NASA Explorer Schools Pre-Algebra Unit

Lesson 1 Student Workbook

Solar System Math

Comparing Size and Distance

What are the parts of the solar system and how do they compare?

EG-2007-01-202-ARC

Name: ________________________________ Date: _______________

Pre-Lesson Activity

Step 1: On the back of this paper draw a picture of our solar system. In your drawing, show the different sizes of the planets and where they are located. Label *everything*. If you have time, add color to your picture.

Step 2: Using the chart below, list what you know about our solar system in the column titled "What I know." In the column titled "What I want to know" write questions you have about our solar system and space exploration.

What I know	What I want to know

Name: ______________________________ Date: ______________

Math Review: Converting Units

Length	Volume	Mass
1 kilometer = 1,000 meters	1 gallon ≈ 3.78 liters	1 pound ≈ 454 grams
1 meter = 100 centimeters	1 gallon = 4 quarts	1 kilogram = 1,000 grams
1 centimeter = 10 millimeters	1 quart ≈ 0.95 liter	1 gram = 100 centigrams
1 mile = 5,280 feet	1 liter = 1,000 milliliters	1 centigram = 10 milligrams
1 yard = 3 feet	1 pint = 0.5 quart	
1 meter ≈ 3.28 feet	1 pint = 16 fluid ounces	
1 foot = 12 inches		
1 inch ≈ 2.54 centimeters		

Directions: Use the table of relationships above to solve practice problems 1-5 below. You may use additional paper for doing calculations.

1. Yna bought 3 gallons of milk at the store.
   How many liters did she buy? __________ liters

2. Jamal caught a pass and ran 57 yards to make a touchdown.
   How many feet did he run? __________ feet

3. A car weighs 850 pounds. *How much does it weigh in kilograms?* (Hint: change pounds to grams, then change grams to kilograms) __________ kilograms

4. Jessica runs the 100-meter dash at the track meet.
   How many feet does she run? __________ feet

5. **Bonus:** Juan and his family traveled 339 miles from San Jose to Los Angeles.
   How many kilometers did they travel? __________ kilometers

