C-1 Speed, Acceleration, and Free Fall

1 Creating a hypothesis

a. In this Investigation, you will be measuring the speed of a steel marble at certain places in its fall. Do you think the speed of the marble will increase, decrease, or stay the same as it falls? Your answer to this question will be your hypothesis for the Investigation.

b. Write a short paragraph to justify the hypothesis you created in the previous question.

2 Setting up the experiment

There are no questions to answer in Part 2

3 Doing the experiment

Table I: Time and Speed Data

Falling distance (m)	Time A to B t_{AB} (s)	Time from A t_A (s)	Speed at A v_A (m/s)	Time from B t_B (s)	Speed at B v_B (m/s)
0.05					
0.10					
0.15					
0.20					
0.25					
0.30					
0.35					
0.40					
0.45					
0.50					
0.55					
0.60					
0.65					
0.70					
0.75					

a. Describe what happens as the marble falls through the light beam of a photogate. Write your answer as a series of steps.

b. Compare the times at photogate A to photogate B. Are they the same or different? Do you see a pattern? If so, what is it?

4 Calculating speed

Calculate the speed of the marble through A (v_A) and B (v_B). The diameter of the marble is 1.9 cm. Record these speeds in the data table.

5 Analyzing the data

a. How does the speed of the marble at photogate B change as you move it further down the physics stand pole?

b. Write a short paragraph describing the motion of the marble as it falls.

6 Graphing the data

There should be a clear pattern in the measurements, but it is not easy to see by looking at the data in Table 1.

1. **Graph 1: Speed vs. Distance**
   Make a graph with the speed of the marble at photogate B on the y-axis and the distance from A to B on the x-axis. Be sure to label each axis, and to draw a best fit curve, or straight line.
2. **Graph 2: Speed vs. Time**
   Make another graph with the speed of the marble at photogate B on the y-axis and the time from photogate A to photogate B on the x-axis. Be sure to label each axis, and to draw a best fit curve, or straight line.

a. Describe what each graph looks like.
b. Which of the graphs has the clearest pattern?

7 Predicting speed

The speed of the marble can be predicted using the eqauation

$$v_B = v_A + at$$

Determine the value for the acceleration due to gravity by measuring the slope of the speed vs. time graph. Also calculate the average initial velocity (v_A).

g = **average v_A =**

Using the equation above, calculate the predicted speeds for the times given in Table 2.

Table 2: Predicted speed

Time (s)	0.010	0.090	0.170	0.250	0.330	0.410
Predicted speed at B						

a. Plot the times and predicted speeds on the graph. Use red to plot the calculated points.
b. How do your predicted values compare with the line that represents the experimental values?
c. The acceleration of gravity is 9.80 m/s^2. The acceleration you calculated above represents the acceleration of gravity. Calculate your relative error.

8 Gravity challenge: Improving your experimental technique

a. It is a challenge to get accurate values for the gravity drop because the distances and times you are working with are very small. For example, the distance you use to calculate speed is 0.019 m. If the marble is a little off-center, the distance might actually be different by as much as 1.5 mm. Calculate speed using a time of 0.0191 s and a distance of 0.019 m. Then, calculate speed using the same time but 0.018 m. What is the relative deviation between the two answers?
b. Re-examine the experimental technique you used in the Investigation. List three ways that you can reduce experimental error.

Questions

None