

Foucault Pendulum

Exhibit: Foucault Pendulum

Location: First floor

Ties to other exhibits:

Small pendulum, Rotation video kiosk

Pre-visit

Students will prepare for the planetarium visit by discussing the fact that Earth rotates or turns on its axis.

Directed questioning: Does Earth Rotate? How can we tell? If it does, what direction does it rotate? Does it turn E to W or W to E? What is a pendulum? What have they been used for throughout history? What effect would changing the weight, length of cable, or size of swing (amplitude) have on the pendulum? What keeps it running? What factors act to stop it? How long does it take to knock down all the pegs? (see picture on internet)

***Don't forget to take the worksheet for Galileo III along to the planetarium!**

Activities

Objective: Students will experiment with the Galileo activities in detail and make observations at the planetarium, then try to verify their answers to the above questions.

Directions

Galileo I.

Provide supplies and let the students work through the worksheet.

Help students realize that friction due to air resistance is a factor in their experiments.

Galileo II.

The fundamental pendulum system has three variables; **mass, string length, and amplitude** (how far the string is pulled from vertical). Each variable has a different effect on the period of the Pendulum. The nature of experiment design becomes real as students try to separate the three functional relationships. You may need to use guided questioning to get students to identify the three variables.

Galileo III.

**They will need to collect data while at the planetarium to support their project in Galileo III. It is this activity that has the most direct tie to the planetarium. The answer can be found by taking the total number of pegs and multiplying by the time it takes for 1 peg to fall. Timing should start immediately after the previous peg has fallen. Will the computed answer be the exact time for all pegs to fall? What other factors must be considered that can affect the results (are all pegs equally spaced etc.)? Why is your answer different than the stated value (on the pendulum graphic)?*

Sample Calculation: 49 pegs per gang X 8 gangs X 3 min per peg **divide by** 60 minutes per hour = 19.6 hours to knock down all pegs. You must multiply by 2 if you want to know how long it takes to go around the whole circle.

Science, Galileo-style

Teacher Lesson Plan

Credit: this activity was modified from *Thursday's Classroom* on the web.
<http://www.thursdaysclassroom.com/03feb00/lesson4.html>

Background:

Galileo Galilei (1564-1642) is, in the eyes of many, the first modern scientist. Before Galileo, people accepted without question the ideas of ancient Greek philosophers about the laws of nature. These ideas were based on observations and pure thought.

While Galileo made important astronomical discoveries with the telescope, many historians believe that Galileo's greatest contribution to science was the popularization of experiments (as opposed to observation and pure thought) as the primary means for understanding the natural world. Thanks to Galileo and others like him, experiments are an important part of the way we do science today.

In this activity, students are invited to conduct some open-ended experiments in the spirit of Galileo. The instructions are intentionally vague in hopes of promoting original thinking and problem solving skills.

In the first experiment, students will examine the ancient misconception that objects fall at a rate that depends on their weight. The ancients thought that heavy objects fall faster than light ones. That's false. Galileo showed that if you take two objects that are the same size (like a grape and a ball bearing) and drop them from the same height, they will hit the ground at the same time.

Galileo also did experiments with pendulums (weights attached to the ends of strings). Galileo noticed a lamp swinging overhead while he was in a cathedral. Curious to find out how long it took the lamp to swing back and forth, he used his pulse to time large and small swings. Galileo discovered something that no one else had ever realized: the time for each swing remained the same as the swings became smaller. The law of the pendulum would eventually be used to regulate clocks.

Objective:

Students will learn that Galileo popularized experiments as a way of doing science. Then they will design their own experiments to study how fast objects fall and how pendulums behave.

Materials:

Students will need a copy of the [falling objects activity sheet](#) (Galileo I.) and the [pendulum activity sheets](#) (Galileo II and III). For the pendulum experiments, useful materials include a ball of string, scissors, a ruler, and common hardware store washers in a variety of weights. For the falling objects activity, useful materials include grapes, ball bearings, ping pong balls, golf balls, pebbles and feathers. A weight-measuring scale will come in handy for both activities as will a clock or timer with a second hand.