Name: ______________________________ Date: _______________

Travel Planning

1. If you planned a family vacation, ***how*** would you decide where to go?

____

____

2. What factors (details about your trip) would you need to think about?

a. ______________________ c. __________________________

b. ______________________ d. __________________________

Space Exploration

3. What are some reasons for humans to explore our solar system?

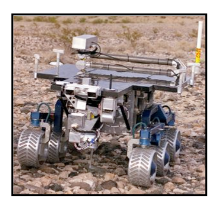
____

____

4. Why should ***humans*** explore space in addition to robots?

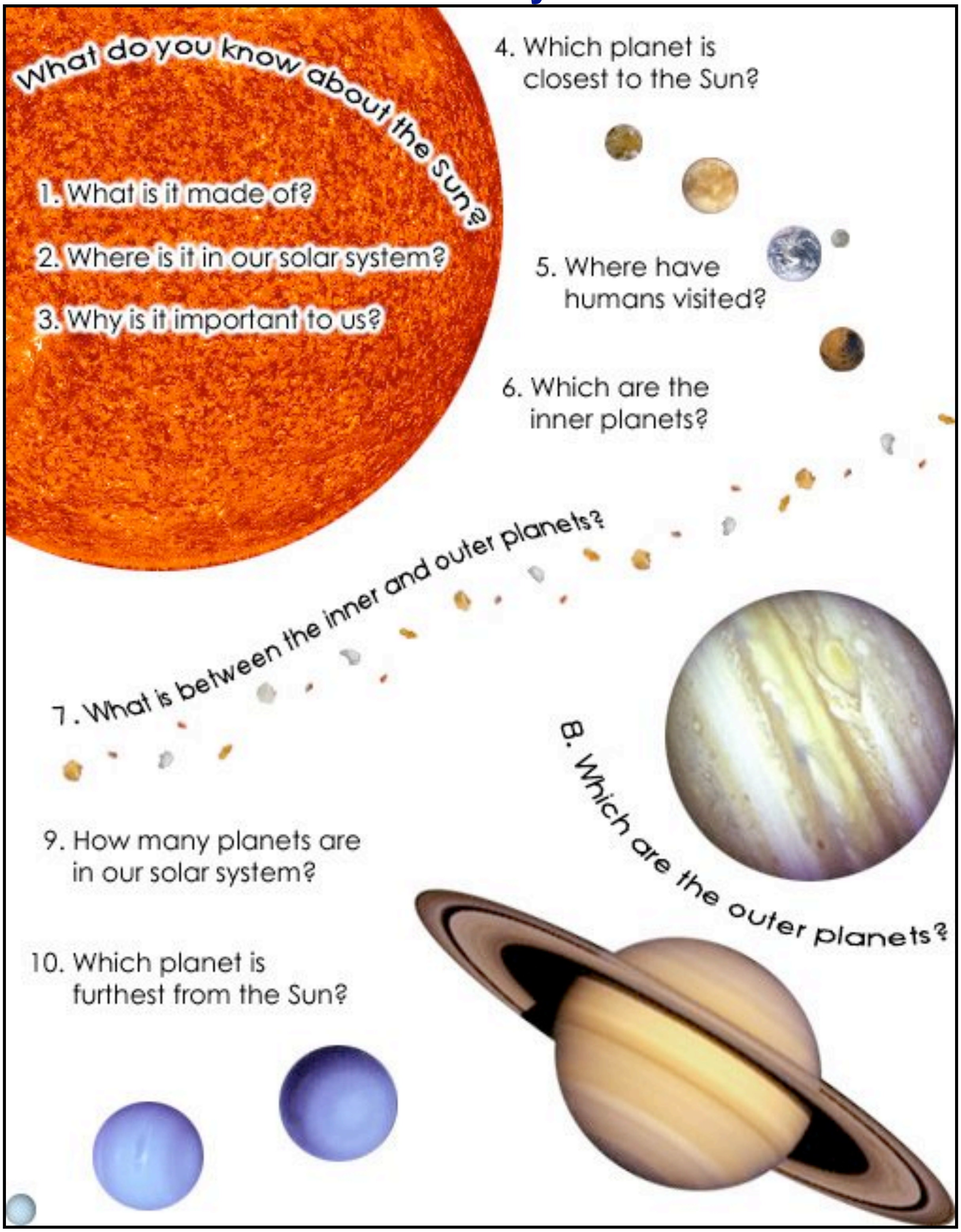
____

____



Name: ________________________________ Date: _______________

Our Solar System



Name: ______________________________ Date: _____________

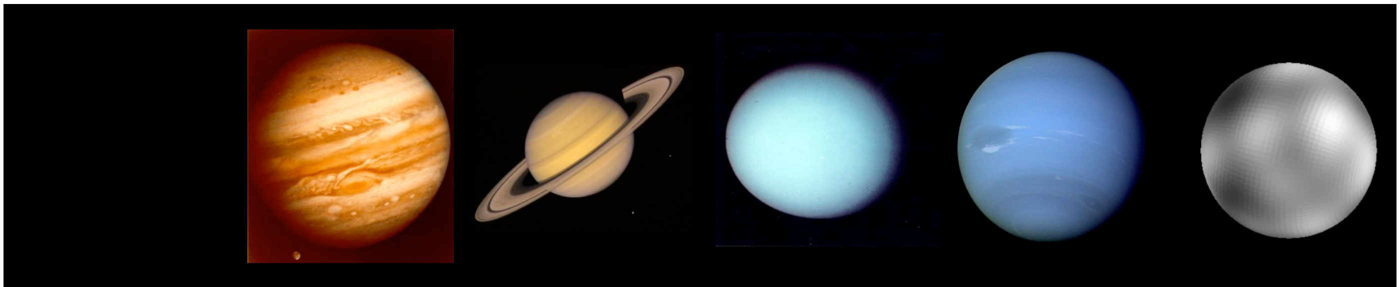
Lesson 1 Planet Data Sheet – Inner Planets




Planet	**Mercury**	**Venus**	**Earth**	**Mars**
Distance from Sun in km				
Distance from Sun in AU				
Diameter in km				
Avg. Surface Temperature				
Atmosphere				

Name: ______________________________ Date: ______________

Lesson 1 Planet Data Sheet – Outer Planets



Planet	**Jupiter**	**Saturn**	**Uranus**	**Neptune**	**Pluto**
Distance from Sun in km					
Distance from Sun in AU					
Diameter in km					
Avg. Surface Temperature					
Atmosphere					

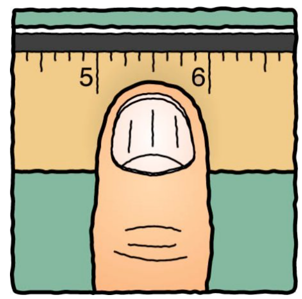
Name: ______________________________ Date: ______________

A Brief History of Units of Measurement

Student Reading

To measure a distance between two objects you need two things: a unit of measurement (how much you are measuring by) and a tool (what you measure with). Long before measuring tools like rulers and tape measures were common, people needed a way to measure things. In early times, people who did not have tools used parts of their bodies (like their thumbs) to measure.

About 950 years ago, the width of a person's thumb was considered an inch. In many languages, the word for thumb and inch are the same or very close. A person's foot was used to measure feet. A yard was the length from the tip of the king's nose to the end of his fingertips.



Everyone had a way to measure distances, but there was a problem. Everyone knew what to measure with, but there was no standard for how big things were. For example, if you measured the length of your bedroom with *your* feet, and then your friend did the same with *his* feet, you would not get the exact same measurement because your feet and your friend's feet are different sizes.

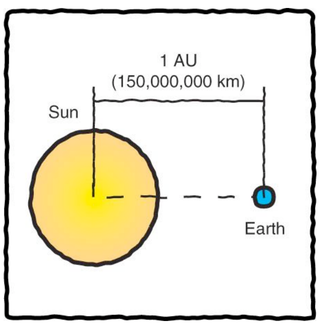
Eventually people agreed on standards—measurements that were the same for everyone. The Romans liked to divide things into units of 12. This is why we have 12 months in the year. They decided that a foot contained 12 inches. In England in the 1100's, King Henry I decided to use the Roman standard of measurement for feet, and he spread the word to his people that a foot was 12 inches long. Once the standards were set and everyone agreed on the lengths of units of measurement, the system worked better. But it still is not perfect.

In the 1800's, the French Academy of Sciences was asked to develop a system of measurement that was based on scientific measurements and used the base-10 system. The Academy set their standard of

measurement (a meter) as a fraction of the distance from the North Pole to the equator on the surface of the Earth. Larger and smaller units were made by multiplying or dividing a meter by factors of 10. One thousand meters is a kilometer. One hundred centimeters is a meter. Ten millimeters is a centimeter. Even the names of the units indicate how big they are: kilo- means 1000, centi- means 100. Now we can just move the decimal point to change from larger or smaller units.

By the year 1900, thirty-five countries decided that the metric system would be their standard system of measurement. Some countries, like the USA, did not decide that the metric system would be their standard system of measurement. This can be a challenge when international scientists and engineers try to work together on the same project!

While kilometers are useful for measuring distances on Earth, they are too small for measuring distances throughout the solar system. For example, the distance from the Sun to Jupiter is 778,000,000 km (778 million kilometers). Scientists decided to create a new unit of measurement, which would be helpful when measuring the solar system. They called the average distance between the center of the Earth and the center of the Sun one Astronomical Unit (1 AU). This distance is 150,000,000 km, which is roughly the number of kilometers between the center of the Earth and the center of the Sun. The rest of the solar system ranges between 0.4 AU (from Mercury to the Sun) to 39.3 AU (from Pluto to the Sun).



When leaving the solar system and looking at other star systems, the AU is too small for scientists' needs. So they created a LARGER unit of measurement. Scientists measure a light-year as the distance light can travel in one year. The next closest star to Earth (after the Sun) is Alpha Centauri, which is 4.34 light-years away. This means that the light we see from Alpha Centauri at night actually left the star 4.34 years ago.

Our system of measurement has evolved from using thumbs and feet to using the distance traveled by light in one year. As our scope of the universe continues to expand, so will our need for new standards of measurement.

