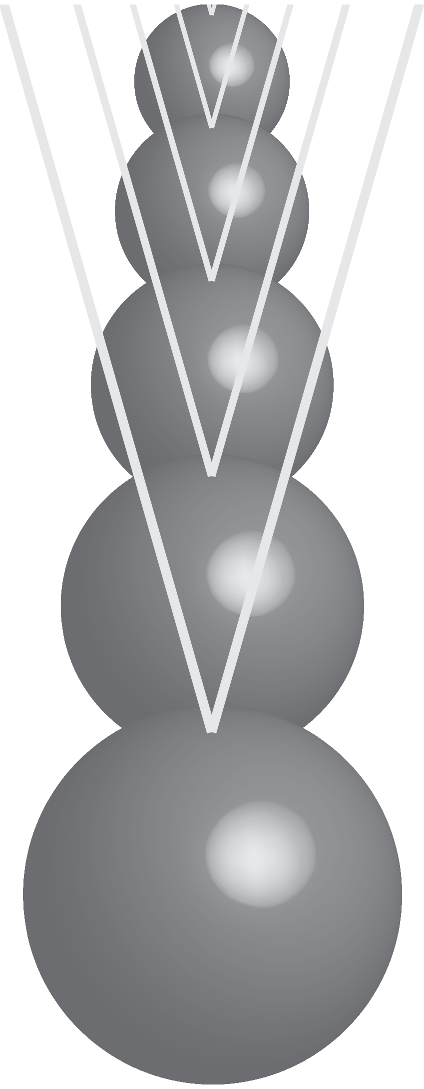

TAKE-HOME PHYSICS:

65 High-Impact, Low-Cost Labs

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EDUCATION

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INTRODUCTION

Research has shown that homework can be an effective and meaningful learning tool for secondary school students if it is relevant, engaging and hands-on. These take-home physics activities are designed to match those criteria. Educational writer Alfie Kohn said in a 2006 interview that there are only two ways that homework is effective for secondary school students. One of those is "activities that have to be done at home, such as … a science experiment in the kitchen" (Oleck 2006).

This book is a collection of physics labs that lend themselves to being performed at home with simple materials. It is not intended to be a physics textbook or to cover every topic encountered in a physics curriculum. Most of the labs are written as Structured or Level 2 inquiry (see Inquiry in Physics, page ix), and some include instructions to raise the level of inquiry if the teacher feels comfortable doing so. A few activities just aren't compatible with inquiry at home and are written as verification labs. Most of the activities involve measuring, graphing, calculating, extrapolating graphs and other science-process skills.

Because this is one piece of a complete physics curriculum, it is assumed that traditional learning and hands-on activities in the classroom will fill in where take-home labs are not practical. Teachers may choose to eliminate some of the labs and substitute others without breaking the flow of the labs.

Used in this way, the hands-on activities can be a powerful tool for learning physics concepts and preparing students for physics assessments that are highly dependent on charts, graphs and conceptual questions. These activities have been piloted in schools across the United States and used by teachers who received the material during conference presentations. The success that these teachers have had with the labs helps refute the common misconception among teachers and students that lectures are for learning and labs are for fun. Students *can* learn physics from labs.

Although the labs are written as take-home activities for high school students, many of the activities in the book are well suited for home-schooled students as well as those who take online courses. These activities would also be appropriate for family science nights and museum outreach programs. If a teacher does not have sufficient materials to send an activity home with every student, the lab could be performed in class as an alternative. One teacher used the activities in after-school intervention programs for students who were not proficient after being exposed to the concepts in the classroom.

Why Take-Home Labs?

These take-home labs, if implemented effectively, can address most or all of the following problems, which are common with physics labs and homework:

Students won't do homework. This sentiment could be rephrased as *Students won't do busywork at home*. When presented with fun and challenging assignments that open doors to understanding the physical world around them, students will rise to the occasion. Throughout four years of implementing these activities, the homework completion rate improved greatly, and test scores indicate that student achievement increased as well.