Estimated Time:

This will take two to three class periods if done as detailed here.

Procedure:

1. Distribute the [activity sheets](#) and read through them. Explain that before Galileo, scientists simply thought about problems. They rarely did experiments to test their ideas. Galileo changed all that.
2. Ask your students which will fall faster, a golf ball or a ping pong ball? Both are the same size, but the ping pong is much lighter. A grape and a ball bearing form a similar pair. (You may have other pairs of objects that are more convenient to use in your class. Grapes and ping pong balls are not required.) You may wish to break them into small groups at this time.
3. After everyone has given their answer, and time has been allowed for discussion, direct the students to their activity sheet to design their own experiment. In science, if you have an idea or prediction, it must be verified by experiment. That's Galileo's legacy. You may wish to tell them what materials they will be allowed to work with, or simply leave it as a completely open-ended exercise. Before the end of class, confirm that all the materials you need will be available for the experiments, which may be conducted during the next class period.
4. Repeat the procedure with the pendulum activity sheet. This experiment is even more open ended than the other one, because students have to decide what they want to learn about a pendulum before they design their experiment. If you want to suggest ideas to your class, a great source is the web page [Galileo's Pendulum Experiments](#) from Rice University. It's easy to make simple pendulums from string and hardware store washers, string and pencils, string and erasers. The choices are nearly endless. You may wish to demonstrate a simple pendulum before beginning this activity.

Rationale:

Designing an experiment from scratch is an important component of problem solving and ***the most*** important aspect of the scientific method.

Science, Galileo-style I

Galileo was a great scientist. In addition to studying the stars, he changed the way we do science. Before Galileo, scientists simply accepted the ideas of the ancient Greeks about the laws of nature. These ideas resulted from observations and thought. Galileo showed us that conducting experiments and observing the results was an important part of science. Cool, huh?

You can invent an experiment just like Galileo. Ancient scientists believed that objects fall at different speeds based on their weight. Heavier things fall faster, lighter things fall slower. Galileo wondered if this was so. He did experiments to find out. He dropped objects of the same size, but different weights. Does the speed at which something falls depend on its mass or size? What other factors might affect your experiments?

Now pretend you're Galileo. Design and conduct an experiment using a balance scale (for massing things), tiny pebbles, leaves, feathers and other objects to prove this ancient theory wrong.

Experiment (What do you want to know?):

Scientific Prediction (*write what you think will happen*):

Materials (*write what materials you will need*):

Procedure (*write the steps to performing your experiment*):

Observation (*write what happened when you did it*):

Conclusion (*write what your experiment proves*):

Science, Galileo-style II

Galileo also did experiments with pendulums. You can make a simple pendulum by tying a pencil to the end of a piece of string. Pendulums act differently depending on the length of the string and the weight of the object tied to the end.

Imagine that you are Galileo. Think of some good questions about pendulums, and then design an experiment to answer them. Make sure that your experiment is different from your friend's experiment.

Questions (*what do you want to learn about your pendulum?*):

Scientific Prediction:

Materials:

Procedure:

Observations:

Conclusion:

Science, Galileo-style III

Imagine that you are Galileo. On a trip to the Clark Planetarium to see a 3-D IMAX show, you realize that you have time to look at all of the exhibits. One of your favorites is the Foucault Pendulum. What information will you need to collect while observing the Foucault Pendulum to answer the question below? How can you figure out the answer?

Question (*How long does it take the pendulum to knock down all the pegs?*):

Scientific Prediction:

Data collection/Procedure:

- 1) # of pegs _____
- 2) Fractional part of the outside of the circle the pegs cover? _____
- 3) How long to knock down 1 peg? _____ (When should you start timing?)
- 4) ?? _____

What must you do to answer the question from above?

Combine your data with your observation while collecting the data and show how you can figure out the answer to the question. **Show your work here: Drawing a picture may help.**

Conclusion: