PHYSICS 4AL

EXPERIMENT 2: MEASUREMENT OF G

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Contents

DERIVATION OF EQUATION 2.1

We first set the velocity V_1 to be the distance d travelled between the first photogate and the second photogate over time T_1. Similiarly, the velocity V_2 is equal to the distance D over time traveled T_2 between the second photogate and the landing pad.

$$V_1 = \frac{d}{T_1} \qquad \text{and} \qquad V_2 = \frac{D}{T_2}$$

We substitute these velocities into the kintic equation $V = V_o + g(t)$, where $V = V_2$, $V_o = V_1$, and t is equal to the average of the two times, or $t = \frac{T_1+T_2}{2}$.

$$V_2 = V_1 + g\left(\frac{T_1 + T_2}{2}\right)$$

By substituting in the values for V_1 and V_2, we get an equation that only contains the units that Equation 2.1 contained.

$$\frac{D}{T_2} = \frac{d}{T_1} + g\left(\frac{T_1 + T_2}{2}\right)$$

By rearranging the equation so that g is isolated, we end up with Equation 2.1.

$$g = \frac{2}{T_1 + T_2}\left(\frac{D}{T_2} - \frac{d}{T_1}\right), \text{ in terms of m/s}^2$$

PLOTS

DATA TABLES

Ball Drop Tables

Below are three tables

Trial	Photogate Spacing d(cm)	Gap to impact Sensor D(cm)	Measured Acceleration g(m/s^2)
1	8.00 ± 0.05	45.50 ± 0.05	10.03 ± 0.02
2	8.00 ± 0.05	54.00 ± 0.05	10.03 ± 0.03
3	8.00 ± 0.05	63.00 ± 0.05	10.07 ± 0.03
4	8.00 ± 0.05	27.00 ± 0.05	10.32 ± 0.01
5	8.00 ± 0.05	72.00 ± 0.05	10.05 ± 0.03

Table 2.1 Experiment Results and calculated acceleration values. The calculated value of the acceleration due to gravity g is 10.10 ± 0.02 m/s^2. The systematic and statistical uncertainties are not the same. The following Tables 2.2 and 2.3 list out the contributions to uncertainty systematic and statistical uncertainty made.

Trial	Photogate Spacing d(cm)	Gap to impact sensor D(cm)	Systematic Uncertainty in Measured Acceleration g(m/s^2)
1	8.00 ± 0.05	45.50 ± 0.05	± 0.02
2	8.00 ± 0.05	54.00 ± 0.05	± 0.02
3	8.00 ± 0.05	63.00 ± 0.05	± 0.02
4	8.00 ± 0.05	27.00 ± 0.05	± 0.01
5	8.00 ± 0.05	72.00 ± 0.05	± 0.02

Table 2.2 Uncertainty due to Systematic Uncertainty This table depicts the uncertainty that resulted from systematic variables. Uncertainty due to measurement in distances d and D was 0.05 cm, or 0.0005 m, because milimeters are the smallest unit on a meter stick. The best values for T_1 and T_2 were used along with the upper and lower limits of d and D to calculate g_{min} and g_{max}.
Upper limits for measured distances: $d = d_{best} + \delta d$ and $D = D_{best} + \delta D$
Lower limits for measured distances: $d = d_{best} - \delta d$ and $D = D_{best} - \delta D$

Trial	Photogate Spacing d(cm)	Gap to impact sensor D(cm)	Statistical Uncertainty in Measured Acceleration g(m/s^2)
1	8.00 ± 0.05	45.50 ± 0.05	± 0.003
2	8.00 ± 0.05	54.00 ± 0.05	± 0.01
3	8.00 ± 0.05	63.00 ± 0.05	± 0.01
4	8.00 ± 0.05	27.00 ± 0.05	± 0.003
5	8.00 ± 0.05	72.00 ± 0.05	± 0.01

Table 2.3 Uncertainty due to Statistical Uncertainty Using the standard deviation equaiton on STDEV on Excel, the uncertainties were calculated by dividing the standard deviations by the square root N number of data points.

$$\delta g = \frac{1}{\sqrt{N}} * \sqrt{\frac{1}{N-1} * \sum_{i=1}^{N} \left(x_i - \bar{x}\right)^2}$$

CONCLUSION

EXTRA CREDIT

REPORT

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