

Sample Lesson for Grades 3-4 from  
**The Science Detectives**



**SETI INSTITUTE**

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## Lesson Nine

# Cosmic Wheels

### Measuring the Orbits of Planets.

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#### Overview

Students will build a model of planetary orbits that will be a scale model of the Solar System. They will also use the scale distance the model Earth travels in one year to compare the time other planets take to travel around the Sun (their "year") by measuring their orbits. They will observe that planets farther away from the Sun have orbits much larger than Earth's. They will also learn that these outer planets move more slowly in their orbits than Earth does. Amelia's last clue described two planets with "years" equal to 84 and 165 Earth years. By measuring the model orbits, students will find that Amelia's next destinations are Uranus and Neptune.

The video segment for this lesson will confirm those destinations, and give the Science Detectives their next clue: Amelia will visit the planet in our Solar System that has the most rings and the most moons.

#### Concept

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- Orbits are larger when a planet is farther from the Sun.
- Orbital speed is slower when a planet is farther from the Sun.

#### Skills

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- Use a scale model to compare orbit sizes for the planets.
- Measure planet "years" using "Cosmic Wheels".
- Observe that planet "years" increase for planets farther from the Sun.

## What You Need

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### PART ONE

#### For the Class:

- > A large paved or cement area, at least 15 m (40 feet) across, with a smooth surface for making chalk circles
- > 250 ft of heavy string
- > Pencils
- > long pieces of chalk
- > 1 roll of masking tape
- > Scissors
- > Permanent marker

#### For Each Pair or Team of Students:

- > Activity Sheet: Cosmic Wheels
- > 1 Styrofoam or heavy cardboard plate,  
*exactly nine inches in diameter*
- > 1 Push pin
- > 1 Wooden meter stick

### PART TWO

#### For the Class:

- > TV and VCR
- > Videotape: "Science Detectives", Lesson 9

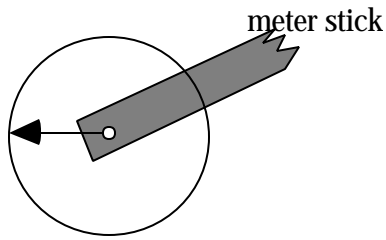
## Getting Ready

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### PART ONE

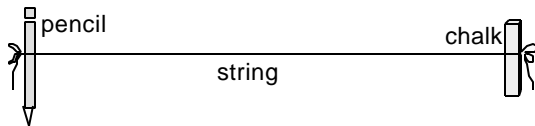
1. Making the Cosmic Wheels: Make plates with radii as shown in Figure 9.1. Use the permanent marker to draw a line from the center of the plates to the outer rim. Attach the plates to meter sticks at the 1 cm mark with the push pins. For the outer planets, you will have to attach the plates at less than 1 cm. The plates should be secure but still turn freely.

Figure 9.1. Cosmic Wheel.



2. Make orbit measuring strings as shown in Figure 9.2. Tie a pencil to one end of a string to represent the Sun. Tie a piece of chalk to the other end to mark the distance of the planet's position from the Sun. Roll the extra string around the pencil. Mark it with tape showing the name of the planet. The distances between the planets and the Sun are given in Table 9.1.

Figure 9.2. Cosmic Wheel.



**Teacher's Note:** You should know that the reason that the "years" for the outer planets are so much longer than an Earth year is because of two factors: their orbits are bigger, and they travel more slowly along those orbits. The latter is a consequence of Kepler's Laws. As an example, note that the Space Shuttle orbits the Earth in 90 minutes, while our Moon, which is much farther away, takes a month to orbit. The same mechanism applies to planets orbiting the Sun. If you feel your students are ready for this more complex idea, you might explain it in terms of objects that orbit Earth.

Table 9.1. Cosmic Wheels Data Table.