Discussion Questions

1. What is the problem with using parts of the body as a unit of measurement?

____

2. Why were customary (or standard) units established?

____

3. What is the advantage of metric units?

____

4. Why is using kilometers to measure distances in our solar system a problem?

____

5. What standard unit in astronomy was developed to measure large distances?

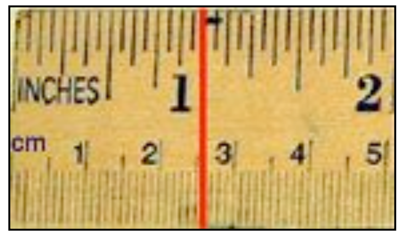
____

Name: ________________________________ Date: ______________

Unit Conversion: Building the Concept

1. Looking at the picture of the ruler marked with inches and centimeters, we see that there are approximately 2.54 centimeters in 1 inch. Write this in the spaces below.

   1 inch ≈ ___.___ ___ centimeters



2. Now that you know there are approximately 2.54 centimeters in one inch, use this information to solve the problems below. There are many ways to find the answers. For example, you may use a ruler, or draw a picture, or add, multiply, or divide. Show your work, and then discuss your method (or strategy) with the class.

Solve	Show your method (strategy).
5 inches ≈ ________ centimeters	
10 inches ≈ ________ centimeters	
________ inches ≈ 15 centimeters	

Name: ______________________________ Date: ______________

Unit Conversion: Applying the Concept

1. "*A Brief History of Units of Measurement*" talked about the average distance between the center of the Sun and the center of the Earth.

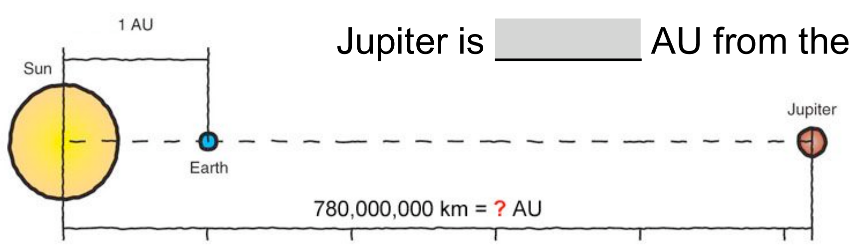
   Name this unit of measurement: ____________________________

   Draw a picture…

2. *How many kilometers are in 1 AU?* ___________________________

3. Jupiter is 778,000,000 kilometers from the Sun. *How many AU is Jupiter from the Sun?* Show your work so you can discuss your strategy with the class.

Jupiter is _______ AU from the Sun.



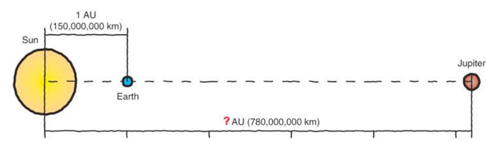
Show your work here…

Name: ______________________________ Date: ______________

Unit Conversion: Using Unit Ratios

Sample Problem

This sample problem will help you learn to use “**unit ratios”** to convert from one unit to another unit.

<table>
<tr><th>What we know:</th><th>What we want to know:</th></tr>
<tr><td>1 AU = 150,000,000 km.</td><td rowspan="2">How many AU is Jupiter from the Sun?

</td></tr>
<tr><td>Jupiter is 778,000,000 km from the Sun.</td></tr>
</table>

If we want to know how many AU Jupiter is from the Sun, then we need to convert 778,000,000 km to AU. We can do this using a unit ratio.

To convert km to AU, use the **unit ratio**:

$$\frac{\textbf{1 AU}}{\textbf{150,000,000 km}}$$

This unit ratio is equal to _____ because 1 AU is equal to 150 million km.

When you multiply a distance by this unit ratio, you are multiplying the distance by _____. You are not changing the value of the distance. The distance is the same. You simply changed the unit used to measure it.

First, set up the problem.

$$778{,}000{,}000 \text{ km} = 778{,}000{,}000 \text{ km} \cdot \frac{1 \text{ AU}}{150{,}000{,}000 \text{ km}}$$

Second, cancel the kilometers by marking through the km.

$$= 778{,}000{,}000 \text{ km} \cdot \frac{1 \text{ AU}}{150{,}000{,}000 \text{ km}}$$

Third, multiply 778,000,000 by 1 AU.

$$= \frac{\_\_\_\_\_\_\_\_ \text{ AU}}{150{,}000{,}000}$$

Fourth, cancel the zeros by marking through them.

$$= \frac{778{,}000{,}000 \text{ AU}}{150{,}000{,}000}$$

Fifth, divide the numerator (top number) by the denominator (bottom number).

$$= \frac{778 \text{ AU}}{150}$$

Sixth, round to the nearest tenth and state your answer.

778,000,000 km ≈ ___ AU

or

Jupiter is approximately _____ AU from the Sun.

Name: ______________________________ Date: ______________

Rounding, Estimation, and Appropriate Units

1a) When measuring really large distances, such as the distance from Mars to the Sun, what unit(s) would be most appropriate to use?

❑ astronomical units ❑ kilometers/miles ❑ meters/feet

1b) Why is meters or centimeters a poor choice? ________________

____

2) In the "Using Unit Ratios" Sample Problem on pages 13-14, you divided 778 by 150. Using a calculator, the answer is 5.1866667. *How precise does this measurement need to be when calculating the scale model distance to Jupiter?*

❑ 5.1866667 AU ❑ 5.187 AU ❑ 5.2 AU

3a) Do the calculations below. (Remember 1.0 AU = 150,000,000 km.)

0.1 AU ≈ __________ km or _____million km
0.01 AU ≈ __________ km or _____million km
0.001 AU ≈ __________ km or _____thousand km

3b) To what place value (tenths, hundredths, or thousandths) is it reasonable to round AU for your scale model calculations? Why?

____

Creating a Clay Model of the Solar System

MATERIALS: 9 index cards, marker, 3 pounds of clay (or dough)

DIRECTIONS: Using a marker, label the 9 index cards with the names of the 9 planets. Then using 3 pounds of modeling clay, follow the 7 steps listed below.

Step 1. **Divide the clay into 10 equal parts (tenths).**

- Use 6 tenths to make Jupiter.
- Use 3 tenths to make Saturn.
- Use the remaining clay (1 tenth) in step 2.

Step 2. **Divide the remaining clay into tenths.**

- Add 5 tenths to Saturn.
- Use 2 tenths to make Neptune.
- Use 2 tenths to make Uranus.
- Use the remaining clay (1 tenth) in step 3.