Students do poorly on standardised tests. Most standardised science tests are weighted toward science-process skills. These skills include drawing and interpreting charts and graphs, finding patterns, interpreting diagrams and analysing experimental data. These take-home labs contribute to the improvement of every one of those skills.

There is not enough class time to cover all the standards. A great deal of class time is used on simple labs that students could do at home. These labs are important, but they consume valuable class time. By having students perform these labs at home, teachers recover days of class time in which new concepts can be taught or reinforced.

Students do not experience enough labs. By assigning take-home lab work, teachers can increase the number of labs students complete over the course of the year to nearly 100 labs in class and at home. This will lead to a more engaging, fulfilling learning experience for students, which will lead to deeper, more lasting learning.

Physics labs are expensive. There are 65 labs in this book, and the collection of materials needed to complete the labs costs around $25, or approximately 40¢ per lab per student the first year. After the first year, only breakages and consumables (mostly batteries) have to be replaced at a cost of less than a couple of dollars per kit.

Physics students lack basic skills when they get to my class. Some of the take-home labs teach about background information and skills that students are supposed to remember from the middle years but rarely do. These labs are a good refresher that you can refer back to throughout the year. As mentioned earlier, it can also buy you days of class time to teach the physics curriculum for your level.

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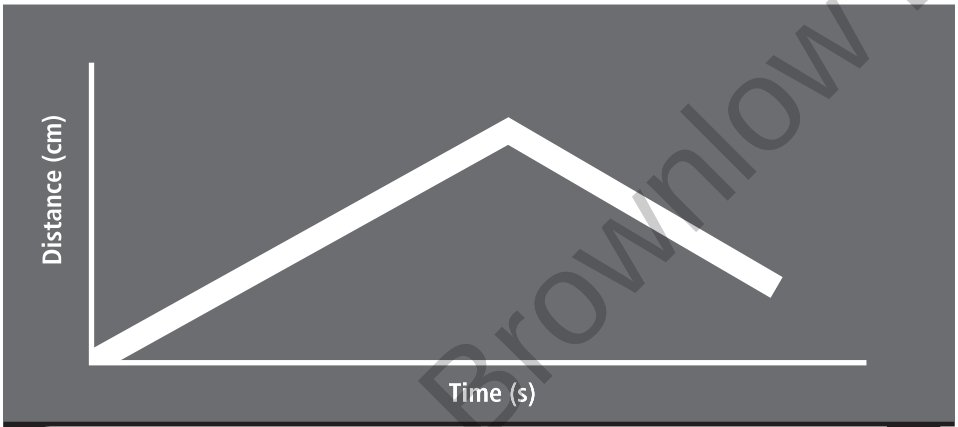
LAB 1: DISTANCE VERSUS TIME GRAPHS 1

This inquiry activity should be used before students learn about velocity and distance versus time graphs. Students will discover how the slope of a distance versus time graph is related to the speed of the object.

SCI LINKS THE WORLD'S A CLICK AWAY
Topic: Graphing Speed, Velocity, Acceleration
Go to: *www.sciLINKS.org*
Code: THP01

Post-Lab Answers

1. The larger (steeper, higher) the slope, the higher the speed.
2. Answers will vary, but should be less than 100 cm/s. The units are cm/s. The slope represents the speed of the marble.
3. See graph below.



LAB 1: DISTANCE VERSUS TIME GRAPHS 1

QUESTION

How does a distance versus time graph look for an object travelling at constant speed?

SAFETY

Do not leave the marble in a place where someone might step on it or a child might swallow it.

MATERIALS

Plastic metric ruler with groove down the middle, stopwatch, marble (any)

PROCEDURE

In this lab, you will be drawing distance versus time graphs for objects travelling at different constant speeds. The shape and trend of the graph will give you information about other distance versus time graphs you'll see in physics.

