Elementary Physical Science

Forces & Motion
From High-speed Jets to Wind-up Toys

Teacher’s Guide

Tom DeRosa
Carolyn Reeves
Table of Contents

Introduction .................................................................................................................... T4
Investigation #1: Wind-up Walking Toys................................................................. T6
Investigation #2: Which Way Did It Go? ................................................................. T8
Investigation #3: Investigating Friction ................................................................. T10
Investigation #4: Friction — Does It Rub You the Wrong Way? ......................... T12
Investigation #5: That’s Heavy, Dude ................................................................. T14
Investigation #6: Floating Pencil Race ................................................................. T16
Investigation #7: What Floats Your Boat? .............................................................. T18
Investigation #8: Giving Airplanes a Lift ............................................................... T20
Investigation #9: Crash Test Dummies ................................................................. T22
Investigation #10: Cars and Ramps ........................................................................ T24
Investigation #11: The Mighty Conquering Catapults ......................................... T26
Isaac Newton ........................................................................................................ T28
Drama Project: An Interview with Sir Isaac Newton ............................................. T29
Investigation #12: Round and Round without Stopping ....................................... T30
Investigation #13: Roller Derby with Flour ............................................................ T32
Investigation #14: Balloon Jet Propulsion ............................................................. T34
Investigation #15a: Balancing Act with a Stick ..................................................... T36
Investigation #15b: Balancing Act 2 ....................................................................... T37
Investigation #16: Spinning Tops ........................................................................... T38
Investigation #17: He Ain’t Heavy, He’s Just My Load, Brother ......................... T40
Investigation #18: How Do You Like Your Pulleys — Fixed, Moving, or Combined? ............................................................................................................. T42
Investigation #19: And the Wheel Goes Round .................................................... T44
Investigation #20: If It Doesn’t Move, How Can It Be a Machine? ....................... T46

Scientists:
Archimedes (287–212 BC)
Daniel Bernoulli (1700–1782)
Galileo (1564–1642)
Isaac Newton (1642–1727)
Investigation #1

Speed, Time, and Distance

Think about This

Many people still consider “Bullet” Bob Hayes to be the world’s fastest runner. In the 1968 Olympic Games, he was part of a 4 X 100 relay race. He was already running when he took the baton. He completed his 100 meters of the relay in 8.9 seconds. He also ran the 100-meter dash in 10.05 seconds. In this race, he started from a still position. Four years later at the Mexico City Olympics, James Hines ran an official time in the 100-meter dash that was less than 10.0 seconds for the first time ever. His record stood for several more years, but Bullet Bob’s relay race time will be a hard record to break.

These very fast runners were moving an average of about ten meters every second. Use a meter stick to mark off ten meters along the ground. The batter in his 100-meter dash record stood for several more years, but Bullet Bob’s relay race time will be a hard record to break.

We can calculate the speed of a moving object by testing wind-up toys. How far a wind-up toy moves can be measured with a ruler. How long it takes the toy to move a certain distance can be measured with a watch. Three numbers can be used to calculate its speed.

Objectives

Investigation #1 shows how motion of an object can be described by its speed, time in motion, distance, and direction. Students learn to accurately use a metric ruler. They measure time elapsed and distance traveled for a walking toy. They use this information to make a graph and to calculate speed. Motion can be measured and represented on a graph.

Procedure & Observations

1. For these measurements, you will need a metric ruler where each centimeter is divided into tenths. Look carefully at the markings on the ruler. Notice there is a long line for each number. There are shorter lines following each number. The short lines are written as decimal numbers. Measure the line to the right by putting the zero mark of the ruler at the beginning of the line. The correct answer is found by writing the last whole number, a decimal, and the number of short marks following the number. The abbreviation “cm” is written after these numbers. Did you get 15.3 cm for your answer? Work with a partner. Each of you should draw two or three more lines. Measure each other’s lines. Check each other’s answers.

2. Lay the ruler out in front of you. Wind up the walking toy next to the ruler every time the instructor calls out a five-second interval. Record. Calculate its average speed by dividing the total distance it walked in centimeters by ten seconds.

3. Measure how long it takes for the wind-up toy to walk one meter. Record. Did it make it that far? Record how far it walked and the time it walked. Calculate its average speed by dividing the distance it walked by the time. The speed will be in m/s (meters per second).

4. Go back to the starting point. Wind up the toy again. This time lay down a toothpick next to the ruler every ten seconds. Measure the distances between toothpicks and record in the chart below.

5. Graph the results of distance versus time. Your teacher will show you how to put this information in the graph. Draw your graph make a straight line or a curved line? Try to think of a reason for this.

6. Did your walking toy start out fast and then get slower until it stopped, or did it keep walking at the same speed all the way?

7. Race your walking toy with someone else’s. Which one was the faster?

Note

Measurement is such a basic scientific skill that all students should master how to use a ruler. The measurement of the line should be exact to the nearest tenth of a centimeter. Include exact length of the line students measure. Be sure to give them opportunities to measure other items if some students seem uncertain. For example, have them estimate and measure some things at their workstations, such as the height of the pages in their book in centimeters or the height of a particular letter or number. Measurements smaller than 1 cm should be written as 0.1 cm. A letter might be 0.2 cm in height. Remind students that all scientific measurements are done in metric units. Also, be sure that every measurement includes a number and a unit (cm, m, g, etc.). Generally, a number alone is not a correct answer — an answer must include both a number and a unit.

In making graphs, students should identify evenly spaced lines. Use 0 through 30 seconds for the bottom horizontal axis. For the distance on the vertical axis, you may need to go from 0 to 30 cm, 0 to 60 cm, or 0 to 120 cm, depending on how far they walked.
1. What two things do you need to know in order to calculate speed? Time and distance.

2. What is the formula for calculating speed? Speed = distance/time.

3. How would a line graph of the speed of a runner look when the runner goes slower and slower? It would curve down. Or faster and faster? It would curve up. Or maintains the same speed? It would be a straight line.

4. What are three ways in which motion can be described? By change of position, direction, and speed.

5. If you are riding in a car that is traveling at 60 miles per hour, and you travel for 3 hours, how far have you traveled? 60 mi/hr X 3 hr = 180 miles.

6. Suppose an object is traveling at a supersonic speed of 800 m/s. Write this speed using all words and no symbols. Eight hundred meters per second.

7. Calculate the speed of an animal that ran 50 meters in 10 seconds. Write the number answer with the correct unit symbols. 50 meters divided by 10 seconds = 5 m/s.

8. What is the source of energy for the walking toys you used for this activity? A wind-up spring.