13 Bring Home the Bacon

Purpose

To investigate the motion of an object as it rolls down an incline

Required Equipment/Supplies

sonic ranger
computer and printer or graph paper
1–2 meter incline
can of soup with solid, nonsloshing contents (such as bean with bacon) or large ball
meterstick

Note: For best results, use an incline that is as smooth and flat as possible. If you are using wood, laminated shelving is preferred to solid boards because boards tend to warp. Using an undented can of soup works well; balls have a tendency to roll to one side. If you use a ball instead of a can, a smooth, massive ball such as a billiard ball is recommended.

Discussion

By sensing the echoes of squeaks it emits, a bat can fly in complete darkness without bumping into things. 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, as does the *sonic ranger*.

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 computer processes the data from the sonic ranger and the graphs in real time. The program can display the data in three ways: distance vs. time, velocity vs. time, and acceleration vs. time.

In this experiment, you will use a sonic ranger to compare the motion graphs of an object accelerating down an incline.

Procedure

Step 1: Set up an incline and adjust it to about 5–10 degrees above the horizontal. Set your sonic ranger to collect data. Your teacher will assist you with the setup and operation of the sonic ranger. Position the sonic ranger at the *top* of the incline. Mark a release point on the incline *no closer than 15 cm* from the ranger (its minimum range) with a piece of masking tape or small pencil mark. Practice releasing the can and allowing it to roll down the incline several times.

Release the can as soon as your lab partner activates the sonic ranger. Remember that the can must be released at least 15 cm from the sonic ranger. After successfully collecting data, plot the distance-vs.-time data.

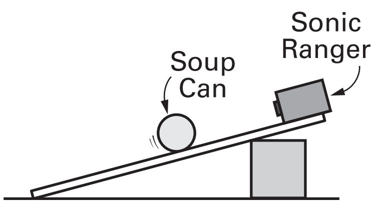

Fig. A

Step 2: After you have plotted the data, describe the shape and character (positive or negative slope, steep or not steep) of the distance-vs.-time graph. Does the slope increase, decrease, or remain constant as time increases? If a printer is available, make a printout of the graph. If not, draw the graph on a piece of graph paper. Be sure to label the axes with both quantities and units.

Step 3: Now plot the data as a velocity-vs.-time graph. Describe the graph. Is the slope of the graph constant? Does the slope increase, decrease, or remain constant as time increases? Make a printout or draw this graph. Be sure to label the axes completely.

Step 4: Repeat the experiment but this time roll the can up the incline to the point where you released it in Step 1. This may require some practice to roll the can and coordinate activating the sonic ranger with your lab partner. Try to keep your hand flat and straight as you roll the can so that it goes straight up the incline. Take care *not* to overshoot the 15-cm mark on the incline.

Step 5: Repeat Steps 2 and 3 to collect and analyze the data.

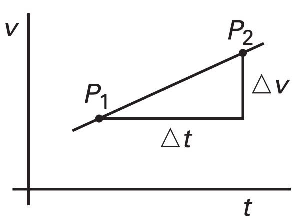

Fig. B

Step 6: If the slope is constant (or nearly so), select the coordinates of two points on the velocity-vs.-time graph and use them to calculate the slope. Pick two points that represent a good average of your data (the straight portion of the graph). Label these two points as P_1 and P_2 on the velocity-vs.-time graph in your lab book. Make a right triangle formed by the velocity-vs.-time graph and the horizontal and vertical lines passing through P_1 and P_2. Use the sides of the triangle to calculate the slope (rise/run) of the graph, $\Delta v/\Delta t$.

Analysis

1. How are the distance-vs.-time and velocity-vs.-time graphs related for objects undergoing constant acceleration?

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2. How would your results differ if the sonic ranger were positioned at the bottom of the incline instead of at the top? Try it and see if you are correct.

3. How are your results comparable to the distance-vs.-time and velocity-vs.-time graphs for a ball thrown in the air?

Going Further

Step 7: Manipulate the power of the *x*- and *y*-values of the distance-vs.-time data on the computer until the graph is linear. Ask your teacher for assistance on how to go about doing this.

4. What combination of powers of distance and time graph as a straight line? How are distance and time related?

Step 8: Your software can calculate the area under a velocity-vs.-time graph by calculating the area of the trapezoids formed by the data. Select this option for your velocity-vs.-time graph. Record the calculation displayed by the computer.

area under the graph = _______ m

5. How does this compare with the distance traveled by the can as measured by a meterstick?