the measurements, h, and m were determined by the instruments used. The uncertainty of the measured acceleration was taken equal to the uncertainty in the slope of the best linear fit of the velocity vs. time graph. The uncertainty of the thoretical value for the acceleration was calculated based on the formula for the acceleration:

$$a_{\mathrm{th}} = g\frac{h}{L} \ .$$

Thus, the relative uncertainty of the theoretical acceleration becomes::

$$\frac{\triangle a_{\mathrm{th}}}{a_{\mathrm{th}}} = \frac{\triangle g}{g} + \frac{\triangle h}{h} + \frac{\triangle L}{L} = 2\% \ ,$$

where, we have used for the value of the gravitational acceleration 9.8 ± 0.1 $\frac{\mathrm{m}}{\mathrm{s}^2}$ and for the difference between the airtrack support $L = 100 \pm 0.1$ cm.

The relative uncertainty of the measured acceleration is:

$$\frac{\triangle a_{\text{meas}}}{a_{\text{meas}}} = 2.5\%$$

5 Conclusion

In this experiment, we determined the acceleration of a sliding object along a frictionless ramp in two independent ways. The uncertainty in the theoretical value (2%) and the measured value (2.5%) exceeds their relative difference (4%). Therefore, the two values agree within their uncertainties.