Step 3. **Divide the remaining clay into fourths.**

- Add 3 fourths to Saturn.
- Use the remaining clay (1 fourth) in step 4.

Step 4. **Divide the remaining clay into tenths.**

- Use 2 tenths to make Earth.
- Use 2 tenths to make Venus.
- Add 4 tenths to Uranus.
- Combine the remaining clay (2 tenths) and use in step 5.

Step 5. **Divide the remaining clay into tenths.**

- Use 1 tenth to make Mars.
- Add 4 tenths to Neptune.
- Add 4 tenths to Uranus.
- Use the remaining clay (1 tenth) in step 6.

Step 6. **Divide the remaining clay into tenths.**

- Use 7 tenths to make Mercury.
- Add 2 tenths to Uranus.
- Use the remaining clay (1 tenth) in step 7.

Step 7. **Divide the remaining clay into tenths.**

- Add 9 tenths to Uranus.
- Use 1 tenth to make Pluto.

Check your work!

When you finish making your 9 planets, you should double-check your work!

Use a metric ruler to measure the *diameter* of your clay planets in millimeters (mm).

The diameter of your planets should be close to the "*scale diameter*" measurements in the chart on page 20.

Name: ________________________________ Date: ______________

Calculating Scale of the Clay Model, Part I

Purpose

Now that you have created a scale model of the solar system in terms of size, you need to **establish a scale for your model in terms of distance.** Then you will need to calculate the distance from the Sun for each planet in your model.

Finding the scale between the model of the solar system and the actual solar system is the mathematical challenge of this activity. For a model, the "scale" is the amount by which the size of the original has been changed proportionally. *The key to finding the scale distances is using ratios and proportions*—relationships between the model distances and the actual distances.

Let's Begin!

In your clay model, Pluto is the furthest object from the Sun. For the Clay Model, Pluto is approximately 4,205 meters from the Sun.

If 4,205 meters represents the distance from Pluto to the Sun, then *how many AUs are represented by 4,205 meters?* (Hint: Refer to your Planet Data Sheet – Outer Planets on page 7.)

4,205 meters represents ________ AU.

This allows us to set up a ratio.

$$\frac{\text{Distance from Pluto to the Sun in the scale model}}{\text{Distance from Pluto to the Sun in the solar system}} = \frac{\_\_\_\_\_\_\ \text{m}}{\_\_\_\_\_\_\ \text{AU}}$$

The relationship between ______________m and __________AU will be our *scaling ratio*. We can use this relationship to find the distances from all of the planets to the Sun in the model.

Begin with the information you know:

1. What is the distance between the Earth and the Sun? _______

2. The scaling ratio for this model is: $\dfrac{\underline{\qquad\qquad} \text{ m}}{\underline{\qquad\qquad} \text{ AU}}$

Next, to find the scale of the model, we want to know ***how many meters represent 1 AU?***

Step 1: Set up a ratio of the distance from a planet to the Sun in the model and the distance from a planet to the Sun in the solar system. Write an "x" in the gray space below to represent the number we do not know.

$$\frac{\text{Distance from Earth to the Sun in scale model}}{\text{Distance from Earth to the Sun in solar system}} = \frac{\underline{\quad}\text{ m}}{1 \text{ AU}}$$

Step 2: Set this ratio equal to the *scaling ratio*.

$$\frac{\text{Distance from Pluto to Sun in model}}{\text{Dist. from Pluto to Sun in solar system}} = \frac{\text{Distance from Earth to Sun in model}}{\text{Dist. from Earth to Sun in solar system}}$$

$$\frac{\underline{\quad}\text{ m}}{\underline{\quad}\text{ AU}} = \frac{x}{\underline{\quad}\text{ AU}}$$

Step 3: Solve the problem using the same steps in the sample problem on page 14.

$$\frac{4{,}205 \text{ m}}{39.3 \text{ AU}} = \frac{x}{1 \text{ AU}}$$

Cross multiply.

_______ m • 1 AU = x • _______ AU

Divide both sides by 39.3 and cancel the AUs.

$$\frac{\_\_\_\_\_\_ \text{ m} \cdot 1 \text{ AU}}{\_\_\_\_\_\_ \text{ AU}} = \frac{x \cdot \_\_\_\_\_\_ \text{ AU}}{\_\_\_\_\_\_ \text{ AU}}$$

Rewrite the problem as a single ratio.

$$\frac{\_\_\_\_\_\_ \text{ m}}{\_\_\_\_\_\_} = x$$

Divide the numerator by the denominator. Round to a whole number.

_______ m = x

State the answer.

1 AU = _______ m

Or the distance from Earth to the Sun in the model is _______ meters.

Congratulations!

Now that you know how many meters represent 1AU, you have successfully calculated the scale of the Clay Model.

Name: ________________________________ Date: ______________

Calculating Scale of the Clay Model, Part II

Based on the *scale diameter* of the clay planets, it has been determined that the *scale distance* of the clay model of the solar system is ______ **meters**. This represents 1 AU in our solar system. Use this information to:

- Calculate how many meters (m) each planet is from the Sun. (column A) ***Round your answers to the nearest whole meter.***
- Convert the meters to half-meter paces. (column B)
- Calculate the number of paces that are between each object. (column C)

				A	B	C
Object	**Actual Diameter (km)**	**Scale Diameter (mm)**	**Distance from Sun (AU)**	**Scale Distance (m)**	**# of Half-Meter Paces from Sun**	**# Paces from Previous Object**
Sun	1,391,900	993	—	—	—	—
Mercury	4,878	3.5	0.4			
Venus	12,104	8.6	0.7			
Earth	**12,755**	**9.1**	**1.0**	**107**	**214**	**64**
Mars	6790	4.8	1.5			
Asteroid Belt	1 to 1,000	0.0007 to 0.7	2.0 to 4.0	___ to ___	___ to ___	___ to ___
Jupiter	142,796	102	5.2			
Saturn	120,660	86	9.5			
Uranus	51,118	36	19.2			
Neptune	49,528	35	30.0			
Pluto	2,300	1.6	39.3			

Creating a 1000-Meter Model of the Solar System

Collect and label the 10 objects below. If certain items cannot be found, then items of similar size may be substituted. *(The pictures below are not to scale.)*

Body		**Scale Model Object**	**Scale Model Size**
Sun		bowling ball	235 mm
Mercury		regular pin head	0.8 mm
Venus		green peppercorn	2.0 mm
Earth		black peppercorn	2.1 mm
Mars		regular pin head	1.1 mm
Jupiter		pecan	24.1 mm
Saturn		hazelnut	20.4 mm
Uranus		coffee bean	8.6 mm
Neptune		coffee bean	8.4 mm
Pluto		small pin head	0.4 mm

Name: ________________________________ Date: _______________

Calculating Scale of the 1000-Meter Model, Part I

Purpose

Now that you have created a scale model of the solar system in terms of size, you need to **establish a scale for your model in terms of distance.** Then you will need to calculate the distance from the Sun for each planet in your model.

