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TEACHER NOTES
Making Waves Introduction

In this activity, students will explore the motion of waves. By using a sonar ranger attached to the computer, the students will be able to make and compare different types of waves.

Students will develop a number of key concepts related to line graphs that change over time:

- making and interpreting different graphical shapes;
- comparing line graphs that show different amounts of change;
- 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.

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Discussion Guide

Begin a discussion with the class to review graphs they have made that tell a story of changes over a period of time. Ask a few students to share examples. Show the class an example of a line graph that shows change over time. Ask them to describe the story that the graph represents. Show the class another graph that represents a repeated pattern. Ask them to describe the pattern. Tell the students that the name that scientists have given to these repeating patterns is a wave.

Ask the class: How could we collect and record the data that would represent the movement of an object over time? Suggestions would most likely include some fairly laborious simultaneous distance and time measuring. Why might they want to do this? One example might be the movement of a baseball from the pitcher to the catcher in a baseball game.

Propose to the class that there is a tool that can be used to do this task easily. Show the class the sonar ranger. Ask the class if anyone has heard of sonar. Some examples children might mention include ships using sonar to find objects on the ocean floor or a sonogram to "view" a fetus as it is developing. With out an in-depth discussion, indicate that all of these are examples of measuring the time it takes sound to travel from a source, reflect off an object, and return to the source, to determine the distance of the object. If an object has an irregular shape many sound emissions must be used to map the shape of the object.

To introduce repeated waves, it is helpful to show the motion of a slinky. This can be done by just holding a slinky and letting one end drop and vibrate up and down or by using the sonar detector. If you decide to use the sonar detector, direct the sonar ranger at a flat index card attached to the bottom of a slinky hanging from the ceiling. It may be necessary to place a small weight on the backside of the index card. As a result, each vibration of the slinky will be large enough to detect for some time before dying out. Pull the slinky out of its rest position so that when the sonar detector is activated, repeated oscillations will be graphed.

Indicate to the student that they will be able to try out the sonar ranger to collect and record distance-time data about moving objects in the room. Ask the students to read the first paragraph in "Thinking About the Question". After the students have had an opportunity to share their thoughts hold a brief discussion. Direct the students to complete the reading before moving to the "Investigation I".

To use the sonar ranger with students, it is helpful to divide the class into two teams (each with a sonar ranger). Allow the two teams time to experiment with the sonar ranger. Once the teams have had time to "mess around", ask the students to review the first graph. Have the team discuss each movement needed to reproduce the graph. Each team member should be active in the process. Several different members of each group should try to reproduce the graph. Take time to allow each group to select their best wave maker and have them print out the graph. Have that member display their method for reproducing the graph. Repeat this process for each of the graphs.

The sonar ranger doesn't really measure distance. Instead it measures the time needed for the pulse to leave the sonar ranger and bounce off the target and return to the sonar ranger. The software determines and displays the distance the pulse covered based on the speed of sound.

To obtain reasonable graphs, the surface that the sound pulse bounces off should be flat. If the object is a box, a flat and smooth side must be facing the sonic ranger at all times. As the sound pulse travels further away from the sonar ranger, it spreads out about 10 degrees. Make sure that nothing else but the object that you are detecting is in the spreading path of the pulse. The sonar ranger is very sensitive to movement. Students should be careful to not shake or move the sonar ranger sideways will graphing. This will result in sudden added peaks in the graph that are not expected.

After the students have completed questions 1-3 in the "Analysis" hold a class discussion to share their responses. Display an example of each kind of waves on an overhead. Ask students to trace the graph of the motion from its starting point in one direction until it returns to that point. Repeat this procedure for each graph. Tell the students that this represents **one cycle** or **wave**. Direct the students to complete the remainder of questions in the "Analysis". When they have finished hold a class discussion to share responses.

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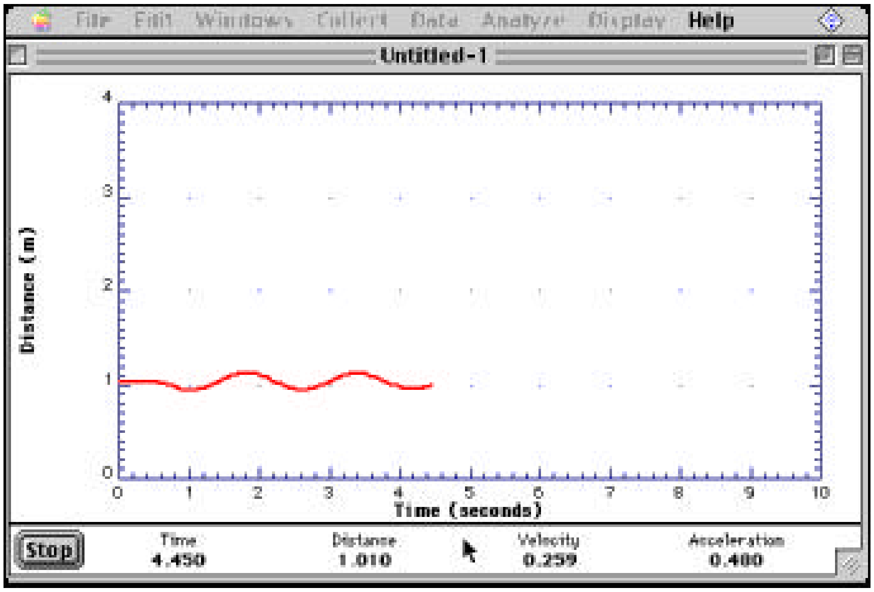
Additional Teacher Background

Amplitude and wavelength are special terms used to describe a wave. In the curved wave shown below, the **amplitude** is the height (or depth) of a wave. Amplitude is measured by calculating half the total distance from the top of the wave to the bottom. The **wavelength** is the distance between successive identical parts of the wave, that is, from the top of one wave to the top of the next wave. If you look closely, you may notice that the amplitude of the wave shown below decreases over time.



Another special term that is used to describe a wave is based on time. The number of complete waves in a second is the **frequency** of the wave. If two waves occur in one second, the frequency is two waves (or vibrations) per second. In the case of the slinky, the waves become less frequent as the slinky loses energy.

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Making Waves 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: Observing and making curved waves
- One class period - Investigation II: Observing and making a square waves
- One class period - Investigation III: Observing and making a triangular waves
- One class period - Analysis

Additional days can be used for further investigations.

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