TEACHWITHPORTALS™

## Subject: Physics

## Title: Portal "Bouncing" and Oscillations, Lesson 1

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**School / Organization, City and State / Province:**

Belmont University, Nashville, TN

**Grade level:** 9th grade

**Standards met:**
Frameworks PS2.C: Stability and instability in systems (5th through 12th)
Frameworks PS4.A: Properties of waves—Amplitude (by end of grade 8)
Frameworks Practice 4: Graphing

**Time needed for lesson:**
45 minutes

**Objective(s) / Overarching question:**

- What is an oscillation?
- How does an oscillation in Portal 2 compare to oscillations in the real world?
- How can you measure and graph an oscillation?

**Summary:**
Students see that they can create an oscillation by passing through two portals themselves or by dropping a cube through two side-by-side portals. They observe what happens and discover that they can measure the period of the oscillation and graph its motion.

**Vocabulary:** Oscillating, Oscillator, Oscillation, Friction, Period

**Student Prerequisites:**
Experience with a stopwatch and graphing; familiarity with the term friction

**Teacher Materials needed:**
None

**Student Materials needed:** A stopwatch, Graph paper

APERTURE LABORATORIES

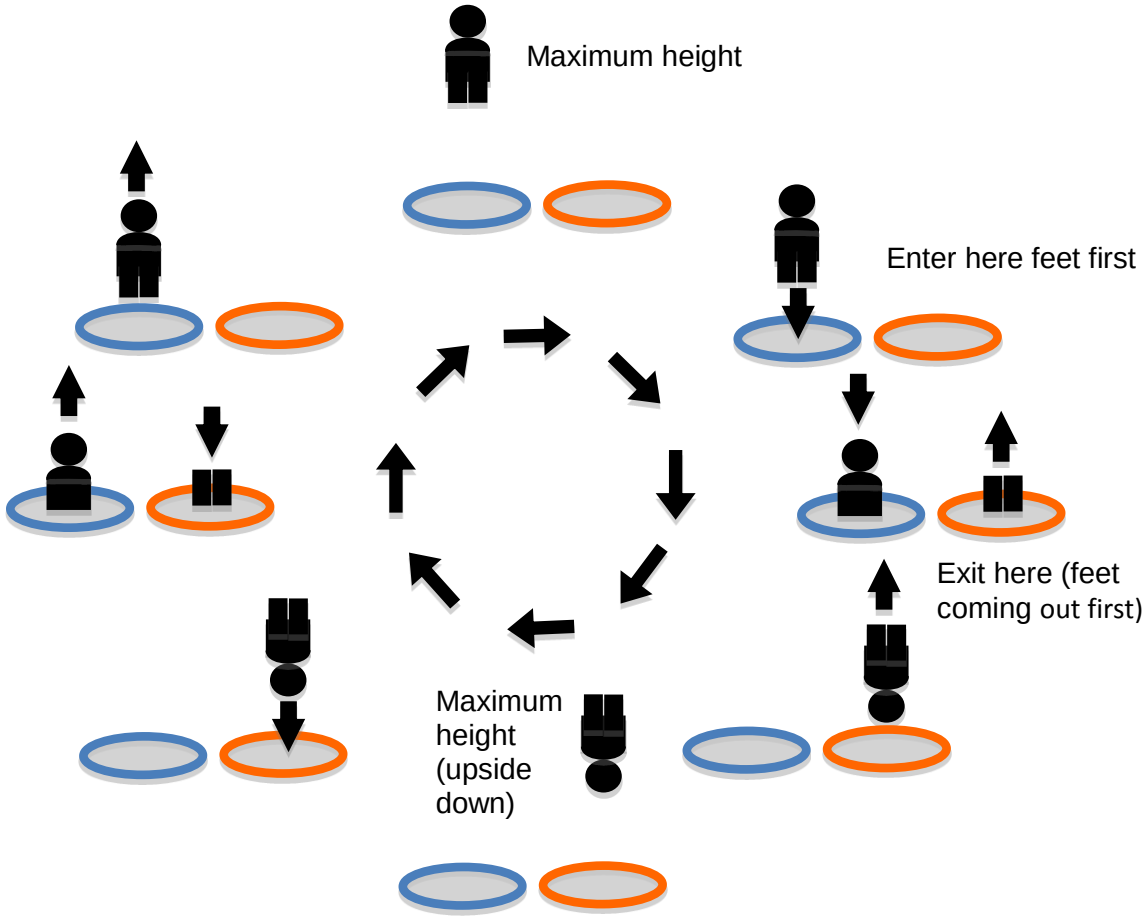
## Lesson Plan

### Making observations

Open two portals, next to one another, on the floor of a test chamber. Drop a cube—or yourself—inside one of them! Describe what happens and make a sketch that illustrates what happens.

### Creating an oscillator

This graphic illustrates what happens to you when you drop into a portal.




Whatever gets dropped in one portal comes out moving upward through the other portal. Then the object—or you—reaches a maximum height, starts falling, and eventually comes back upward from the original portal. It's like bouncing off the floor, but you turn upside down each time you bounce!

## What is an oscillator and oscillation?

When something moves repeatedly back and forth (or up and down), we say that it is **oscillating**. And an object that oscillates is an **oscillator**. One example is a pendulum, such as a girl on a swing, going back and forth. In this case, the girl is oscillating.

**Oscillation** is one of the most basic processes in the universe. From piano strings, to tree branches in the wind, even to stars within galaxies, so many things in nature oscillate!

Here's another example of an oscillator. Imagine a little red ball that can roll down a hill. If you start the ball in the place shown, it will roll down and to the right, into the valley and back up on the other hillside until it comes to a stop. Then it will start rolling back down and to the left, into the valley and up the first hillside. If there's not much in the way to slow the ball down, this oscillation will continue for a very long time.

a. Describe how a cube moving through two portals is similar to a girl on a swing and the ball rolling through a valley.
b. Predict how the height at which the ball is placed on the hill affects where it might roll on the opposite hill. Explain your answer.
c. If the hillside and valley had a rough surface, the red ball would encounter a lot of **friction**. In this case, the ball will not continue to roll back and forth for long. Does friction affect the oscillation of a cube through two portals?
d. Many things in nature and daily life oscillate. Describe a couple of examples.

## Measuring oscillation

The time it takes for the ball to make it back to its original position is called the **period** of the oscillation.

Many things in nature have some period of their motion that we use to time things. The time it takes for the moon to go around Earth and come back to its starting point, for example, is called a month. If you or your parents have a digital watch, you happen to be using a tiny oscillator. Inside a digital watch is a tiny crystal. The crystal oscillates with a certain period that is used to tell the time!

a. What is the period for Earth revolving around the sun?
b. What is the period for Earth making one complete revolution?

c. Let's say the ball on the hill in our example makes 5 complete back-and-forth trips in 5 minutes. What is the period of the ball?

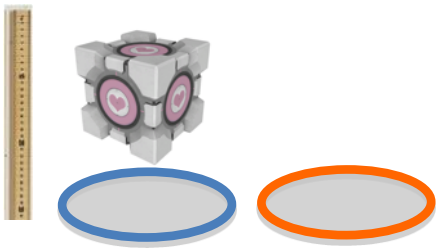
## What's the period of a cube?

Now go back to Portal 2. Using a clock or a stopwatch, find the period of the oscillation of a cube through two side-by-side portals.

a. Compare the period of your cube with the data for period of other players. Are the values the same or different? What might explain similarities or differences in timing the period?
b. Does the period of the cube stay the same over time? Why or why not?

## Extension: Graphing the motion of an oscillator

Imagine there is a tall measuring stick placed on its short end right next to each portal. This measuring stick would allow you to measure the height of the cube over time as it moves in and out of each portal.



Now imagine what a graph of this motion would look like. Make a sketch of your idea. Here are some hints: Place height on the *y*-axis and time on the *x*-axis. Consider that motion through one of the portals could be considered to be negative motion.

Hint: The result will show *simple harmonic motion*, which is the subject of our next lesson…