MAKE A Pendulum

LEARNING OBJECTIVES

Students will learn to:

- **Create a simple scientific experiment**
- **Measure the "period" of pendulums as a function of their length**
- **Collect and plot data**
- **Determine a law of nature**
- **Make predictions based on that law**
- **Understand the power and generality of laws of nature**

MATERIALS NEEDED

- **String**
- **Scissors**
- **Key**
- **Stopwatch (or phone with a timer function)**

Above: You can see an actor depicting "young Alan" experimenting with pendulums of different lengths in SEARCHING part 1. Watch this TikTok video to learn more.

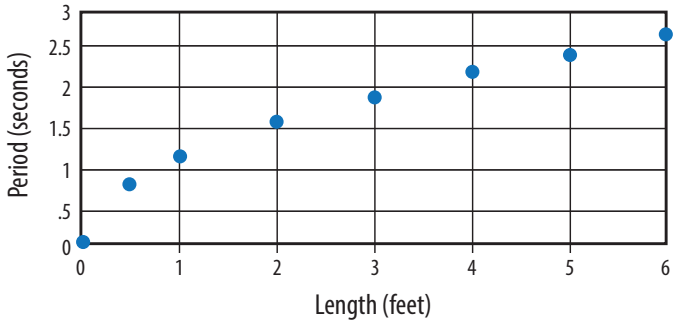
Learn the science of pendulums by making your own, and graphing the results of your experiments.

Activities

Cut off a length of string, attach a key at the end of it to provide some weight, and let the key swing back and forth, as shown in this video.

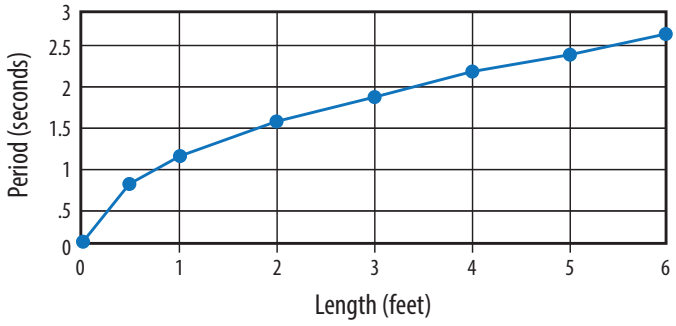
Now, let's see if there is any definite relationship between the length of the string and the time it takes the pendulum to make one complete swing, called the period. Let the pendulum swing back and forth 4 times, measuring how long that takes, and then dividing by 4 to get the time for one swing, the period. (Letting the pendulum go several times averages out any small mistakes in starting and stopping your stopwatch. Such a recognition of small errors and compensating for them is part of the "scientific method.")

Figure A: PENDULUMS



If you have a good supply of string and a pair of scissors, you can make pendulums of different lengths. For a string length of 1 foot, you should get a period of about 1.1 seconds; for a length of 2 feet, you should get a period of about 1.6 seconds; for a length of 4 feet, you should get a period of about 2.2 seconds. But don't take my word for it. Make your own pendulums and do the experiments. If you want, you can plot your data, as in the figure A.

Figure B: PENDULUMS



If we draw a curve through our data points, it looks like the curve in figure B.

The more data points you have, the smoother the curve. In fact, you can now use this curve to predict the period of a pendulum even before you have made it and timed it. Try that out. Make a new pendulum at a length you

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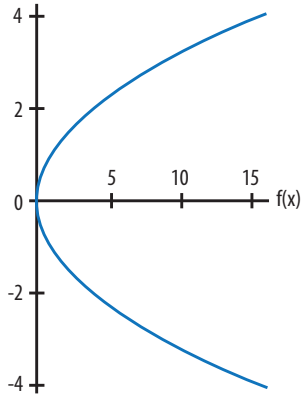
have not made before, use the curve to predict its period before letting it swing, then measure its period. Voila! You can make a successful prediction with the law you have found for pendulums. The curve is the law. That curve is called a parabola.

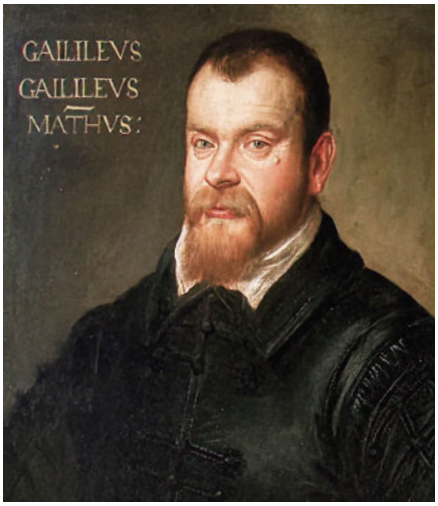
Figure C: PARABOLA



For the more advanced students:

Mathematically, the relationship is: **Period = 1.1 seconds x √ length** where √ is the symbol for "square root" and can be found on most calculators, and Length is in feet. This law for pendulums was first found by Galileo around the year 1590. It is not true because we believe everything the great man Galileo says, or because we read it in some book, or because we *want* it to be true. It is true because nature tells us that's the way she operates. Nature is lawful. And you have just discovered a law of nature for yourself. You are a scientist!

There are a couple more things to say about the pendulum law and about the parabola. We did indeed discover the law experimentally. But with a bit of college physics, using very general equations for force and acceleration not particular to pendulums, we could also have *theoretically derived* the law, even without ever making any pendulums. When we do that, we find that the 1.1 seconds in our formula actually comes from the number 2 x **π** / √g , where g stands for the acceleration of gravity and **π** is the number equal to the circumference of any circle divided by its diameter, equal to about 3.14. On Earth, g is 32 feet per second per second. On the Moon, the acceleration of gravity is about 5.3 feet per second per second, so the 1.1 seconds in the above law for earthly pendulums would be replaced by 2.7 seconds for the Moon. The rest of the formula is the same.



Galileo

Discussion

- **What have you learned about the behavior of nature from this activity?**
- **Do you think the law for pendulums that you have found would be true if you repeated the experiment tomorrow ("yes"), or in another country ("yes"), or on another planet? ("Likely not!")**