Orbital Paths

Purpose

To compare the lengths of the terrestrial planets' orbital paths and revolution times.

Materials
- ❑ data sheet
- ❑ sidewalk chalk
- ❑ 4 lengths of precut string: 1.2 m (3′11″), 2.2 m (7′2″), 3.0 m (10′0″), and 4.6 m (15′2″)
- ❑ basketball court or other large, paved area
- ❑ stopwatches

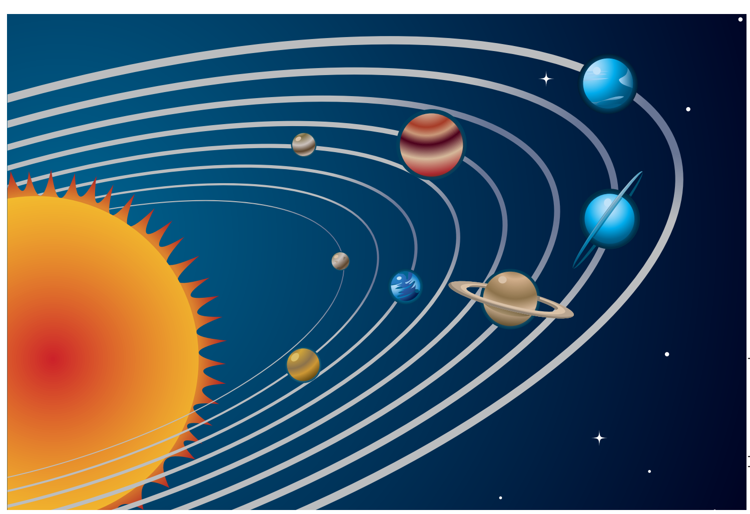
Process Skills

Measure, form a hypothesis, predict, observe, collect data, interpret data, communicate, draw conclusions

Background

The **Sun**, a medium-sized star, lies in the center of our **solar system**. Eight planets, including Earth, **revolve** around (or orbit) the Sun. They are held in their **orbital paths** by the Sun's **gravity**. Each planet travels a unique distance around the Sun and does so in a unique amount of time.

Terrestrial planets are the four closest planets to the Sun. They include Mercury, Venus, Earth, and Mars. These planets all have solid, rocky surfaces. The four outer planets include Jupiter, Saturn, Uranus, and Neptune. These outer planets are also called **gas giants** because they are enormous balls of gas that lack solid surfaces. This experiment will focus on the orbits of the terrestrial planets.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Time – Part 1: 30 minutes; Part 2: 45 minutes

Grouping – Whole class and groups of four

Procedure

Part 1: Marking Orbital Paths

1. Find the center of a large, flat, hard surface. Your teacher will choose one student to represent the Sun. That student should use a piece of sidewalk chalk to draw a simple picture of the Sun on this spot and then write *Sun* to label the drawing. The student should stand in this spot to represent the Sun (see Figure A).

Figure A

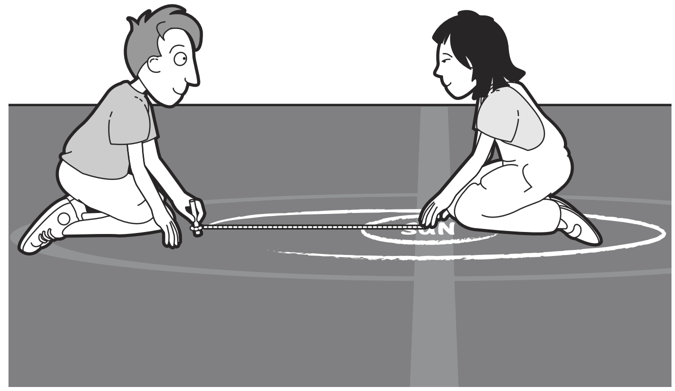

Figure B

2. To represent the orbital path of the closest planet to the Sun (Mercury), tie a piece of chalk to the shortest (1.2 meter) length of string. The student who represents the Sun should hold one end of the string against the center of the drawing of the Sun, at ground level. Another student should pull the string until it stretches its full distance, also at ground level. While slowly moving in a circle and keeping the string straight, the second student should use the chalk to draw a circle (see Figure B). Label this circle *Mercury.*

3. Repeat Step 2 using the other lengths of string to mark the orbital paths of Venus (2.2 m), Earth (3.0 m), and Mars (4.6 m). Label each circle with the correct planet's name (see Figure C).

