Inclined Pendulum — Leader Guide

Description: Learners discover how gravity affects the speed of a planet's orbit.

Background: Kids often get the terms "revolve" and "rotate" confused when referring to planetary motion. When planets rotate, they spin on their axis. This rotation is what causes day and night on Earth. A planet revolves around the Sun by orbiting the Sun. The Earth revolves around the Sun in about one year. Many learners may not know that planets move around the Sun at different speeds. In this activity, learners model the fact that a decrease in gravity causes a decrease in orbital velocity using a simulation, and those more distant planets revolve around the Sun at slower velocities.

National Science Standards[1]

3-5 Nature of Science

Understands the nature of scientific inquiry

Plans and conducts simple investigations

3-5 Earth and Space Sciences

Understands the composition and structure of the universe and the Earth's place in it

Knows that the Earth is one of several planets that orbit the Sun and that the Moon orbits the Earth

3-5 Physical Sciences

Understands motion and forces

Knows that an object's motion can be described by tracing and measuring its position over time

Knows that when a force is applied to an object, the object either speeds up, slows down, or goes in a different direction

[1]Kendall, J.S. & Marzano, R.J. (2000). *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education.* (3rd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Materials

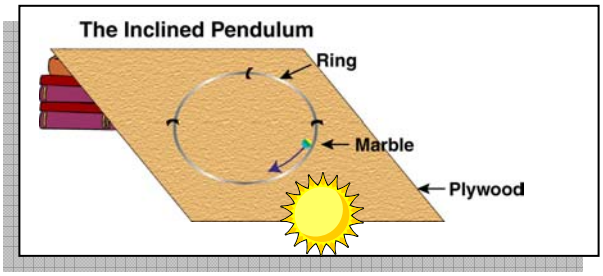
For each group:

- Metal ring mounted onto a piece of plywood (A plastic or wooden embroidery ring works well also. Plywood could be substituted with sturdy, corrugated cardboard)
- Five textbooks (all about the same size)
- Marble (or a variety of different sized marbles)
- A ball (soft ball-sized or larger) to represent the Sun
- Stopwatch or other timing device
- Write-On Sheet, "Inclined Pendulum"

The plywood for "The Inclined Pendulum" can be purchased at the local hardware store. The metal rings can be purchased at the local craft store.

Advance Preparation:

There is some advance preparation for this activity. The leader should obtain enough plywood and metal rings for each participant group. The rings can be mounted on the plywood with a couple of industrial staples or heavy-duty tape.



Procedure:

1. Ask learners to describe what they know about how the Earth moves. Ask them to describe how the Earth and Moon move in relation to the Sun. Some learners will state that the Earth rotates around the Sun, and that the Moon moves around the Earth. Explain that the Earth travels around the Sun one time per year, and that the Earth spins on its axis (like a top) once per day. Explain that the Moon moves around the Earth but that the same side is always facing the Earth. Ask learners what the force is that keeps the Earth moving around the Sun. Some may mention the force of gravity.

2. Ask learners if they think all planets move around the Sun at the same speed or different speeds. Allow learners to think about which planets might move faster and which might move slower. Explain that they will conduct an experiment that models how gravity affects the speed a planet revolves around the Sun.

3. Position the model of the Sun (e.g. softball) in front of the plywood. Set the plywood and ring apparatus on a book and demonstrate how to roll the marble. Place the marble on the inside of the ring at the designated release point (indicated with a sticker, marker line, or masking tape). Once marble is released, participants should practice counting the number of times the marble swings in 10 seconds. Repeat this several times so the learners determine the best way to count swings. One way might be to count the number of times it passes by a specific mark on the wood by the bottom of the ring. The mark could be indicated with a sticker, masking tape or marker line. Emphasize how it is important for the participants to release the marble from the same point for each trial. Explain to everyone that after completing three trials for one book, they should add a second book under the apparatus and repeat. Ask participants if the additional book makes the marble closer or further away from the model of the Sun. (Many will point out that the additional books seem to make the marble in the ring closer to the Sun model). Tell participants that this simulates an increase in gravity. You can view the activity online in the Genesis Webcast titled "Kids Get Down With Gravity" at: http://www.jpl.nasa.gov/webcast/genesis.html

Alternate Strategy Tip

This activity can be completed as a class demonstration with the students collecting the data from one apparatus.

4. Distribute the Write-On Sheet, "Inclined Pendulum." Learners should follow the procedure, and then fill in the data table.

> **Leader Tip**
> As an adaptation, have participants try the experiment with different sizes of marbles to see how size affects the force of gravity and speed.

5. Ask learners questions similar to the following:

   - Based on your results, how does the amount of gravity affect the speed of the marble? (Learners may state that the more books that are used, the more swings the marble makes in 10 seconds. Therefore, an increase in the gravity results in faster marbles.)

   - In what ways does this compare with planets orbiting the Sun? (Learners may suggest that planets that are closer to the Sun have more gravity and travel at a faster speed around the Sun. Planets farther from the Sun have less gravity and travel at a slower speed around the Sun.) (According to Newton's Law of Gravitation, masses at greater separations have less gravitational force than those closer together. Therefore, planets that are farther from the Sun have less gravity than those that are closer.)

This activity was adapted for Community Quest from an activity in the Genesis education module *Destination L1: A Thematic Travel Unit* found at: http://www.genesismission.org/educate/scimodule/Destination_L1.html

Resources for Extension and Enrichment Activities

http://chicago.space-explorers.com/internal/mss/teachers/lessons/module3/ellessons/CAI/lesson4.pdf
Space Explorers offer a variety of lessons focusing on our solar system including a great solar system simulation activity that uses different colors of balloons to represent the Sun and nine planets. This activity could be done either before or after "Inclined Pendulum" as a supplement.

http://kids.msfc.nasa.gov/Sites/ExternSite.asp?url=%2FSolarSystem%2FSolarSystemJava%2Easp
The NASA Kids Web site provides informative text and visual images in "3D Solar System."

http://liftoff.msfc.nasa.gov/academy/space/solarsystem/solarsystemjava.html
This NASA site features the same 3D animation at the Web site above; however, it shows the planets' current orbital positions.

http://sln.fi.edu/tfi/activity/space/sp-3.html
A hands-on activity for upper elementary and middle school students that explores how gravity and centrifugal force affect a satellite's orbit.

http://www.eyeonthesky.org/lessonplans/05sun_daynight.html
This kinesthetic activity "What Makes Day and Night?" offers a simulation for learners in grades 1 through 3 to understand how the Earth's rotation affects changes

http://www.eyeonthesky.org/lessonplans/06sun_motionplayground.html
A playground is the setting for this simulation activity in which participants model the rotation of the Earth and Sun as well as how the Earth revolves around the Sun.