Planet	Orbit String	Radius of Cosmic Wheel (plate radius)	Orbital Period
Mercury	1.7 inches	(no wheel)	0.24 Earth years
Venus	3.2 inches	(no wheel)	0.62 Earth years
Earth	4.5 inches	4.5 inches	1 Earth year
Mars	6.8 inches	3.6 inches	1.9 Earth years
Jupiter	23 inches	1.9 inches	11.9 Earth years
Saturn	43 inches	1.5 inches	29.5 Earth years
Uranus	86 inches	1.0 inches	84 Earth years
Neptune	135 inches	0.8 inches	165 Earth years
Pluto	178 inches	0.7 inches	248 Earth years

3. Make sure you have a large enough room. Note that the orbit of Pluto is almost 30 feet in diameter. If you do not have space for Pluto, end the model at the orbit of Neptune.

#### PART TWO

1. Class charts. Label the Class Clues Chart Eighth Transmission.
2. TV and VCR. Forward the video tape to "Science Detectives," Lesson 9.

### ***Classroom Action***

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#### PART ONE

1. **Discussion.** Review Amelia's last clue. She said that she was going to two planets this time, one whose "year", or time to revolve once around the Sun, was 84 Earth years and another whose "year" was 165 Earth years. Explain to the students that a year is the amount of time it takes a planet to travel around the Sun. For the Earth, that is 365 days or one year. Ask students if they have any hunches about which planets Amelia could be going to. Ask them to explain their hunches. Make a list of the planets the students suggest.

2. **Activity.** Clear the floor space for the Solar System model. Tell the students that today they will make a realistic scale model of how far apart the planets are in the Solar System. They will also find out what it means to say that a planet has "an orbit of 165 Earth years."

Use the chalk to mark an X on the ground to represent the Sun. Choose one student to hold the "Sun" (pencil) end of the Earth orbit string at the center of the X. Choose another student to play the part of the Earth, and orbit the "Sun" by holding the chalk and slowly making a circle around the Sun, marking the orbit as he or she goes.

**Teacher's Note:** *If you can't find a large area, try putting the Sun in the corner of your room and measuring one-quarter of the orbit. This can be multiplied by four.*

Other students should use do the same thing with the orbit strings of the other planets. The orbits for the two inner planets (Mercury and Venus) may be omitted, if desired.

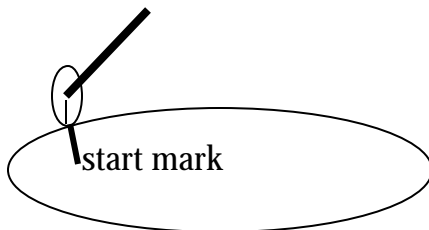
3. **Discussion.** How do the sizes of the orbits compare? Is there much difference between the size of orbits for the first four planets and the outer five?

Can the students draw any conclusions about how long it might take one of the outer planets to go once around the Sun? What if the outer planets moved at different speeds than the Earth? Ask if any of their hunches about Amelia's destinations have changed, and why.

Explain that now that the students have a realistic scale model of the Solar System, they are going to measure how long each planet takes to go once around the Sun. This amount of time is its "year". The Cosmic Wheels give the distance traveled by planets in one Earth year. Different teams of students will measure the "years" of different planets. Perhaps they will find some that agree with Amelia's clues.

**4. Demonstration.** Use the Cosmic Wheel for the Earth to demonstrate how much distance our planet travels in 1 year. Roll the Wheel in a straight line on the ground, marking a start and end point of one rotation as shown in Figure 9.3. Explain that this is the distance that our planet could go in one year, if it were going in a straight line. Now put a start mark on the Earth's orbit circle. The radial line on the Earth's Cosmic Wheel should be lined up with the bottom of the plate, on the start line. Explain that Earth isn't going in a straight line, but is in an orbit around the Sun. How far does it go in one year? Have a student roll the wheel once around Earth's orbit. The wheel will trace out one complete orbit.

**Figure 9.3. Using the Cosmic Wheel.**



**5. Activity.** Now have other student teams measure the length of "years" for other planets. Begin with Mars. While one student rolls the Mars Cosmic Wheel around its orbit, another student (or group of students) counts the number of revolutions. The number should be about two, so Mars' "year" is about two Earth years. Continue with the other planets, and record all results on the Activity Sheet.

