12 Blind as a Bat

Purpose

To produce and compare graphs of different motions

Required Equipment/Supplies

computer, sonic ranger and sonic ranging software
masking tape
marking pen
can of soup (such as bean with bacon)
board
printer (optional)

Discussion

A bat can fly around in the dark without bumping into things by sensing the echoes of squeaks it emits. These squeaks reflect off walls and objects, return to the bat's head, and are processed in its brain to provide the location of nearby objects. The automatic focus on some cameras works on very much the same principle. The sonic ranger is a device that measures the time it takes for ultra-high frequency sound waves to go to and return from a target object. The data are fed to a computer where they are graphically displayed. The program can display the data in three ways: distance vs. time, velocity vs. time, and acceleration vs. time. Imagine how Galileo would marvel at such technology!

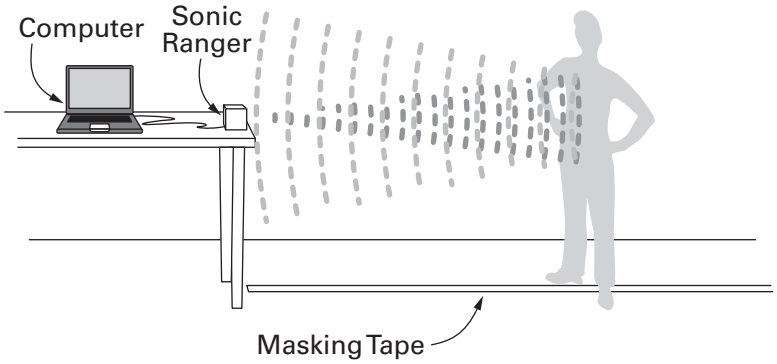
Procedure

Step 1: Your instructor will install the sonic ranger software on the computer for you. Familiarize yourself with the operation of the sonic ranger. Place the sonic ranger on a desk or table so that its beam is about chest high. (Note: Sometimes sonic rangers do not operate reliably on top of computer monitors.)

Select the option that plots distance vs. time. Adjust the sonic ranger so it graphs continuously. Depending on the ranging device you're using, readings at distances closer than 15 cm may be erratic. Test and see. Make small pencil marks or affix a piece of string to the floor in a straight line from the sonic ranger. Point the sonic ranger at a student standing at the 5-meter mark. Mark where the computer registers 0 m, 1 m, 2 m, etc. Set the maximum range approximately between 4 to 6 meters.

Part A: Analyzing Motion Plots

Step 2: Stand on the 1-meter mark. Face the sonic ranger and watch the monitor. Back away from the sonic ranger slowly and observe the real-time plot. Repeat, backing away from the sonic ranger more quickly, and observe the graph.



1. Make a sketch (or printout, if a printer is available) of each graph. How do the graphs compare?

Step 3: Stand at the far end of the string. Slowly approach the sonic ranger and observe the graph plotted. Repeat, walking faster, and observe the graph plotted.

2. Make a sketch of each graph. How do the graphs compare?

Step 4: Walk away from the sonic ranger slowly; stop, then approach the sonic ranger quickly.

3. Sketch the shape of the resulting graph. How do the slopes change?

Step 5: Repeat Step 2, but select the option to display a plot of velocity vs. time.

4. Make a sketch of the graph. How do the distance-vs.-time and velocity-vs.-time graphs compare?

Step 6: Repeat Step 3, but select the option to display a plot of velocity vs. time.

5. Make a sketch of the graph. How do the two new graphs compare?

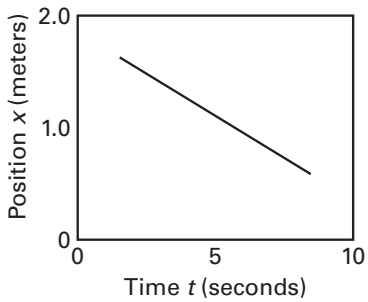
Step 7: Repeat Step 4, but select the option to display a plot of velocity vs. time.

