



Lesson 3 - Understanding Distance in Space (optional)

Background

The distance between objects in space is vast and very difficult for most children to grasp. The values for these distances are cumbersome for astronomers and scientists to manipulate. Therefore, scientists use a unit of measurement called an **astronomical unit**.

An astronomical unit is the average distance between the Earth and the Sun - 150 million kilometers. Using a scale model to portray the distances of the planets will help the students begin to understand the vastness of space.

Astronomers soon found that even the astronomical unit was not large enough to measure the distance of objects outside of our solar system. For these distances, the **parsec** is used. A parsec is a unit of **light-years**. A parsec equals approximately 3.3 light-years. (Keep in mind that a light-year is the distance light travels in one year - 9.5 trillion km - and that light travels 300,000 km per second!)

Teacher Notes and Hints

Prior to lesson

- Discuss and review measuring length or distance. How far is one meter?
- Discuss the use of prefixes that add or subtract to “basic” units of length.

Example: meter is the basic metric unit for length

“kilo” means 1000 - kilometer is 1000 meters

“centi” means 1/100 - centimeter is 1/100 of a meter

Adapt the discussion for grade level. For example, fifth graders can learn the metric prefixes for more “lengths” and may add to decimal work in math class:

Kilo - 1000

Hecto - 100

Deka - 10

Deci - 1/10 (0.1)

Centi - 1/100 (0.01)

Milli - 1/1000 (0.001)

- When discussing kilometers, it is helpful to know the number of km’s to local places (for example, _____ kilometers to the Mall).

- Look at different maps and discuss why the scales are different. Then, relate this to space distances.
A map of the U.S. has a different scale than a map of your state. What scale would be needed for space? (Such large distances would not fit on a map!!)
- Discuss the unit that astronomers use to measure such large distances in space - the astronomical unit. Make sure the students understand that an AU is:
 1. The distance from the Earth to the Sun
 2. 150,000,000 km

Skills and Objectives

Students will be able to:

- Learn key vocabulary for distances in space
- Review measurement units and instruments
- Find out how to create a scale for modeling distances of the planets
- Calculate the relative distances between the planets using a scale distance
- Display the distances by constructing a model that accurately depicts the distances and provides information on each planet

Activity Overview

In this activity, the students will learn how to use a scale distance to accurately depict large distances in space. They will gain an understanding of the vastness of space and why the use of astronomical units is necessary. Using adding machine tape, they will construct a scale distance for the planets and use this scale to calculate the distance between the planets and the Sun.

Vocabulary

Astronomical unit - AU - the distance from the Earth to the Sun; 150 million kilometers

Meter - a metric unit for measuring distance or length

Kilo - prefix meaning 1000

Centi - prefix meaning 1/100; 0.01

Scale - using smaller measurements to represent larger measurements

Key Concepts

1. Distances in space are too great to measure with “earth-sized” units of measure.
2. Astronomers use kilometers, astronomical units, light-years, and parsecs to measure the distances between objects in space.
3. Using a scale for distances can accurately model the distances between the planets.

Materials

- Meter stick
- Adding machine tape
- Paper
- Scissors
- Tape

Procedure

Prior to the lesson

Be sure that your students have a good understanding of the units of measurement for length and can measure using a meter stick or metric ruler.

Be sure to review the vocabulary with the students before they begin the activity and be sure to also review the procedure after distributing the student worksheet. Allowing the students to then proceed more independently with their own procedure will reinforce reading and following direction skills.

If some students have difficulty processing the math component, you may want to let them check their work with calculators.

Review the concept of using a scale to measure large distance on a map. Also, review the information listed in “Teacher Background” to tie in scale with astronomy application.

- Copy and distribute the Student Worksheet to each student and allow the students to work in teams of 3-4 to generate the data for the table.
- Work through several examples listed on their worksheet and make sure they are recording their answers in the correct columns in the table.
- Instruct the students to answer the questions at the end of the activity individually; this allows you to assess their level of understanding for this activity and also allows you to review their progress in writing skills. This entire class can work collectively on the display in the hall of class room.

- Students should come to the realization of why traditional “Earth” units are not relevant to measuring distances in space. Have several different maps available to initiate the discussion of scale: A map of the U.S. will have a different scale for miles or kilometers than a map of your state.

Planet Name	Distance to Sun (Earth = 1 AU)	Distance to Sun (1 AU = 1 meter)	Distance to Sun (1 AU = 10 cm)
Mercury	0.4	0.4 meters	4.0 cm
Venus	0.7	0.7 m	7.0 cm
Earth	1.00	1.00 m	10 cm
Mars	1.5	1.5 m	15.0 cm
Jupiter	5.2	5.2 m	52.0 cm
Saturn	9.5	9.5 m	95.0 cm
Uranus	19.2	19.2 m	192.0 cm
Neptune	30.1	30.1 m	301.0 cm
Pluto	39.5	39.5 m	395.0 cm

Extensions

The scale model concept can be extended by having the students model the diameters of the planets to scale. This is particularly useful to illustrate the differences between the smaller rocky planets such as Mercury, Venus, Earth and Mars, and the larger gaseous planets, such as Jupiter, Saturn, Uranus and Neptune.

The activity uses the adding machine tape the students constructed and labeled in the distance model activity (above). The students practice measuring and modeling a distance using a scale. This time, create the planets using the diameters given. This activity is also particularly useful in reviewing some math concepts, such as diameter of a circle.

Using 2 cm for the diameter of the Earth makes the larger planets more manageable, although Pluto is extremely small at this scale. You may want the students to then draw in or color notable features, such as Saturn’s rings, Jupiter’s Great Red Spot, or Mars’ red color.

The students can simply measure diameters and color the planets the correct color on white paper and add the features, or you can provide them with an assortment of construction paper. They can cut out their planets and tape them at the correct location on the adding machine tape. (Some of the planets are quite small when using the scale; coloring may present a problem with the smaller ones.)

Students will be very surprised to see the distances when displayed on the wall in the hallway - the display should attract a lot of attention from other classes! You may want some of the students who finish early to make a sign that identifies the class project.

This activity can be adapted to different grade levels depending on their level of mastery for measuring and math skills. If you or your school is running multiple missions across grade levels, you may want to use only the distance model with 3rd graders and the distance and planet diameter model activity with the 4th and 5th grade. The older students can then be allowed to present their planet models to the third graders.

Planet Name	Diameter (km)	Diameter of Planets (to scale)
Mercury	4880	0.8
Venus	12,103	1.9
Earth	12,756	2.0
Mars	6794	1.06
Jupiter	142,984	22.46
Saturn	120,536	18.92
Uranus	51,118	8.12
Neptune	49,532	7.76
Pluto	2274	0.38

The students can round their measurements to the nearest tenth of a cm and you can reinforce measuring in millimeters on a ruler.



Teacher Answer Key

Questions:

1. What is an AU?

An AU is an astronomical unit; the distance between the Earth and the Sun.

2. Why did you decide on the scale that you used for your model?

If the larger scale (1 AU - 1 meter) is used, the model would not be as workable.

Thirty-nine meters of adding machine tape would be needed and it probably wouldn't fit in the hall or the classroom

3. Why do astronomers have to use AU's to measure distances in space?

Distances between objects in space are so large that using units such as kilometers or meters is not very convenient for the calculations needed in astronomy.