4

Accelerated Motion

Bring Home the Bacon

Purpose

To investigate graphs of the motion of an object rolling down an incline.

Required Equipment and Supplies

Super Sonic Plus ultrasonic ranging system
Apple II Series computer
1–2 meter incline
can of soup with solid, non-sloshing contents (such as bean with bacon)

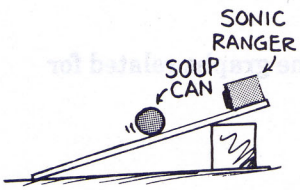
Note: For best results, use an incline that is as smooth and flat as possible. If you are using wood, laminated shelving is preferred to solid boards because boards tend to warp. Using a can of soup works well; balls have a tendency to roll to one side. If you use a ball instead of a can, a smooth, massive, steel ball or 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, and so 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. With the *Super Sonic Plus* program, the data from the sonic ranger 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.

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

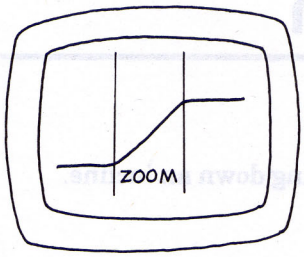
Procedure



Step 1. Adjust the incline to about 5–10 degrees to the horizontal. Boot the *Super Sonic Plus* disk and go to the "Graph Set-Up" screen. Position the sonic ranger at the *top* of the incline. Set the "Maximum Range" of the sonic ranger to slightly more than the length of the incline. Mark a release point on the incline *no closer than 40 cm* from the sonic ranger (its minimum range) with a piece of masking tape or small pencil mark. Release the can and allow it to roll down the incline several times. Estimate the time it takes for it to roll down the incline. Adjust the "Graph Duration" to somewhat *longer* than your estimate.

Select "Collect Data" to prepare the sonic ranger. Release the can as soon as your lab partner activates the sonic ranger by pressing any key. Remember that the can must be released at least 40 cm from the sonic ranger. Release the can several times, making any adjustments to the "Maximum Range" and "Graph Duration" that may be necessary. You may return the main menu to "Collect Data" at any time in the program by pressing

"Control-R" or selecting "Recollect Data." After successfully collecting data, select "Regraph" to plot the data.

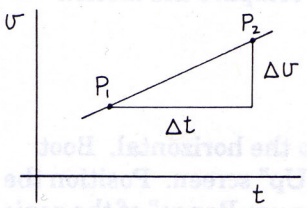


Step 2. After you have regraphed the data as a graph of distance vs. time, describe the graph. Use the "Zoom" option to omit non-relevant data. Describe the distance vs. time graph. Does the slope increase, decrease, or remain constant as time increases? Make a printout of the graph and tape it into your lab book or sketch it in your lab book. Be sure to label the axes completely.

Step 3. Regraph the data as a graph of velocity vs. time. 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 below. Be sure to label the axes completely.

Step 4. Adjust the "Graph Duration" to be approximately twice as long and collect data as in Step 1, 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 40 cm mark on the incline.

Step 5. Repeat Steps 2 and 3 with these new conditions.



Step 6. If the slope is constant (or nearly so), use the "View" option to 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. 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, $\Delta v/\Delta t$.

Analysis

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

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 and velocity vs. time graphs for a ball thrown in the air?

4. Suppose the can and the incline were replaced by a glider sliding down a nearly frictionless sloping air track. In what way(s) would you expect the motion graphs of the glider to be the same as those for the can rolling down the incline? How would they be different?

Going Further

Step 7. Select the "Data Manipulation" option from the "Graph Menu" screen.* Manipulate the power of the x and y values of the distance vs. time data until the graph is linear. What powers of distance and time graph as a straight line? How are distance and time related?

Step 8. *Super Sonic Plus* can estimate the area under a velocity vs. time graph by calculating the area of the trapezoids formed by the data. Select the "Area" option for your velocity vs. time graph. Record the estimate displayed by the computer.

area under the graph = _____ m

5. How does this compare with the distance traveled by the can?

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* Data manipulation routines are included in the *Super Sonic Plus* program but not in *Super Sonic*. If you are using *Super Sonic*, you can achieve much the same results, however, using the data manipulation routines in *Data Plotter*. To do so, select "Data Options" in *Super Sonic* and save your distance data in the "Data Plotter" format on a separate data disk. Then graph your data using *Data Plotter*. Do this by booting *Data Plotter* and selecting "Super Sonic" on the "Graph Selection" screen. Select your saved data file and "Continue." Manipulate your data with "Graph Set-Up" from the "Graph Menu" screen.