mobile inquiry technology
Teacher Notes

Displaying Velocity Introduction

In this activity, children will use a sonar ranger to observe different rates of movement. Using the sonar ranger will afford them the opportunity to measure and represent motion as a graph. Students will compare graphs that display their movements while speeding up, slowing down, and while changing directions.

Students will investigate and observe graphs at different speeds while:

- realizing that the motion of an object can be described by its position, direction of motion, and speed;
- identifying variables that can affect the outcome of an experiment;
- gaining skills and confidence in using a scientific measurement tool, the sonar ranger, as well as the spreadsheet and graphing capacity of a computer to represent and analyze data;
- observing and understanding when people are accelerating by viewing distance-time graphs of their motion.

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Discussion Guide

Begin the discussion by asking students to describe things that move. What do they mean by motion? How can they prove that motion occurs?

Show the students the sonar ranger. Demonstrate the sonar ranger and its resulting graph on the computer by having a student walk at a steady pace away from the sonar ranger. Have the students draw and label the graph on paper. Be sure to draw attention to the distance and time axes. Explain that a distance versus time graph shows the same speed as a flat line.

Demonstrate changing motion by having a student quickly move away from the sonar ranger for two seconds and for the next three seconds have the student continue to move away but more slowly. After five seconds have the student stop moving. Show the resulting distance versus time graph on the computer. Ask the students to draw and explain the graph within their groups. Explain and show the students that the distance versus time graph shows a line with a lean (right to left or forward) for changing motion at the same speed away from the sonar.

Repeat having students walk at a steady pace (but with different speeds) away from the sonar. This will demonstrate that graphs will become steeper with greater speeds.

Demonstrate changing direction of an object by having a student walk away fast and return rapidly at the same speed to the sonar. Ask the students to work within their groups to draw a distance versus time graph that results from this motion. Display the graph to the students and explain that the lean of the line changes direction (right to left for forward and left to right for backwards) as the motion changes direction.

Direct the students to "Thinking About the Question". After a few minutes, review the student lists. Explain the term "acceleration" by identifying the objects on the list that are truly accelerating---changing in speed or direction or both. Point out to the students that if they are moving at a constant speed in the same direction, they are **not** accelerating. Emphasize that their rate must change over time or they must change their direction.

Dividing the class into two teams (each team with a sonar ranger) is helpful. Refer to Technical Hints to see how to set up the walking track. Direct the students to "Investigation I." Have the teams discuss each movement needed to reproduce the graph. Students should draw the distance-time graph on paper and label the motion needed for each portion of the graph before using the sonar ranger.

Each team should be active members of the process. One student will need to start the sonar ranger by clicking the trigger and another student will need to walk the track with their back to the sonar. All of the other students should count time out loud to provide a good walking pace. At the end of the first try, compare the graphs of the two teams. Allow the students to repeat several times until they are sure that they know the exact motion needed to reproduce the given graph. Have each group print out their best trial.

After the first graph is successfully reproduced, switch roles within the group so other students have the chance to be the focus of the motion. Repeat the process for "Investigation II" and "Investigation III."

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Additional Teacher Background

The sonar ranger doesn't really measure distance or velocity. Instead it measures the time needed for the pulse to leave and return to the ranger. The software determines and displays the distance the pulse covered based on the speed of sound. The velocity is calculated by the software as the rate of change of distance over time and is plotted on the y-axis, while time is plotted on the x-axis.

As you can see from the graph samples, small instantaneous jerks in motion on a distance-time graph will result in large variations on a velocity-time graph. Several attempts may be needed to obtain a smooth velocity-time graph.

To obtain reasonable graphs, the surface that the beam bounces off of should be flat. For this reason, the clothing of the student walking should be free of folds. If the student is walking away from the detector, make sure that they stand straight. Since the width of the beam is only 10 degrees, make sure that nothing else but the student is in the path of the pulse.

Displacement and distance are often used interchangeably. They are not really the same. Displacement is a vector quantity. Vectors describe magnitude and direction. For example, if you leave the front door of your house and run 2 blocks North, 3 blocks West, 2 blocks South, and 3 blocks East, you will end up back at your front door. The displacement is zero, but your overall distance covered is 10 blocks.

Speed and velocity are also used interchangeably, but velocity is a vector. This means that it describes both direction and the magnitude of the speed. Distance and speed are considered scalar quantities, showing only magnitude not direction.

Acceleration is also a vector. An object is accelerating if the rate of speed is not constant and, or, if it changes direction. This is why an object moving in a circular path is accelerating, since it may not be changing in speed, but it is changing direction.

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Displaying Velocity Suggested Timeline

The amount of time you spend on introductory discussions, data collection, and analysis, will determine your overall timeline. The following represents a possible timeline.

- One class period - Introductory Discussion
- One class period - Investigation I: Moving at the same speed...
- One class period - Investigation II: Speeding up!
- One class period - Investigation III: Am I coming or going?
- One class period - Analysis

Additional days can be used for further investigations.

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