Finding the scale between the model of the solar system and the actual solar system is the mathematical challenge of this activity. For a model, the "scale" is the amount by which the size of the original has been changed proportionally. *The key to finding the scale distances is using ratios and proportions*—relationships between the model distances and the actual distances.

Let's Begin!

In your 1000-meter model, Pluto is the furthest object from the Sun. For the 1,000-Meter Model, Pluto (small pin head) is approximately 1,000 meters from the Sun (bowling ball).

If 1,000 meters represents the distance from Pluto to the Sun, then *how many AUs are represented by 1,000 meters?* (Hint: Refer to your Planet Data Sheet – Outer Planets on page 7.)

1,000 meters represents _______ AU.

This allows us to set up a ratio.

$$\frac{\text{Distance from Pluto to the Sun in the scale model}}{\text{Distance from Pluto to the Sun in the solar system}} = \frac{\_\_\_\_\_\ \text{m}}{\_\_\_\_\_\ \text{AU}}$$

The relationship between ____________m and _________AU will be our *scaling ratio*. We can use this relationship to find the distances from all of the planets to the Sun in the model.

Begin with the information you know:

1. *What is the distance between the Earth and the Sun?* ______

2. *The scaling ratio for this model is:* $\frac{\_\_\_\_\_\_\_\_\_\_\ m}{\_\_\_\_\_\_\_\_\_\_\ AU}$

Next, to find the scale of the model, we want to know ***how many meters represent 1 AU?***

Step 1: Set up a ratio of the distance from a planet to the Sun in the model and the distance from a planet to the Sun in the solar system. Write an "x" in the gray space below to represent the number we do not know.

$$\frac{\text{Distance from Earth to the Sun in scale model}}{\text{Distance from Earth to the Sun in solar system}} = \frac{\_\_\ \text{m}}{1\ \text{AU}}$$

Step 2: Set this ratio equal to the *scaling ratio*.

$$\frac{\text{Distance from Pluto to Sun in model}}{\text{Dist. from Pluto to Sun in solar system}} = \frac{\text{Distance from Earth to Sun in model}}{\text{Dist. from Earth to Sun in solar system}}$$

$$\frac{\_\_\_\ \text{m}}{\_\_\_\ \text{AU}} = \frac{x}{\_\_\ \text{AU}}$$

Step 3: Solve the problem using the same steps in the sample problem on page 14.

$$\frac{1{,}000\ \text{m}}{39.3\ \text{AU}} = \frac{x}{1\ \text{AU}}$$

Cross multiply.

$$\_\_\_\_\_\_\ \text{m} \cdot 1\ \text{AU} = x \cdot \_\_\_\_\_\_\ \text{AU}$$

Divide both sides by 39.3 and cancel the AUs.

$$\frac{\_\_\_\_\_\_\ \text{m} \cdot 1\ \text{AU}}{\_\_\_\_\_\_\ \text{AU}} = \frac{x \cdot \_\_\_\_\_\_\ \text{AU}}{\_\_\_\_\_\_\ \text{AU}}$$

Rewrite the problem as a single ratio.

$$\frac{\_\_\_\_\_\_\ \text{m}}{\_\_\_\_\_\_} = x$$

Divide the numerator by the denominator. Round to one decimal point.

$$\_\_\_\_\_\_\ \text{m} = x$$

State the answer.

$$1\ \text{AU} = \_\_\_\_\_\_\ \text{m}$$

In the model, the distance from Earth to the Sun is ______ meters.

Congratulations!

Now that you know how many meters represent 1AU, you have successfully calculated the scale of the 1000-Meter Model.

Name: ______________________________ Date: ______________

Calculating Scale of the 1000-Meter Model, Part II

Based on the *scale diameter* of the model planets, it has been determined that the *scale distance* of the 1,000-meter model of the solar system is ______ **meters**. This represents 1 AU in our solar system. Use this information to:

- Calculate how many meters (m) each planet is from the Sun. (column A) ***Round your answers to the nearest whole meter.***
- Convert the meters to half-meter paces. (column B)
- Calculate the number of paces that are between each object. (column C)

					A	B	C
Object	**Actual Diameter** (km)	**Scale Diameter** (mm)	**Model Object**	**Distance from Sun** (AU)	**Scale Distance** (m)	**# of 1/2 Meter Paces from Sun**	**# Paces from Previous Object**
Sun	1,391,900	**235**	bowling ball	—	—	—	—
Mercury	4,878	**0.8**	pinhead	0.4			
Venus	12,104	**2.0**	peppercorn	0.7			
Earth	**12,755**	**2.1**	**peppercorn**	**1.0**	**25**	**50**	**14**
Mars	6,790	**1.1**	pinhead	1.5			
Jupiter	142,796	**24.1**	pecan	5.2			
Saturn	120,660	**20.4**	hazelnut	9.5			
Uranus	51,118	**8.6**	coffee bean	19.2			
Neptune	49,528	**8.4**	coffee bean	30.0			
Pluto	2,300	**0.4**	small pinhead	39.3			

Name: ________________________________ Date: ______________

Think About It!

You just created a model of the solar system that is to scale for both size and distance. Reflect on what you noticed and learned.

