Level A Investigations

A-1 Introduction to the Gravity Drop

How do you use the gravity drop?

The gravity drop is an excellent tool for studying the motion of an object in free fall. The objects used with the gravity drop are a steel marble and a plastic marble. In this A-level version of the Investigation, students learn to set up the gravity drop.

A-2 Speed and the Gravity Drop

How do you measure the motion of a falling object?

The gravity drop is an excellent tool for studying the motion of an object in free fall. The objects used with the gravity drop are a steel marble and a plastic marble. In this A-level Investigation, students learn to measure the speed of the marble as it falls. The Investigation also provides students with an opportunity to develop their understanding of gravity.

A-3 Falling Motion

How do you graph the motion of a falling marble?

Everyone knows that when you drop something, it falls down. How can you describe this motion? Does an object fall at the same speed until it lands on the ground, or does its speed change? In this Investigation, students discover the answers to these questions on their own by graphing the motion of a falling marble.

Level B Investigations

B-1 Introduction to the Gravity Drop

How do you measure the motion of a falling object?

In this B-level version of the Investigation, student first learn to use the gravity drop and to measure the speed of the marble as it falls. Then, they compare their speed values with other values of speed using unit conversion. In the process of doing the Investigation, students develop their understanding of gravity.

B-2 Speed, Acceleration, and Free Fall

How do you measure the acceleration of a falling object?

Everyone knows that when you drop something, it falls down. How can you describe this motion? Does a falling object fall at the same speed until it lands on the ground, or does its speed change? In other words, does a falling object accelerate? The answer to this question is yes. In this Investigation, students use the gravity drop to map the motion of a falling marble and measure its acceleration.

B-3 Newton's Second Law

Do heavier objects accelerate faster?

Students explore how the weight of an object affects its acceleration. They compare the motion of stell and plastic marbles and demonstrate Newton's second law—that the ratio of an object's weight to its mass is proportional to the acceleration of gravity.

Level C Investigations

C-1 Speed, Acceleration, and Free Fall

How do you measure the acceleration of a falling object?

Everyone knows that when you drop something, it falls down. How can you describe this motion? Does a falling object fall at the same speed until it lands on the ground, or does its speed change? In other words, does a falling object accelerate? The answer to this question is yes. In this Investigation, students use the gravity drop to map the motion of a falling marble and measure its acceleration.

C-2 Measuring Gravity

Do heavier objects accelerate faster?

An object in free fall experiences uniform acceleration caused by gravity. Gravity pulls all objects towards the center of Earth with a force called *weight*. The more mass an object has, the greater its weight. In this Investigation, students explore how the weight of an object affects its acceleration. In the process, they demonstrate Newton's second law—that the ratio of an object's weight to its mass is proportional to the acceleration of gravity. If air friction is not a factor, all objects fall at the same rate.

C-3 Interpreting Graphs of Accelerated Motion

What can be learned from graphs of accelerated motion?

In a previous Investigation, students demonstrated that an object in free fall accelerates uniformly. In making graphs with collected data, students learned that these graphs conveyed important information. In this Investigation, students explore methods used to interpret graphs and see that data of natural phenomena (like acceleration due to the force of gravity) can be represented using graphical models and described using simple equations.

Question: How do you graph the motion of a falling marble?

In this Investigation, you will:

1. Make a graph of the motion of a falling marble.
2. Learn to interpret your motion graph.
3. Learn the difference between the terms speed and acceleration.

How does gravity affect the motion of a falling object? A good way to answer this question is to create a graph showing where the motion of a falling object changes or stays the same. The change in speed over time is called *acceleration*.

In this Investigation, you will use the gravity drop to measure the speed of the marble at points in its path as it falls. The data you collect will allow you to make a graph of the marble's motion. Using this graph, you will be able to make predictions about the marble's motion.

1 Creating a hypothesis

Describe the motion of the marble as it falls. Your description *before* you have studied the motion of the marble is your *hypothesis*. Your hypothesis will help guide you in the Investigation. By answering the following questions, you will develop your hypothesis for the Investigation.

a. If you dropped a stone off a bridge into a river, how would you describe the motion of the falling stone? Does the speed of the stone change during the fall?

b. What about a falling marble? 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 changes as it falls? If so, how will the speed change? Your answers to these questions will be your hypothesis for the Investigation.

