69 Grandfather's Clock

Purpose

To investigate how the period of a pendulum varies with its length

Required Equipment/Supplies

ring stand
pendulum clamp
pendulum bob
string
graph paper or data plotting software and printer
stopwatch or
computer with photogate timing system
ring stands with clamps

Discussion

What characteristics of a pendulum determine its period, the time taken for one oscillation? Galileo timed the swinging of a chandelier in the cathedral at Pisa using his pulse as a clock. He discovered that the time it took to oscillate back and forth was the same regardless of its amplitude, or the size of its swing. In modern terminology, the period of a pendulum is independent of its amplitude (for small amplitudes, angles less than 10°).

Another quantity that does not affect the period of a pendulum is its mass. In Activity 68, Tick-Tock, you discovered that a pendulum's period depends only on its length. In this experiment, you will try to determine exactly *how* the length and period of a pendulum are related. Replacing Galileo's pulse, you will use a stopwatch or a computer.

Procedure

Set up pendulum.

Step 1: Set up a pendulum using the listed equipment. Make its length 65 cm. Measure its period three times by timing the oscillations with the stopwatch or the computer system. (If you are using a computer to measure the period of your pendulum, set up the light probe. Use clamps and ring stands to position a light source (such as a flashlight) so that the pendulum bob eclipses the light probe somewhere in its path.) Record the average period in Data Table A.

Shorten pendulum and repeat.

Step 2: Shorten the pendulum length by 5 cm. Measure its period as in Step 1, and record the average period in Data Table A.

Length (cm)	Period (s)
65	
60	
55	
50	
45	
40	
35	
30	
25	
20	
15	
10	

Data Table A

Step 3: Complete Data Table A for the remaining pendulum lengths indicated there. Measure periods as you did in Step 1.

Step 4: Make a graph of the period (vertical axis) vs. the length of the pendulum (horizontal axis).

1. Describe your graph. Is it a straight line that shows that the period is directly proportional to the length? Or is it a curve that shows that the relationship between period and length is not a direct proportion?

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Step 5: Often data points lie on a curve that is not a straight line. It is very difficult to determine the relationship between two variables from such a curve. It is virtually impossible to extrapolate accurately from a curve. Experimenters instead try to produce a straight-line graph by plotting appropriate functions (squares, cubes, logarithms, etc.) of the variables originally used on the horizontal and vertical axes. When they succeed in producing a straight line, they can more easily determine the relationship between variables.

The simplest way to try to "straighten out" a curve is to see if one of the variables is proportional to a power of the other variable. If your graph of period vs. length curves upward (has increasing slope), perhaps period is proportional to the square or the cube of the length. If your graph curves downward (has decreasing slope), perhaps it is the other way around; perhaps the square or the cube of the period is proportional to the length. Try plotting simple powers of one variable against the other to see if you can produce a straight line from your data. If you have a computer with data plotting software, use it to discover the mathematical relationship between the length and the period. A straight-line plot shows that the relationship between the variables chosen is a direct proportion.

2. What plot of powers of length and/or period results in a straight line?

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Predict pendulum length.

Step 6: From your graph, predict what length of pendulum has a period of exactly two seconds.

predicted length = ___________

Measure pendulum length.

Step 7: Measure the length of the pendulum that gives a period of 2.0 s.

measured length = ___________

3. Compute the percentage difference between the measured length and the predicted length.

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