Space: Distance and Time: Teacher's Guide

Grade Level: 9-12 | **Curriculum Focus:** Astronomy/Space | **Lesson Duration:** One to two class periods

Program Description

We may have a grasp on how long a foot is or how far a mile is, but measuring the universe has presented a world of difficulties. See how scientists came up with a whole new set of measurements, including the light-year and the luminosity of stars, to measure distances of cosmic proportions.

Onscreen Questions

Before watching the video

- Our solar system stretches for billions of miles, but it is minuscule in the context of the Milky Way galaxy. What do you know about the extreme distances of planets and stars in the universe?
- As you watch the program, note the many scales of measurement used to calculate the distances between planets, stars, and galaxies.

After watching the video

- Explain how two stars with unequal luminosity may appear to have the same brightness to an observer.
- Describe some factors that limit the apparent brightness of a star as seen from Earth's surface.

Lesson Plan

Student Objectives

- Understand how scaling factors can be used to make representations of astronomical distances.
- Learn how to write and solve equations that relate real-distance measurements to scaled representations of the distances.
- Understand how the use of scientific notation makes calculations involving large numbers easier to manage.

Materials

- Calculators
- Pencils and paper

- Ruler
- Books, magazines, and Internet references about the universe

Procedures

1. Begin by discussing the vastness of the universe. Tell students that light travels at the speed of 300 million meters a second. Still, it takes light years to travel from the stars to Earth and millions of years to travel between galaxies. Put these distances into perspective by thinking of them as multiples of smaller-scale distances.
2. Review your school's "galactic address," (see last page for guide) beginning with its street address and ending with its place in the universe. Discuss the different units of measurement used to describe distances in each part of the galactic address. Give students examples for each step, or have them use reference materials to provide their own examples. Review unfamiliar units of measurement, such as light-years and astronomical units. By thinking about their location on a small scale first and then moving out to a much larger scale, students should get a sense of how distance is measured at each scale.
3. Before students start working on the problems (below), it is useful to review scientific notation, which is a helpful way to deal with large numbers. Use the following examples to illustrate the powers of 10:
    - 1 can be written as 10^0 (because anything to the power zero is 1).
    - 10 can be written as 10^1 (because anything to the first power is itself).
    - 100 can be written as 10^2 (because 10 multiplied by itself, or 10 × 10, equals 100).
    - 1,000 can be written as 10^3 (because 10 multiplied three times, or 10 × 10 × 10, equals 1,000).

    Explain that we can also use these powers of 10 to represent decimal places:

    - 3.4 can be written as 3.4×10^0.
    - 99.1 can be written as 9.9×10^1.
    - 4,526 can be written as 4.526×10^3.

    Review the properties of exponents to make scientific notation even more useful:

    - When multiplying two numbers with exponents, if the base numbers are the same, just add the exponents. For example, $10^5 \times 10^3 = 10^8$.
    - When dividing two numbers with exponents, if the base numbers are the same, subtract the exponents. For example, $10^4/10^2 = 10^2$.
4. Have each pair of students solve the problems listed below. Also included for students are constants that provide helpful information to be used in scaling. Students must figure out the information needed to solve each problem. Students can work with partners to solve the problems, but each student should fill out an individual sheet. (Answers are in parentheses.)

If Earth were the size of a penny...

(1.) ...how large would the sun be? (81 inches, or 6.7 feet, in diameter)

(2.) ...how far away would the sun be? (8718.75 inches, 726.5 feet, 242 yards)

(3.) What is located about that distance from your classroom? (Answers will vary.)

If the sun were the size of a basketball...

(4.) ...how far away would Neptune be from the sun? (3,237 feet, or 0.6 miles)

(5.) ...how far away would the nearest star, Proxima Centauri, be from the sun? (5,538 miles)

(6.) Find two places on a world map that are about this distance apart. (Answers will vary.)

(7.) ...how far would it be to the center of the Milky Way? (36,538,218 miles)

(8.) About how many trips to the moon does this distance equal? (152)

If the Milky Way were the size of a football field...

(9.) ...how far away would the Andromeda galaxy be? (6,600 feet, or 1.25 miles)

(10.) ...how far would it be to the farthest known galaxy? (39 million feet, or 7,386 miles)

(11.) Find two places on a world map that are about this distance apart. (Answers will vary.)

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- **3 points:** Students actively participated in classroom discussions; worked cooperatively in groups to complete the problems; and answered more than three questions correctly.
- **2 points:** Students participated somewhat in classroom discussions; worked fairly cooperatively in groups to complete the problems; and answered three questions correctly.
- **1 point:** Students participated little in classroom discussions; had difficulty working cooperatively in groups to complete the problems; and answered one problem correctly.

Vocabulary

astronomical unit

Definition: A unit of length used in measuring astronomical distances within the solar system equal to the mean distance from Earth to the sun, or about 93 million miles (150 million kilometers)

Context: To express planetary distances, astronomers use multiples of astronomical units.

light-year

Definition: The distance that light travels in a vacuum in one year, or about 5.88 trillion miles (9.46 trillion kilometers)

Context: Many astronomers measure stellar distances in light-years because these units of measurement are easier to work with than others.

parallax

Definition: The angular difference in the direction of a celestial body as measured from two points in Earth's orbit

Context: After measuring the star's parallax, astronomers were able to determine that the star was much closer than previously thought.

scaling factor

Definition: The proportion between two sets of dimensions

Context: The map indicated a scaling factor of 1 inch to every 10 miles.

Academic Standards

National Council of Teachers of Mathematics (NCTM)

The National Council of Teachers of Mathematics (NCTM) has developed national standards to provide guidelines for teaching mathematics. To view the standards online, go to http://standards.nctm.org/.

This lesson plan addresses the following math standards:

- Measurement
- Problem Solving

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit link: http://www.mcrel.org/compendium/browse.asp

This lesson plan addresses the following national standards:

- Mathematics— Uses a variety of strategies in the problem-solving process, Understands and applies basic and advanced properties of the concepts of numbers, Understands and applies basic and advanced properties of the concepts of measurement
- Science—Earth and Space Sciences: Understands the composition and structure of the universe and the Earth's place in it

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Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- http://school.discovery.com/teachingtools/teachingtools.html

Galactic Address Guide

Place	Units of Measurement	Example
[Street address]	Feet, meters (within a house)	A room might be 10 × 14 feet.
[City]	Miles, fractions of miles	You might drive a half mile to the grocery store.
[State]	Tens to hundreds of miles	The distance from Austin to San Antonio is around 50 miles; Texas is about 600 miles across.
United States	Thousands of miles, fractions of miles	The distance from New York to Los Angeles is about 3,000 miles.
Earth	Tens of thousands of miles	Earth's circumference is 25,000 miles.
Solar System	Millions to billions of miles, or astronomical units (AU). (An AU is the average distance from Earth to the sun, or 93 million miles.)	Neptune is 30 AU, or 2.79 trillion miles, from the sun.
Milky Way galaxy	Hundreds of thousands of light-years. (A light-year is the distance that light travels in one year, or about 5.88 trillion miles.)	The Milky Way is about 100,000 light-years across.
Local group (a cluster of about 20 galaxies, including the Milky Way)	Millions of light-years	The Andromeda galaxy is about 2.2 million light-years away from the Milky Way.
Supercluster (a group of clusters)	Hundreds of millions of light-years	The Virgo supercluster of galaxies is about 150 million light-years across.
Universe	Billions of light-years	The farthest known galaxy (the edge of the observable universe) is 13 billion light-years away.