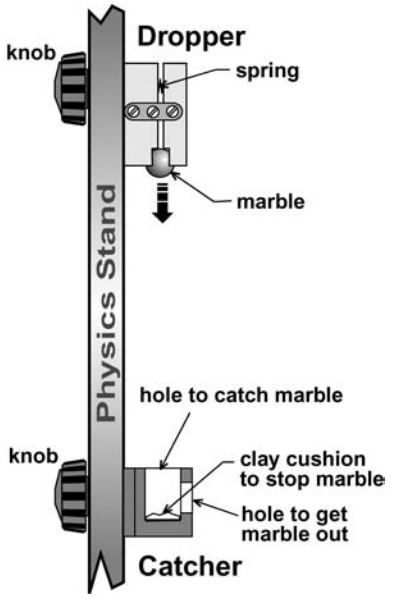
c. Write a short paragraph to justify the hypothesis you created in the previous question.

2 Setting up the experiment

1 Starting at the base of the physics stand, attach the catcher at the first hole, the dropper at the nineteenth hole, photogate A at the seventeenth hole, and photogate B at the sixteenth hole. The photogates should fit tightly against the physics stand. What is the distance between the photogates?

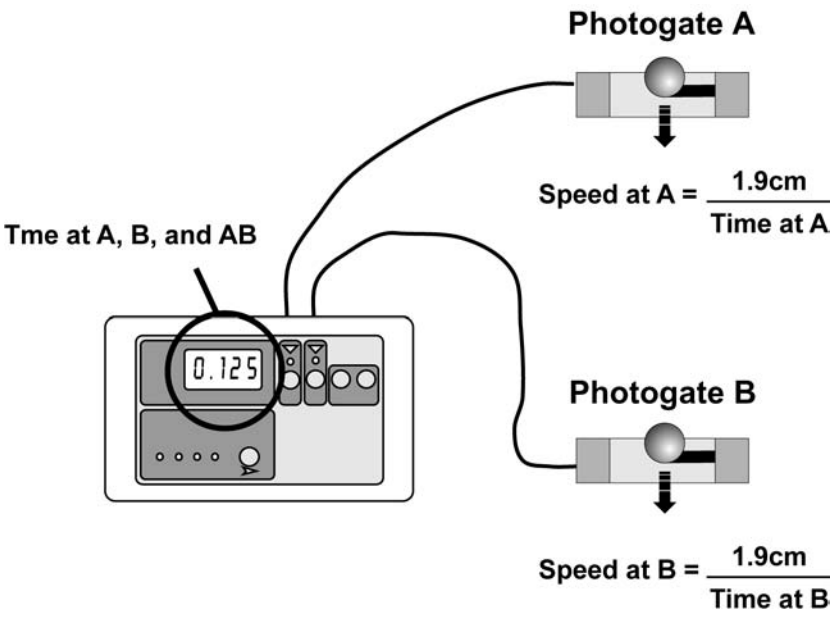
2 Use the plumb line to align the dropper and catcher. If the stand is not level, adjust it by raising or lowering the feet on the underside of the stand. Remember: "Right raises, left lowers."

3 Practice dropping a steel marble from the dropper. Use your thumb to *gently* push the dropper. Wrap your middle fingers around the pole to brace the physics stand. If the physics stand is perfectly level, the marble drops into the catcher without hitting the sides. You will hear a "thunk" as the marble hits the clay in the catcher after a good drop.



3 Doing the experiment

1. Connect photogates A and B to the timer with cords as shown in the diagram. Set the timer to interval mode.
2. Drop the steel marble until you get a good drop, and record the distance between the photogates (5 cm) and all three times (Time at A, Time at B, and Time from A to B) in Table 1.
3. Now, move B so that it is 10 cm below photogate A. Repeat step 2.
4. Repeat step 2 for all the distances listed in Table 1. Remember to only record data from good drops. At this time, you will not calculate the speed of the marble at each photogate.



Note: In the next sections, "A" refers to photogate A and "B" to photogate B.

Table 1: Time and Speed Data

Falling distance between photogates (cm)	Time from A to B (sec)	Diameter of marble (cm)	Time from A (sec)	Speed at A (cm/sec)	Time from B (sec)	Speed at B (cm/sec)
5						
10						
15						
20						
25						
30						
35						
40						
45						
50						
55						
60						
65						
70						
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 A and the times at B. Are they the same or different? Do you see a pattern? If so, what is it?