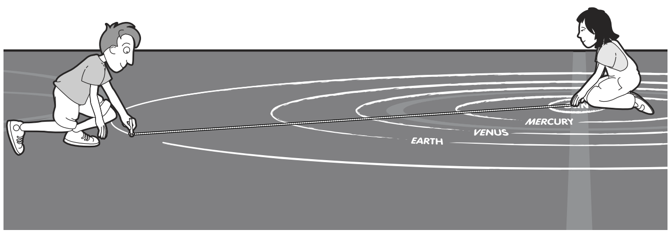

Figure C

4. Get into groups of four (or more) students. Discuss with your group which planet you think takes the longest amount of time to revolve around the Sun and why. Which planet do you think takes the least amount of time and why? Include everyone from your group in the discussion. Then complete the two hypotheses on your data sheet.

Part 2: Testing Orbits of the Terrestrial Planets

<u>Predictions</u>: Select a student from your group to represent each of the terrestrial planets. These students will walk around their planet's orbital path once, using heel-to-toe steps (see Figure D). Predict how many heel-to-toe steps it will take for the student representing each planet to walk one circle around the Sun. Then record your predictions in the correct column of the table on your data sheet. Next, predict how much time it will take each planet to revolve once around the Sun, using heel-to-toe steps. Record your prediction in the correct column of the table on your data sheet.

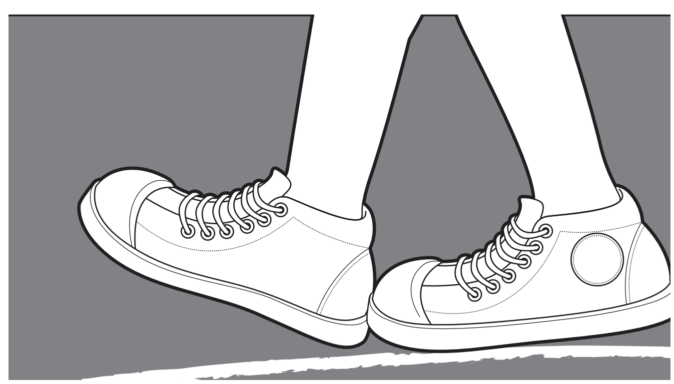
Figure D

1. Have one student from your group pick a starting point on his or her planet's path and stand on that spot. Choose a member of the group to count the steps this student takes to complete the circle once. Choose another member of the group to use a stopwatch to time how long it takes the student to complete the circle.
2. When the student with the stopwatch says, "Go," the first student should begin walking in heel-to-toe steps at a normal walking speed around the orbital path. The step counter should count the steps silently (to avoid confusion in case students from other groups are walking at the same time). As soon as the walking student reaches the starting point, he or she should say, "Stop!" The timer should stop the stopwatch, and the counter should stop counting.
3. Have the fourth member of the group find the correct row on the data sheet to record data for the planet being tested. He or she should record the actual number of heel-to-toe steps and the amount of time the walking student took to complete the circle.
4. One at a time, let each of the remaining students walk his or her planet's orbital path. Rotate the other jobs (step counter, timer, and recorder) so that each student gets to do each job. Repeat steps 1–3 for each remaining planet. **TIP:** Be sure all the members of your group walk at about the same speed when it is their turn.
5. Record all data on your data sheet and use this information to answer the questions on the questions page.

Name________________________________ Date____________

Hypotheses: Which of the four terrestrial planets' orbital paths will take the *longest* and the *shortest* amount of time to walk around? Why?

1. We think it will take the longest amount of time to walk the orbital path of ______________ because ________________________________

____.

2. We think it will take the shortest amount of time to walk the orbital path of ______________ because ________________________________

____.

Collect Data

Planet	Heel-to-Toe Steps Needed to Revolve Once Around the Sun		Time Needed to Revolve Once Around the Sun	
	Prediction	Actual	Prediction	Actual
Mercury	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds
Venus	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds
Earth	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds
Mars	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds

Name_________________________ Date__________

Analyze Data

1. Which planet required the most heel-to-toe steps in order to make a full revolution around the Sun, and which planet required the fewest? Why do you think this was so?

2. Which planet took the longest amount of time to make a full revolution around the Sun, and which planet took the shortest amount of time? Why do you think this was so?

3. What would have to happen in order for Mars to complete one revolution in the same amount of time as Mercury? (Try it!)

4. Were your predictions for the *number of steps* or the *amount of time* closer to the actual results? Why do you think this was so?