7. Based on your scale model, to which of the planets do you think we should send humans? Why?

____

8. To which of the planets do you think we should not send humans? Why not?

____

Name: ______________________________ Date: ______________

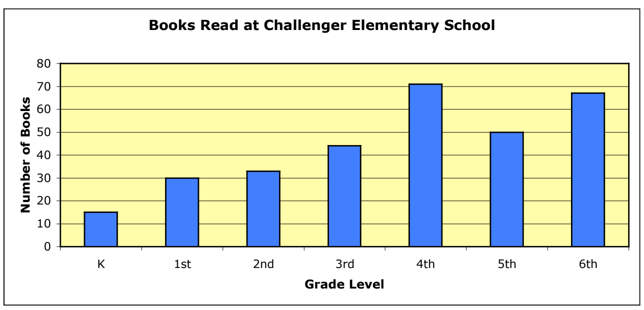
Graphing Resource

Student Guide

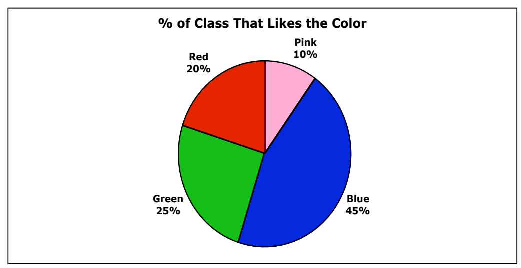
Types of Graphs

There are several types of graphs that scientists and mathematicians use to analyze sets of numbers or data.

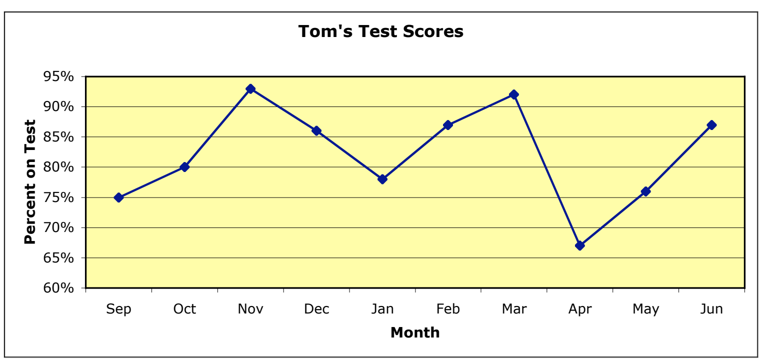
Bar graphs are often used to compare values.



Pie graphs are often used to compare percentages or parts of a whole.



Line graphs are often used to show rates of change.



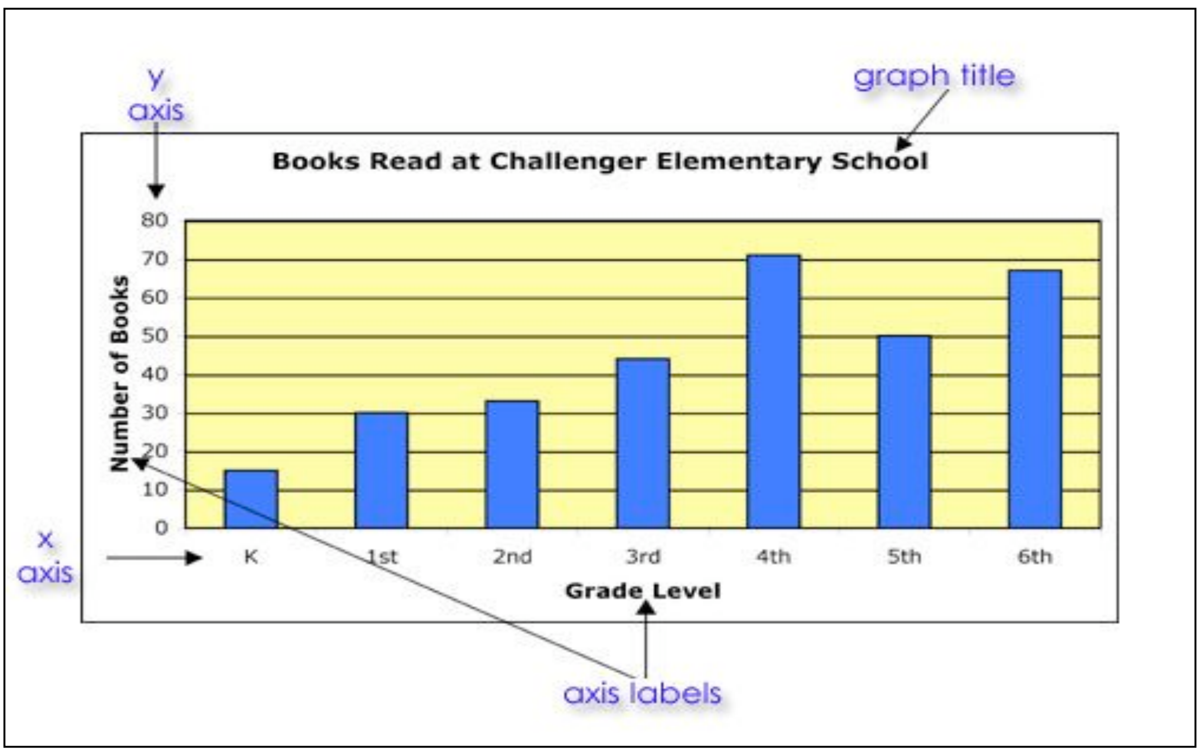
Before You Begin

When you are planning to graph data, you need to answer some questions before you begin.

1. What type of graph will you use?
2. What unit of measurement will you use?
3. What scale will you use?
4. What will be the minimum and maximum values on your graph?
5. Will your graph start at 0?

Making Bar Graphs and Line Graphs

Every graph needs a **title** and **labels** on the horizontal "x" axis (side-to-side) and the vertical "y" axis (up and down).