4 Calculating speed

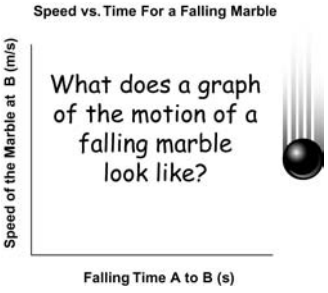
The speed of the marble is calculated by dividing the marble's diameter by the time the light beam was broken as the marble drops through a photogate. The diameter of the marble is 1.9 centimeters.

Using the speed equations below, calculate the speed of the marble at A and at B. You will be dividing the diameter of the marble by the time from the timer. Record your results in Table 1.

$$\text{Speed at A} = \frac{1.9\ \text{cm}}{\text{Time at A}} \qquad \text{Speed at B} = \frac{1.9\ \text{cm}}{\text{Time at B}}$$

5 Graphing the data

Now, you will create a graph of the data. You will see how a graph gives you a "picture" of the motion of the marble as it falls.



1. Make a graph of speed of the marble at B on the *y*-axis and the time from A to B on the *x*-axis.
2. When you have finished the graph, use a ruler to draw a straight line (in pencil) through the points on the graph. Do not draw the line so that the points are connected dot-to-dot.

a. What does your graph look like? In your description, include a sentence that describes how the speed of the marble is related to the time it has fallen.

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

6 Drawing conclusions

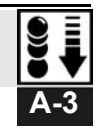
a. Was the hypothesis you created in Part 1 correct? Explain your answer.

b. The terms *speed* and *acceleration* are often used to describe motion. The term acceleration means a change in speed over time. Based on this definition, was the marble accelerating as it was falling? Explain your answer.

c. Let's say you dropped a marble from a height of 5 feet. How could you use your graph to find the speed of the marble after it has fallen for 0.4 seconds?

Name: _____

A-3 Falling Motion



Question: How do you graph the motion of a falling marble?

1 Creating a hypothesis

a. If you dropped a stone off a bridge into a river, how would you describe the motion of the falling stone? Does the speed of the stone change during the fall?

b. What about a falling marble? 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 changes as it falls? If so, how will the speed change? Your answers to these questions will be your hypothesis for the Investigation.

c. 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.

Table 1: Time and Speed Data

Falling distance between photogates (cm)	Time from A to B (sec)	Diameter of marble (cm)	Time from A (sec)	Speed at A (cm/sec)	Time from B (sec)	Speed at B (cm/sec)
5						
10						
15						
20						
25						
30						
35						
40						
45						
50						
55						
60						
65						
70						
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 A and the times at B. Are they the same or different? Do you see a pattern? If so, what is it?

4 Calculating speed

Using the speed equations below, calculate the speed of the marble at A and at B. You will be dividing the diameter of the marble by the time from the timer. Record your results in Table 1.

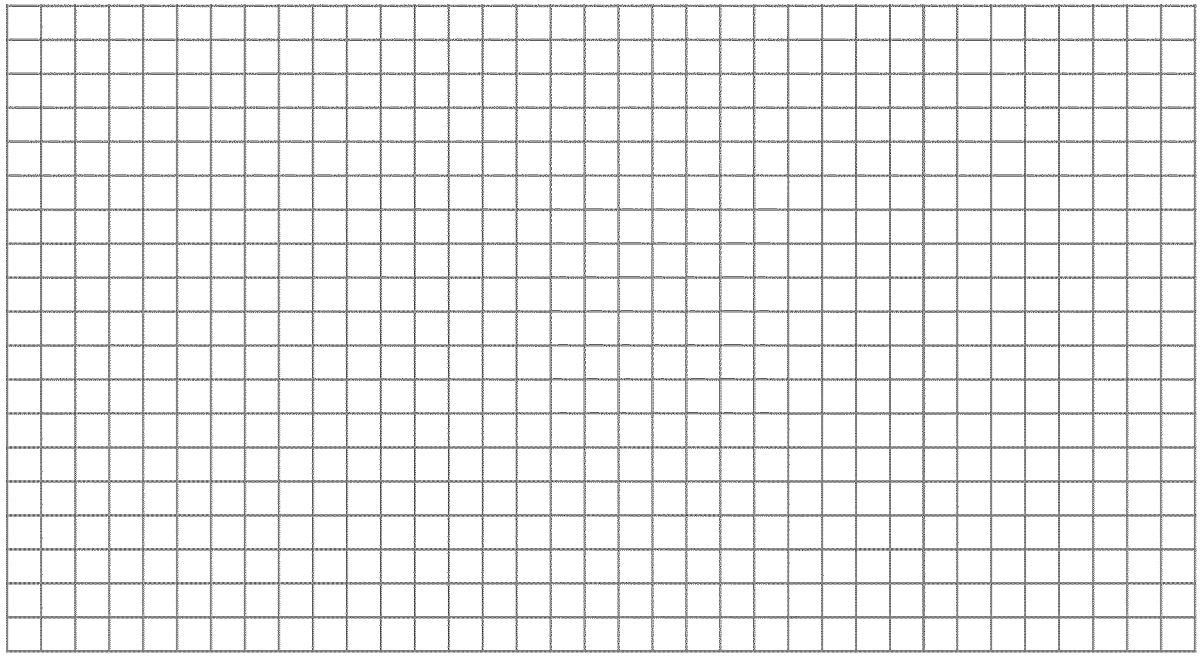
$$\text{Speed at A} = \frac{1.9\ \text{cm}}{\text{Time at A}} \qquad \text{Speed at B} = \frac{1.9\ \text{cm}}{\text{Time at B}}$$

5 Graphing the data

1. Make a graph of speed of the marble at B on the *y*-axis and the time from A to B on the *x*-axis.
2. When you have finished the graph, use a ruler to draw a straight line (in pencil) through the points on the graph. Do not draw the line so that the points are connected dot-to-dot.

Title: _____

y label: _____



x label: _____

a. What does your graph look like? In your description, include a sentence that describes how the speed of the marble is related to the time it has fallen.

_____

_____

_____

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

_____

_____

_____

6 Drawing conclusions

A-3

a. Was the hypothesis you created in Part 1 correct? Explain your answer.

b. The terms *speed* and *acceleration* are often used to describe motion. The term acceleration means a change in speed over time. Based on this definition, was the marble accelerating as it was falling? Explain your answer.

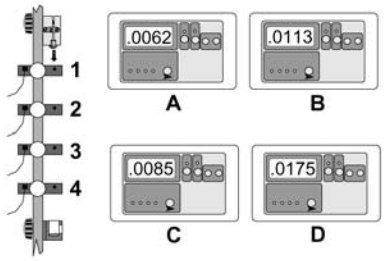
c. Let's say you dropped a marble from a height of 5 feet. How could you use your graph to find the speed of the marble after it has fallen for 0.4 seconds?

Questions

1. In your own words, explain the difference between *speed* and *acceleration*.

2. Four photogates are attached to four timers which each measure the time for the marble to fall through the light beam. Which photogate goes with which timer?

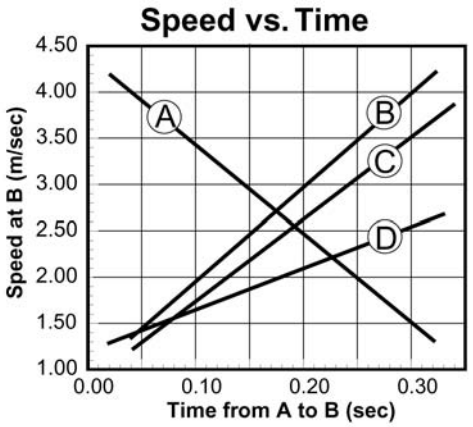
1: 2: 3: 4:



3. The data table shown contains results from a typical gravity drop experiment. Which line in the graph below represents the speed versus time relationship determined by the experiment?

Circle your answer: A, B, C, or D.

Distance A to B (m)	Speed at A (m/sec)	Speed at B (m/sec)	Time A to B (sec)
0.10	1.005	1.769	0.0783
0.20	1.000	2.247	0.1305
0.30	1.000	2.653	0.1724
0.40	1.005	3.081	0.2086
0.50	1.000	3.351	0.2409
0.60	1.000	3.604	0.2703
0.70	1.000	3.898	0.2977



4. You drop a marble off a high building. You know the acceleration of gravity is 9.8 m/sec^2. Use this information to make and fill in a table that shows the speed of the marble for each second that it is falling. Determine speeds in meters per second for 5 seconds of falling.

Time falling (sec)	Speed (m/sec)
1	
2	
3	
4	
5	

Curriculum Resource Guide: Gravity Drop

Credits

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