5. Other groups may have had different results than your group did. Even if your own group tried this experiment again, you might get slightly different results. Why might this be so?

Name________________________________ Date____________

Draw Conclusions

1. Explain in your own words why some planets take longer to revolve around the Sun than other planets.

2. What was the most challenging part of this experiment? Why?

3. Name two difficulties you might have had if you had tried to include the outer planets in this experiment.

Orbital Paths

TEACHING TIPS

Our solar system is home to Earth and seven other planets. Each planet rotates on its own axis while revolving around the Sun. Every planet has unique characteristics and qualities that set it apart from the rest. There are also other components of our solar system, including dwarf planets, moons, asteroids, and comets. The Sun keeps this complex arrangement in order. These activities will help students understand the movements and characteristics of the planets and other objects in our solar system. As they complete these activities, students may come to appreciate the special qualities of our solar system.

SET-UP AND PROCEDURES

- Check the weather report before having students complete Part 1 of this experiment. Part 1 will need to be repeated if rain washes away the chalk lines. Similarly, ensure that the lines that students drew in Part 1 will not be erased before starting Part 2.
- Before students begin Part 2, you may want to have them practice walking using heel-to-toe steps at similar speeds. If students are walking at many different rates, help establish a baseline speed by having students walk to a beat. Take this opportunity to discuss the importance of control within an experiment.
- It may be helpful to instruct students to walk outside the chalk lines rather than right on them. Otherwise, the class may need to redraw the lines after several tests.
- More than one group should be able to walk the circles at once, as long as they start at different points and walk at the same pace.
- It may be helpful to have students draw a mark or write their initials at their starting point on each circle so they know when they have completed one full orbit.
- Share all the groups' predictions and data with the class by using a projector, scans of data sheets, butcher paper, or the chalkboard.

MATERIALS

- Prepare the four lengths of string in advance, according to the specifications described in the student activity. Use strong string such as plastic twine. Have extra string and scissors available in case the precut pieces should break.
- You may want to provide colored chalk so that each planet's orbital path can be a different color.
- Many districts have a science resource center to contact if stopwatches are not readily available at the school. Some students may have timers on their wristwatches.

- It may be helpful to tie one end of each string to the shoelace of the child standing inside the Sun and the other end to the middle of the sidewalk chalk.
- Consider reserving the basketball court or another flat, paved area in advance of this activity to be sure that the experiment can be conducted without the distraction of other classes using the area at the same time.
- Providing clipboards or other portable writing surfaces may help students record their data while outdoors.

EXTENSIONS AND VARIATIONS

- *Variation/Inquiry Science:* Let each student try walking all four planets' paths, recording his or her own data on the number of steps and the time it took to complete each orbit. This approach would eliminate the variable of having multiple students walking at different speeds. It may be helpful to assign each student a partner to help keep track of steps and time.
- *Variation/Inquiry Science:* Tie something soft (e.g., bath towel, throw pillow, rolled T-shirt) to the end of a long rope. Choose a large space and clear it of bystanders. Then let volunteers explore how many times they can swing the object in circles, parallel to the ground, in thirty seconds. Encourage students to change the length of rope several times and compare the results.
- *Variation:* To more closely model the movement of the planets, allow students to rotate their bodies in small circles while traveling the orbital path of their planet. (Caution: may cause dizziness.)
- *Inquiry Science/Math:* Help students calculate the radius and diameter that would be necessary to add each of the four outer planets to the experiment. The distance between Earth and the Sun is equal to one Astronomical Unit (AU). The distances recommended in this experiment used the measurements below, with one AU being represented by a 3-meter (10-foot) piece of string and the other distances being calculated accordingly. To calculate the distances for the other planets, students can multiply each planet's distance in AUs by 3 meters (10 feet).

  Mercury: 0.39 AU; Venus: 0.72 AU; Earth: 1.00 AU; Mars: 1.52 AU;
  Jupiter: 5.20 AU; Saturn: 9.54 AU; Uranus 19.18 AU; Neptune 30.06 AU
- *Art/Math:* Allow students to create a colorful diagram of the four terrestrial planets' orbital paths by using large pieces of butcher paper and string. Use the AU distances listed above to help students draw the lines at their relative distances from the Sun.
- *Writing:* Have students write a poem about the planets and their orbits around the Sun. Visit Reading a-z.com for poetry samples and for a poetry writing program.