6. Sketch the shape of the resulting graph. How do the slopes change?

Part B: Move to Match the Graph

Generate a real-time plot of each motion depicted below and write a description of each. *Do not use the term "acceleration" in any of your descriptions*. Instead, use terms and phrases such as "rest," "constant speed," "speed up," "slow down," "toward the sonic ranger," "away from the sonic ranger." Generate each graph below. When you are ready, initiate the sonic ranger and move so that your motion generates a similar graph. Then describe the motion in words.

Example: Position-vs.-Time Graph

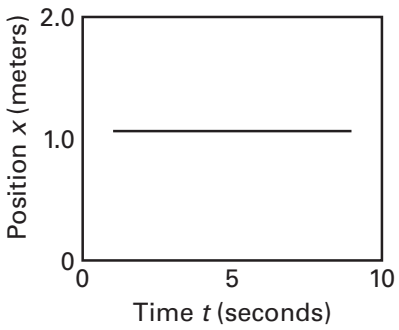


Description

Move toward the sensor (sonic ranger) at constant speed.

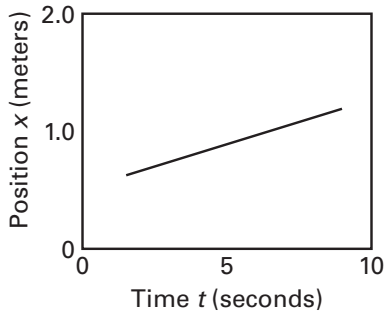
Make sure each person in the group can move to match this graph before moving onto the next graph.

1. Position-vs.-Time Graph



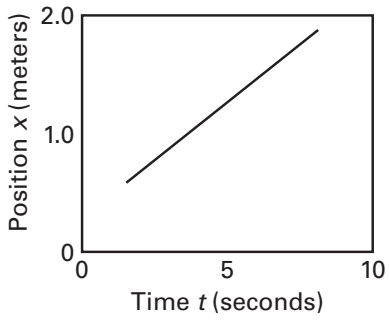
Description

2. Position-vs.-Time Graph



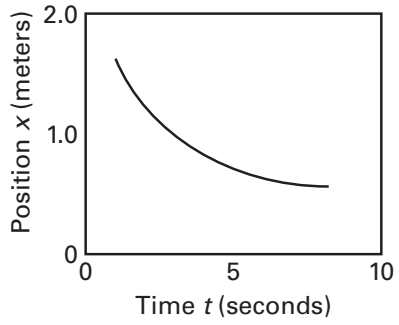
Description

3. Position-vs.-Time Graph



Description

4. Position-vs.-Time Graph



Description

Name Period Date

Part C: Move to Match the Words

Walk to match each description of motion. Draw the resulting position-vs.-time graph.

5. Description

Move toward the sensor (sonic ranger) at constant speed, stop and remain still for a second, and then walk away from the sensor at constant speed.

Position-vs.-Time Graph

6. Description

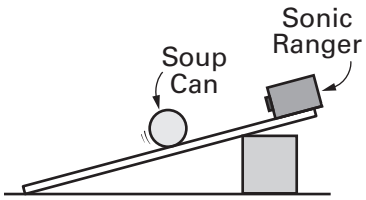
Move toward the sensor at decreasing speed, and then, just as you come to rest, move away from the sensor with increasing speed.

Position-vs.-Time Graph

7. Description

Move away from the sensor with decreasing speed until you come to a stop. Then move toward the sensor with decreasing speed until you come to a stop.

Position-vs.-Time Graph



Going Further: Analyzing Motion on an Incline

Set up the sonic ranger as shown in Figure A to analyze the motion of a can of soup, dynamics cart, or a large steel ball that is rolled up an incline and allowed to roll back. Practice rolling the can up the incline. Make sure the can is always at least 0.2 meter away from the sonic ranger. Predict what the shapes of distance-vs.-time and velocity-vs.-time graphs will look like for the can, cart, or ball as it rolls up and down the incline.

1. Make a sketch of your predicted graphs.

Select the option so that both distance vs. time and velocity vs. time are displayed simultaneously.

2. Sketch the shape of the distance-vs.-time graph and velocity-vs.-time graphs.

3. Is the velocity-vs.-time graph a straight line? Is the slope positive or negative?