If you wish, try also rolling the planet wheels in straight lines to clearly show students that the distance that the outer planets travel in one Earth year is less the farther they are from the Sun. In other words, they move slower. Ask the students if they have any idea why this might be.

## PART TWO

1. **Discussion.** Write down the measurements on the chalkboard. Scientists always expect some error in their experiments, so the results may not be perfectly accurate. We can only say about how long the orbits are.

What is our best guess at Amelia's destinations?

2. **Video.** Announce to the students that it is time to check in with NASA again to see what their scientists have come up with and to find out what Amelia is up to now.

3. **Discussion.** The video confirms Uranus and Neptune as the last destinations. The next clue points to Saturn, the planet with the most rings and the most moons. Discuss the information presented in the video. Record the ideas generated on the Class Chart under Eighth Transmission. Student teams should record the clues in their Science Detectives' Notebook.

## Closure

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1. **Discussion.** Ask the students: "What is a year? Why is it a different length of time on each planet?" Review concepts as necessary. Ask: "Why, did Amelia say that she would 'only be two months old on that planet'?" How old would you be on Uranus? On Neptune?

## Going Further

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### ACTIVITY: MAKE-BELIEVE NEW PLANETS!

What if there were an extra, invisible planet hidden between Mars and Jupiter? How long would its year be? What if there were a tenth planet, far beyond Pluto? How long would its year be? How could you tell?

### MATH ACTIVITY: HOW OLD AM I ON MARS?

Calculate your age on Mars and on the other planets.

**SCRIPT FOR EIGHTH TRANSMISSION****Synopsis: Lesson 9, March 20 (travel time = 78 days)**

Yes, she visited Uranus and Neptune.

Next destination has the most rings and the most moons.

BUZZ SAWYER

[Sawyer is fiddling with MEL.] "Well, MEL, what is the answer?" [MEL replies in deep voice, "I'm sorry, Buzz.]

[Sawyer rips off paper.] "Oh, come off it, MEL. You're a super computer, aren't you?" [MEL replies, "I can't do that."] "Well, according to your analysis of the planetary orbits, it seems that Amelia has visited two outer planets, Uranus, with a year equal to 84 Earth years, and Neptune, with a year equal to 165 Earth years." [snap, crackle EFX]

AMELIA SPACEHART

Date on Screen: March 20

[Express, with Neptune and Sun] "Those last two planets were so far from the center of the Solar System that the Sun blended in with all the other stars, it was just a little bit brighter- something you could be, Sawyer!"

BUZZ SAWYER

[Annoyed.] "Don't hassle me."

AMELIA SPACEHART

"At my next destination, I'm going to check out the planet that has the most rings and the most moons, more than any other planet in the Solar System. See, I figure if the message isn't coming from the planet, maybe its coming from one of the moons!"

DR. ORBIT

"Seven of the nine of the planets in our Solar System have moons. Four of the nine planets have rings. We're going to be researching moons and rings very carefully."

STINGER, BUZZ SAWYER

[turns to computer] "Tell me, MEL, have you ever talked with an extraterrestrial?"

[MEL, deep voice] "Other than you, Sawyer?"

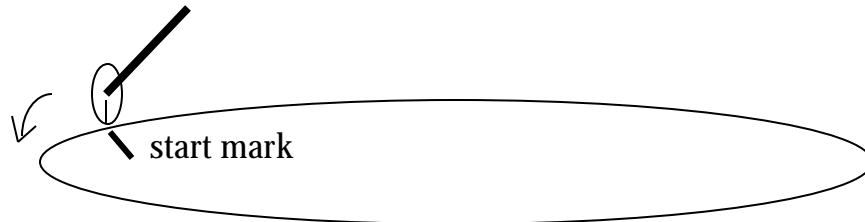
"No jokes, MEL, or I'll pull your plug..."

Science Detectives' Notebook

# Planet Orbits

## Cosmic Wheel Recording Sheet

One Earth year is equal to one full turn of the Cosmic Wheel. On the chart below, record the number of times the Cosmic Wheel goes around.



Planet	Number of Earth Years
Mercury	
Venus	
Earth	
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	
Pluto	