- _ELL/ESL:_ Create a word wall. Include unit vocabulary terms such as *solar system, planet, revolution, orbit, gravity,* and *terrestrial*. Also include other vocabulary relevant to the lesson, such as *orbital path, radius,* and *diameter*. Encourage students to teach the class how to say some of these terms in other languages. For more vocabulary resources, visit VocabularyAZ.com.
- _Home Connection:_ Challenge students to create their own model of the terrestrial planets and their orbital paths at home. Ask students to bring their model to class to be used in further practice.
- _Technology:_ Have students create a presentation about the terrestrial planets using a projected slideshow application.
- _Research:_ See Using the Internet in the *Unit Guide* for suggested websites to extend the learning.

ANSWER KEY

Hypotheses will vary. Students may predict that Mars will take the longest amount of time to revolve around the Sun since it is the farthest terrestrial planet from the Sun. Students may predict that Mercury will take the shortest amount of time to revolve around the Sun since it is the closest terrestrial planet to the Sun. Discuss these hypotheses as a class before students begin the testing.

Predictions will vary. Results may vary between groups but should be reasonable, based on the distances walked by students. Mercury should require the fewest heel-to-toe steps and shortest time, and each subsequent planet should require more steps and more time.

EXPERIMENT The Solar System—Orbital Paths Data Sheet

Name____________________________ Date__________

Hypotheses: Which of the four terrestrial planets' orbital paths will take the *longest* and the *shortest* amount of time to walk around? Why?

1. We think it will take the longest amount of time to walk the orbital path of __________ because ______________________

____.

2. We think it will take the shortest amount of time to walk the orbital path of __________ because ______________________

____.

Collect Data

Planet	Heel-to-Toe Steps Needed to Revolve Once Around the Sun		Time Needed to Revolve Once Around the Sun	
	Prediction	Actual	Prediction	Actual
Mercury	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds
Venus	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds
Earth	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds
Mars	____ steps	____ steps	____ minutes ____ seconds	____ minutes ____ seconds

ANSWER KEY AND EXPLANATIONS

Analyze Data

1. Which planet required the most heel-to-toe steps in order to make a full revolution around the Sun, and which planet required the fewest? Why do you think this was so?

Mars should require the most heel-to-toe steps, and Mercury should require the fewest. This is because the distance each planet travels around the Sun increases with its distance from the Sun. (Circles with greater radii have greater circumferences.)

2. Which planet took the longest amount of time to make a full revolution around the Sun, and which planet took the shortest amount of time? Why do you think this was so?

Mars should require the longest amount of time, and Mercury should require the shortest. As established in question 1, the farther a planet is from the Sun, the longer its orbital path will be, and the greater the time it will take to walk it (assuming students walk at the same pace for each planet).

3. What would have to happen in order for Mars to complete one revolution in the same amount of time as Mercury? (Try it!)

Mars would have to revolve much more quickly than Mercury to complete a revolution in the same amount of time. If students try this, they will either have to move very quickly along Mars's path or move very slowly along Mercury's path.

4. Were your predictions for the *number of steps* or the *amount of time* closer to the actual results? Why do you think this was so?

Results will vary. Students should consult their data sheet to accurately report which set of predictions was closer to its results. Students may find it easier to predict the amount of time rather than the number of steps since it could be difficult to visualize the length of a circle in heel-to-toe steps.

5. Other groups may have had different results than your group did. Even if your own group tried this experiment again, you might get slightly different results. Why might this be so?

A number of variables in this activity are hard to control. One student may have larger feet than another or may walk faster than another. If the class has to redraw the chalk circles, they might not be drawn to exactly the same diameter each time. Students responsible for timing might not start and stop the stopwatches at exactly the same time.

ANSWER KEY AND EXPLANATIONS

Draw Conclusions

1. Explain in your own words why some planets take longer to revolve around the Sun than other planets.

   As a planet's distance from the Sun increases, the distance it has to travel to complete a revolution becomes greater, and therefore the time it takes to revolve around the Sun increases.

2. What was the most challenging part of this experiment? Why?

   Answers will vary. Students may find it challenging to be sure everyone in their group walks at the same pace. Or it may have been difficult to count a partner's heel-to-toe steps if more than one student was walking at the same time.

3. Name two difficulties you might have had if you had tried to include the outer planets in this experiment.

   Answers will vary. The school grounds may not be large enough to conduct the experiment with the full solar system. It could be challenging to draw such large circles. Also, it would take a very, very long time to walk around the largest circles and collect the data.