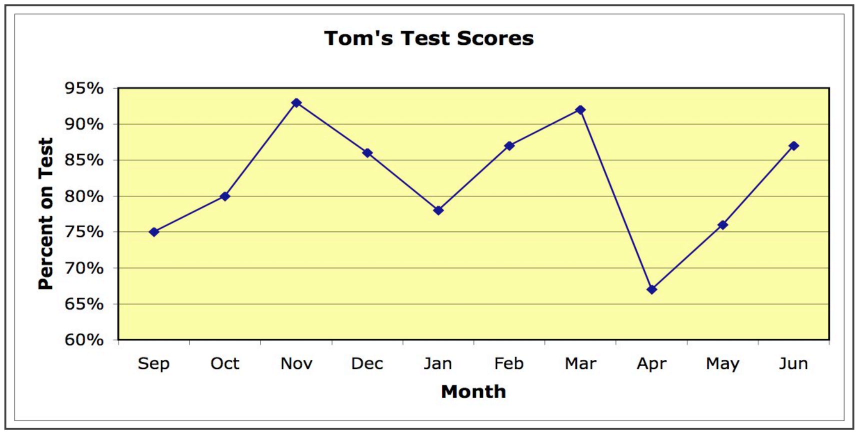
The **unit of measurement** you are using needs to be clearly shown (inches, kilograms, etc.). The unit for the bar graph above is "number of books" as is written in the vertical y-axis label.

You also must choose a **scale** for your vertical y-axis. The vertical scale on the bar graph above goes from 0 to 80 in increments of 10.

The scale is determined by the data you are graphing. To determine the scale, look at the *largest* and *smallest* numbers you will be graphing.

For this line graph, the vertical y-axis goes from 60% to 95% in increments of 5%.

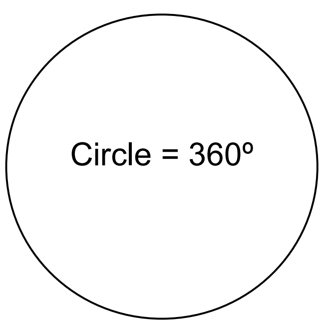
The unit of measurement For this graph is "percent." (%)



Making a Pie Graph

A pie graph is shown using a circle, which has 360 degrees. To make an accurate pie graph you will need a compass or a similar instrument to trace a circle and a protractor to measure angles in degrees.

Start by making a circle. You will then have to multiply your fractions or percents (in decimal format) by 360 degrees to find out how many degrees you will need in each wedge. For example:



Color	% of class that likes the color
Blue	45%
Green	25%
Red	20%
Pink	10%

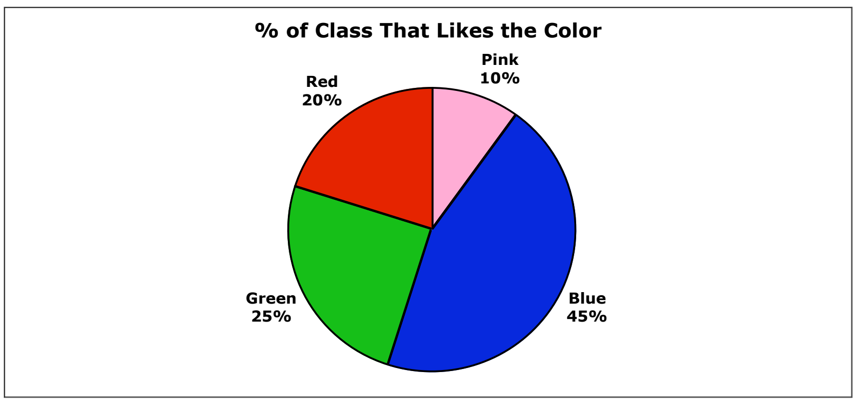
100%

The sum of your fractions should total to 100%!

To find out how many degrees of the pie graph will represent the number of students in the class who like the color blue, you would multiply 360 degrees by 0.45. The result of your calculation is 162 degrees. To find out how many degrees of the pie graph will represent the number of students in the class who like the color green, you would multiply 360 degrees by 0.25. The result of your calculation is 90 degrees.

To mark off the blue portion of the pie graph, start by drawing a radius of the circle (a line segment from the center of the circle to the circle itself). Then use the protractor to measure an angle of 162 degrees and draw the corresponding radius. The green portion will have an angle measure of 90 degrees, the red portion will have an angle measure of 72 degrees, and the pink portion will have an angle measure of 36 degrees. The sum of these angles will have an angle measure of 360 degrees, the number of degrees in a circle.

Pink	= 36°
Blue	= 162°
Green	= 90°
Red	= 72°
Total	**= 360°**



When the portions have been drawn into the circle, you then need to **color** each portion, label each portion with both the **category** and the **percent or fraction**, and give the graph an overall **title**.

Name: ________________________________ Date: _______________

Graphing Distances in the Solar System

You are going to *graph the distances from the planets to the Sun* based on the data you have collected. First you need to *plan* your graph by answering the five questions below. Then you should *create* your graph on graph paper or chart paper. Be sure to give your graph a title and to label your x- and y-axis.

1. What type of graph will you use? ______________________________

   ❑ bar graph ❑ pie graph ❑ line graph ❑ _____________ other

2. What unit of measurement will you use? ________________________

3. What scale will you use? _____ to _____ in increments of _________

4. What will be the maximum and minimum data values on your graph?

   Maximum value = _________

   Minimum value = __________

5. Will your graph start at 0? If not, with what number will your graph begin?

   ____

Name: ________________________________ Date: _______________

So What Do You Think?

Now that you have collected data on the planets, built a scale model of the solar system, and graphed the distances of the planets from the Sun, take a moment to think about what you have learned.

1. What did you learn from *What's the Difference*, the scale model, and your graph?

____

____

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2. Based on the scale model and what you have learned, to which planet or moon do you think we should send humans in our solar system? Why?

____

____

____

3. What else do you need to know about the planets and moons in order to make a recommendation?

____

____

Name: ________________________________ Date:______________

Lesson 1 Extension Problems

Bode's Law

The chart below shows the distance from each planet and the asteroid belt to the Sun *rounded to the nearest tenth* of an Astronomical Unit.

Mercury	Venus	Earth	Mars	Asteroids	Jupiter	Saturn	Uranus	Neptune	Pluto
0.4	0.7	1.0	≈ 1.6	≈ 2.8	5.2	≈ 10.0	≈ 19.6	≈ 30.1	≈ 39.6

Can you find a pattern between the distance from one planet to the Sun and the next planet to the Sun?

For example:

Distance from Venus to the Sun – Distance from Mercury to the Sun = __?__

0.7 – 0.4 = 0.3

Use the chart below to solve this equation for each of the planets. The first one has been done for you.

Mercury	Venus	Earth	Mars	Asteroids	Jupiter	Saturn	Uranus	Neptune	Pluto
0.4	0.7	1.0	1.6	2.8	5.2	10.0	19.6	30.1	39.6
0.3									

What is the pattern for the distance between the planets? Describe the pattern that you see.

