

# SWING ALONG WITH A PENDULUM

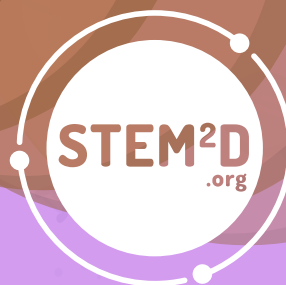
*CLOCKING A SECOND*

**Target Audience:**

*Students, ages 11–18*



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# Swing Along with a Pendulum: CLOCKING A SECOND

**Challenge:** Construct a pendulum that swings 60 times in one minute

**Target Audience:** Students, ages 11–18

## ACTIVITY DESCRIPTION

Students learn the properties of a pendulum and the forces at work as it swings. They apply problem-solving, engineering design, and trial and error to construct a pendulum that swings 60 times in a minute, marking one second with each swing.

## Materials

**For 100 students:**

- 5 Sturdy metal hangers
- 1 Ball kite string
- 5 Metersticks, marked in centimeters or inches
- 200 Metal washers, various weights and sizes
- 1 Box paper clips
- 2 Pairs scissors
- 5 Stopwatches (smartphones or watches with second hands can be used)
- 100 Sheets note paper
- 10 Pencils

## Instructions:

1. Tie a washer to the end of piece of string, 50 cm long. Tie the other end of the string to a hanger. The string should be able to swing back and forth from a fixed point on a hanger. Probe the students' understanding of a pendulum. What two forces are at work? (*Gravity between Earth and the pendulum and friction between the string and the hanger and between the pendulum and air as it passes through*).
2. Have the students cut a piece of string 50 cm (20 inch) long.

3. Have them tie a paper clip on one end of the string and tie the other end to a hanger.
4. Let the students experiment with putting various weights of washers on the paper clip and swinging them on the 50 cm (20 inch) string pendulum. Have them time and record the number of swings in a minute. One swing equals the complete swing movement forward and back.
5. Ask how many swings per minute they recorded for each set of washers.
6. Ask, "Did the weight of the bob (washers) change the number of swings in a minute?" *(The answer should be "No.")*
7. Ask, "If the weight doesn't affect the number of swings, what else might?" *(The length of the string does, but students likely will not know this yet.)*
8. Guide students to realize they can change the length of the string. Ask, "Do you think you need a longer string or a shorter string to have the pendulum swing 60 times in a minute?" They can shorten their 50 cm (20 inch) string and discover that was the wrong direction, and they need to lengthen the string.
9. If time allows, let the students keep trying different lengths of string to meet the 60 swings per minute challenge. If not, suggest they double the length of the string and time a 1 m pendulum. *(A 1 m pendulum is very close because a 97.5 centimeter (39-inch) string should time at exactly 60 swings per minute, marking 1 second per swing.)*
10. Let the students make the needed adjustments to meet the challenge.
11. Remove the string from the hanger.
12. Students can have as a takeaway the 1 m string pendulum with paper clip and washer.

## Background Information/Resources

Pendulums are at work every day in construction, recreation, music, ceremony, science, and art. Every pendulum is some kind of mass hung on a near weightless string or rod from a fixed point that swings freely by the force of gravity and remains in motion until another force stops it. Although, strictly speaking,

the function of most designed pendulums is to regulate movement and provide measurements, anything that hangs from a focal point and swings in an arc is an example of pendulous motion.

A pendulum is used in a metronome, which helps maintain the speed of music. The metronome dates to the 19th century. It is a hollow box with a pendulum attached to a moving weight with a fixed weight at the bottom. A number scale allows the musician to adjust the tempo desired for the piece being played. The scale indicates the number of fluctuations per minute so the tempo of the music can be matched with the beat of the metronome.

Pendulums are used in seismometers, which measure earth motion caused by earthquakes and other Earth events. Pendulums are also used in other scientific instruments. They can be used to prove that the planet rotates on an axis. And they are a popular device used in clocks.



The six-story Foucault pendulum in the Mitchell Physics Building at Texas A&M University.

A pendulum consists of only a few components, including a length of string or wire, some type of weight, called a bob, and a fixed hanging point.

There are two forces that act on a pendulum when it is set in motion. These forces are gravity and friction. Gravity is the force that acts between Earth and the pendulum. Friction is the force that acts between the string and hanger in the student models. Instrumental pendulums are designed to minimize this friction. Friction also acts between the pendulum and the air it moves through. Both these frictional forces will eventually stop a pendulum from swinging.

In the absence of friction, a pendulum takes the same amount of time to make every swing, no matter how heavy the weight at the end of it is. The longer the pendulum, the more time it takes to complete its swing: the shorter the pendulum, the more quickly it travels back and forth. Since it takes one second for a length of string measuring 1 m to swing back and forth, time can be measured with accuracy.



## Questions/Assessment:

1. What did you learn about a pendulum?
2. If you used your pendulum to tell time, would it be accurate?
3. What force would eventually cause a pendulum to stop?



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