NATIONAL GEOGRAPHIC

GIANT MAPS

SOLAR SYSTEM

ROTATION, REVOLUTION, DAYS, AND YEARS

RECOMMENDED GRADES: 6-12

(With math modifications for grades 6-9)

TIME NEEDED: 45 MINUTES

Description

Students will understand the relationship between rotation and revolution and our time system on Earth via mathematical calculations and kinesthetic movements.

Learning Objectives

Students will:

- investigate the relationship between rotation and days, and revolution and years
- compare the lengths of days and years of different planets and Pluto

Materials

- Calculators (optional)
- Giant protractors (9)
- Planetary Model balls (9)
- Stopwatches (12)
- Solar System Information cards (36, 4 copies of each card)

Preparation

None

Tips/Modifications

Tips

- When modeling the revolution speed of the planets, the longest orbit will have a revolution time period of 11 minutes (Neptune) using the scale 4 seconds = 1 Earth year. If you feel that speed around Earth or Mercury is too fast, you can scale down the speed to a more manageable speed for your class.

Modifications

- Instead of using models to represent the tilt of the planet, students can use their bodies and align them to a relatively proper angle. Uranus will have to roll along the floor!
- Have students complete Part Two: Seasons, for the Southern Hemisphere.

Rules

Have students remove shoes before walking on the map.

DIRECTIONS

PART ONE: REVOLUTION AND ROTATION

1. Ask students how we define a day on Earth. Have students stand anywhere on the map facing the giant sun on the edge of the map. Ask them to rotate, or spin, counterclockwise in a circle to represent a day. Call attention to the word rotate and share its definition from the vocabulary section at the back of the guide. Explain to students that one complete rotation of a planet on its axis is one day.

2. Divide the class into nine equal groups, and assign each group a planet or the dwarf planet Pluto. Give each group a Solar System Information Card. The outer planet groups should stand on their planets' relative orbital path around the sun in the center of the map, and the inner planet groups should stand on the image of the planets on the edge of the map. Explain to students that they are going to practice rotating and revolving. Inform students that the relative size of the orbits of the inner planets are too small to have them revolve on the actual orbital path, so when the time comes, they will revolve around their planet image instead.

3. Have students read aloud from their Solar System Information Card their planet's rotation time, and decide as a class which planet group should rotate/spin the fastest or slowest to represent a day on their planet. Have students take turns rotating as different "planets" so they can feel the relative speed of rotation of the planets. Lead a discussion as to how the length of our day is determined by how fast our planet rotates on its axis. Planets with slower rotational times will have longer days; planets with faster rotational times will have shorter days.

4. Ask students: *Other than a day, what other measure of time do we derive from the movement of our planet in space?* (A year.) Explain that a year is defined by how long it takes for a planet to make one complete revolution around the sun.

5. Ask: *Which planet has the longest year compared to Earth?* (Neptune) *The shortest?* (Mercury) Using the scale of 4 seconds = 1 Earth year and the information on the Solar System Information Cards (revolution time), have students calculate and convert the length of their planet's orbit around the sun, or year, in terms of minutes and seconds. Have students do the calculation in their notebooks, away from the map. Have students share the results of their calculations with the group and record all speeds in their notebooks. Check student work using the Revolution and Rotation Answer Key, found at the end of the activity. Ask students to return to the map and stand on either their planet's orbital path or image. Give each group a stopwatch and tell students they must complete their "revolution" in the time they calculated. Yell, "Go!" Some groups will not complete the revolution, but that's OK. Ask: *Which groups had more time? Which groups had less time? How do these times compare to one another? Was anything surprising?*

PART TWO: SEASONS

1. One Earth year, which is defined as how long it takes Earth to revolve around the sun, has four distinct seasons. Ask students: *What factors about our planet in space cause us to have seasons?* Have students walk along an outer planet's orbital path to the location

which they believe would be the summer solstice in the Northern Hemisphere. Lead a discussion on the relationship between perihelion, aphelion, orbital tilt, and seasons. Ask: *Is the summer solstice in the Northern Hemisphere necessarily at the closest point in the orbit?* (Answer: No).

2. Distribute an orbital planet ball to each group. Ask students to walk around the orbital pathway with planet axis tilt given on the Solar System Information Card after measuring their angle against the protractor poster. Discuss if there are similarities and differences between the orbital tilt, orbital velocity, and planet years between the inner and the outer planets. Ask: *If orbital location is not the reason for the season, what other factor could contribute to the changing seasons on Earth and other planets?* (Answer: planet tilt) Ask: *Which has a greater impact on the seasons of all planets, their tilt or the eccentricity of their orbit?* (Answer: Again, planet tilt is important).

EXTENDING THE LEARNING

- Ask older students to calculate and discuss the following, in addition to the other calculations they do in the activity:
    - Students can use Kepler's 3rd Law of Planetary motion, which states that the square of the orbital period is equal to the cube of the semi-major axis (P2 = a3). Students can measure the semi-major axis of the planet on the solar system map and calculate the orbital period.
    - Have students calculate what fraction of an orbital period each of their rotational periods are (e.g. Earth's day is 1/365th its year). Do they notice anything unusual about some of the planets (e.g. Venus and Mercury)?

Check student work using the Extending the Learning Answer Key, found at the end of the activity.

ROTATION AND REVOLUTION ANSWER KEY

Mercury: $87.969\ days \times \frac{1\ earth\ year}{365.25\ days} \times 4\ seconds = 0.963\ seconds$

Venus: $224.701\ days \times \frac{1\ earth\ year}{365.25\ days} \times 4\ seconds = 2.46\ seconds$

Mars: $686.98\ days \times \frac{1\ earth\ year}{365.25\ days} \times 4\ seconds = 7.523\ seconds$

Jupiter: 11.862 *years* ×4 *seconds* =47.448 *seconds*

Saturn: 29.457 *years* ×4 *seconds* =117.828 *seconds* (1.9638 *minutes*)

Uranus: 84.011 *years* ×4 seconds =336.044 seconds (5.6 *minutes*)

Neptune: 164.79 *years* ×4 seconds =659.16 seconds (10.986 *minutes*)

Pluto: 247.68 *years* ×4 *seconds* =990.72 *seconds* (16.512 *minutes*)

EXTENDING THE LEARNING ANSWER KEY

$P^2 = a^3$

	Semi-major axis (AU)	Orbital Period (Earth Years)
Mercury	0.3871	0.2408
Venus	0.7233	0.61562
Earth	1.00	1.00
Mars	1.5273	1.8809
Jupiter	5.2028	11.862
Saturn	9.5388	29.458
Uranus	19.1914	84.01
Neptune	30.0611	164.79
Pluto	39.5294	248.54