In reality, the pattern is more complex than presented here. The original pattern can be described as follows:

- List the numbers, doubling every number after 3. (0, 3, 6, 12, etc.)
- Add 4 to each number.
- Divide each of the resulting numbers by 10. The results are the approximate distances of the planets from the Sun, measured in AU.

Background

Bode's Law is not really a law; it's merely an interesting relationship between the arrangement of the planets around the Sun. In fact, it is based on *rough estimates* of planetary distances (at least as good as the measurements could be in the 1700s), so the actual orbital distances that you calculated in other parts of this lesson will be somewhat different than the values listed here.

This relationship was first discovered by Johann Titius and published by Johann Bode in 1772, hence why it is called Bode's Law. It was calculated *before* Uranus, Neptune, and Pluto were discovered. Astronomers actually found Uranus because they searched the sky at the distance predicted by this relationship! This pattern was also discovered before astronomers knew about the asteroid belt. Many scientists think that the asteroid belt is the remains of a destroyed planet, whose distance would have fit in perfectly with this pattern.

Name: ___________________________ Date:_______________

Lesson 1 Extension Problems continued…

Ratio Problems and Conversion Problems

The following are problems that will take multiple steps to solve. You will need to measure lengths inside the classroom and apply what you know about scale, ratio, and proportion to solve them. You may choose the units you work with as long as they are appropriate. Be sure to include descriptions and pictures to explain how you solved the problem.

1. Scale Movie Stars

Some fantasy characters, such as Hobbits from Lord of the Rings or Hagrid from the Harry Potter series are on different scales than humans. The following calculations will demonstrate how a regular object would need to be changed to fit the scale size of a character.

Hobbits are known as Halflings. They are about *half* the size of a human. Hagrid, however, had a Giantess mother. He is about *twice* the size of a human.

A. If your teacher became a Hobbit, **estimate** how tall he or she would be. Next estimate how tall your teacher would be if he or she were Hagrid's size. **Measure** your teacher and **calculate** his or her Hobbit and Hagrid heights. If possible, mark the Hobbit height, Hagrid height, and actual height of your teacher on the wall or chart paper.

B. Choose an object in the classroom. **Estimate** the height or length that object would be if it were scaled to Hobbit or Hagrid size. **Measure** the object and **calculate** exactly how long or tall it would be for a Hobbit-sized or Hagrid-sized teacher. Draw a scale picture of how that object would look. How close was your estimate?

Example: A standard stapler is 16 cm long and 5 cm high. A Hobbit-sized stapler would be 8 cm long and 2.5 cm high. A Hagrid-sized stapler would be 32 cm long and 10 cm high. Your picture would need to MATCH the new sizes. Remember to label the sizes on your picture.

2. Scale Model Athletes

In order to appear realistic, action figures and dolls are made to scale. *If all athlete models are the same height, are they all on the same scale?*

A. An average sports action figure is about 20 cm tall. Calculate the ratio of this toy's height to the height of your favorite athlete. (Hint: You will need to look up some information on your favorite athlete to solve this problem!)

B. Imagine that you dressed up as your favorite athlete for Halloween. Calculate the ratio between your height and the actual athlete's height. (Hint: You'll need to measure yourself for this one!)

C. Pretend you are making a scale model in clay of your favorite athlete. For your model, 1 cm will represent 15 cm of the height of your athlete. How many cm tall will your scale model be? (Hint: Round your answer to the nearest cm.)

3. How Far *is* an AU?

Astronomical units make measuring distance in our solar system easier. *How LARGE is an AU in relation to distances here on Earth?*

A. One AU is 150,000,000 km. The distance from New York to Los Angeles is 4,548 km. Estimate how many times you would have to travel from New York to Los Angeles to travel one AU. Calculate the actual number of trips and round down to the nearest whole number.

B. Imagine you had a jump rope that was the length of 1 AU. Estimate how many times you could wrap your jump rope around the equator of the Earth. Calculate the actual number of times your jump rope could wrap around the equator and round that value to the nearest whole number.

4. A Desk-Sized Model

As you have seen, making a scale model of the solar system is challenging. *What would the model look like on different scales?*

A. If you wanted to fit a model of the solar system on your desk, what would be the distance from the Earth to the Sun in the model? (Hint: You will need to measure your desk.)

Estimate how big Jupiter would be in this scale model, and then calculate the actual size.

Do you think a model of this size would be helpful? Why or why not?

B. Estimate the distance from the Earth to the Sun in a model that would fit inside your classroom. (Hint: You will need to measure your classroom.)

Calculate the distance from Earth to the Sun in the model.

Estimate how big a model of Jupiter would be in this model and then calculate the actual size.

Would this model be better than the one that would fit on your desk? Why or why not?

AFUs (Absolutely Fabulous Units)

Scientists created an Astronomical Unit (AU) to measure distance in our solar system. Create your own system of measurement. Choose any distance you wish (except, of course, the distance between the Earth and Sun—that one's already taken!).

EXAMPLE

Name: Astronomical Unit

Definition: An astronomical unit is the distance between the Earth and Sun.

Size: One astronomical unit = 150,000,000 kilometers

Mercury: 0.4 AU	Mars: 1.5 AU	Uranus: 19.2AU
Venus: 0.7 AU	Jupiter: 5.2 AU	Neptune: 30.0 AU
Earth: 1.0 AU	Saturn: 9.5 AU	Pluto: 39.3 AU

1. Name your unit: ______________________________

2. Define it: ______________________________

   Tell its size: ____________ = ____________

3. Convert all of the distances in the solar system to your new unit.

Mercury: ______	Mars: ______	Uranus: ______
Venus: ______	Jupiter: ______	Neptune: ______
Earth: ______	Saturn: ______	Pluto: ______

Think About It / Write About It / Discuss It Questions

1. If you made a model of our solar system that would fit on your desk to scale for both distance and size, what would you expect the planets to look like?

Inner: ____

Outer: ____

Why would this be a difficult model to build?

____

____

2. Estimate how long you think it would take to travel to Pluto. ____________

What would you do during that time period?

____

3. Why do you think NASA is interested in learning how to build faster or more fuel-efficient spacecraft?

____

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