1. Put removable marks on a smooth, flat surface (such as a floor or table) at 0, 15, 30, 45, 60 and 75 cm.
2. Using your ruler set up a ramp to roll the marble down. Don't put the bottom of the ramp right on the starting line because you want to let the marble stop bouncing before you start timing it.
3. Place the ramp at a low angle (around 30°) and roll the marble from the top of the ramp. Start the watch when the marble crosses the start line and stop it when it gets to 15 cm. Repeat this three times and average the results. You may put an object at the finish line that will make a loud sound when the marble hits it. This will help you stop the watch at the right time.
4. Repeat Step 3, letting the marble roll to 30, 45, 60 and 75 cm. Record all your data in a chart similar to the one below.
5. Repeat the procedure with a higher ramp placed at approximately 45°. Record your data in another data chart.

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Distance	Time 1	Time 2	Time 3	Average Time
15 cm				
30 cm				
45 cm				
60 cm				
75 cm				

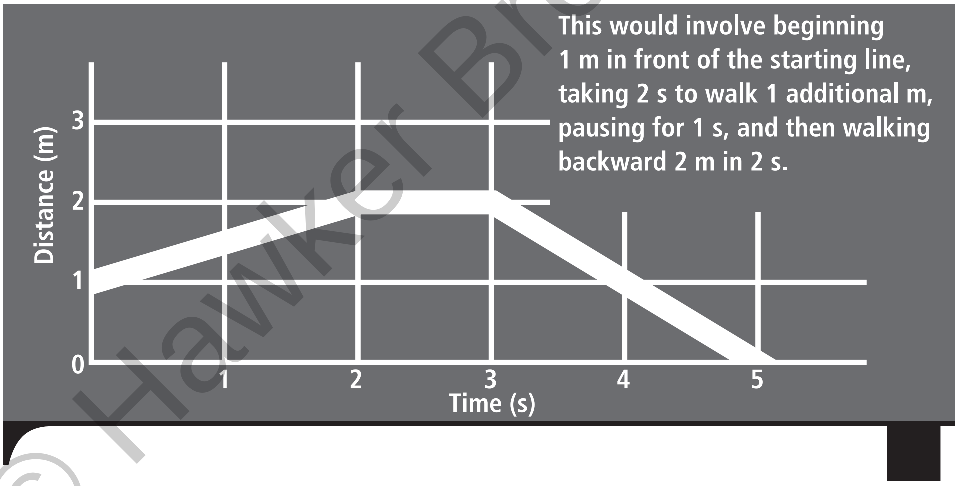
6. On the same axes, draw two line graphs with average time on the horizontal axis and distance on the vertical axis. Be sure to label the axes of your graph.

Post-Lab Questions

1. What is the relationship between the slope of the graph and the speed of the marble?
2. Calculate the slope of the two lines. What are the units of the slope of the line? What does the slope represent?
3. What would the graph in Step 6 look like if the marble approached a wall at a medium speed, collided with a wall at 45 cm, and bounced off and rolled the opposite direction at low speed? Sketch the line on your graph with a dashed line or in a different colour and label it #3.

Extension

Have someone sketch some distance versus time graphs for you and then practice walking in such a way that you would produce that graph. See the example below:



LAB 2: DISTANCE VERSUS TIME GRAPHS 2

This inquiry activity should be performed before students have learned about acceleration but after they have learned about speed. Students should have already completed distance versus time graphs for objects travelling at constant speed (see Lab 1). Some students may know the term *tangent line* and others may not. Teachers are free to change the lab if so desired and should have students create their own data charts. Students should always create their own axes and graphs for experimental data.

Post-Lab Answers

1. The shape is an upward curve. If the object had been slowing down, the shape would be a downward curve.
2. Answers will vary. The first slope will be smaller than the second. This shows that an object travels faster when dropped from a greater height – hence it is accelerating.
3. It takes longer to travel the first half than the last because it is accelerating. Students should see from either their data charts or their graphs that the speed of the marble increases as it falls. A higher average speed over an equal distance will result in a shorter time for the second half.