

Name \_\_\_\_\_

Section \_\_\_\_\_

Partner(s) \_\_\_\_\_

Date \_\_\_\_\_

### THE SCALE OF THE UNIVERSE

Baltimore is about 2,217,600 inches from DC. Is this distance meaningful to you, i.e. do you have a “feel” for how far away this is?

Suppose you now found out that the distance described above is also equal to about 35 miles. Do you now have a better grasp of how far away Baltimore is from DC?

Describing distances efficiently requires us to use appropriate units. In this activity we will attempt to use units and scaling to get a “feel” for distances within the solar system, galaxy, and universe.

#### Activity 1: Our Solar System

Use the data in the table to report how far away the Sun is from the Earth. (This distance is sometimes referred to as one **Astronomical Unit** or **AU**.)

Average distance to sun = \_\_\_\_\_ miles = 1 AU

Without calculating, make an intelligent guess as to how many times farther away the sun is than Baltimore.

Now, calculate how many more times larger one Astronomical Unit is than the distance from DC to Baltimore.

So the Sun is \_\_\_\_\_ times further from Washington than Baltimore is. Does this help put the distance in perspective?

We would like for you to get a “feel” for how far away things in outer space are from the Earth. The distances to these objects are so large that it is hard for us to relate to them as human beings, who are used to dealing with very small distances (relatively speaking). To help us, we will develop a **scale** for these very large distances, referenced to things that are familiar to us.

The diameter of the Earth is about 8000 miles. How many times larger is an AU than this? (Round off to the nearest whole number.)

So, it would take that many Earths, lined up side-by-side, to stretch from here to the Sun! Now, imagine that the Earth were the size of a basketball (say, a diameter of about one foot). That is to say, let’s use a scale of 1 foot = 8000 miles. How many feet away would the Sun be based on this scale?

If one mile = 5280 feet, how many miles away is this?

So if the earth were the size of a basketball, the sun would be \_\_\_\_\_ miles away!

Now, let’s try to get a feel for other distances within the solar system. We will use a different scale for this exercise, in which you (your location) will represent the sun. Let’s use a scale of one AU (93,000,000 miles) = one foot (12 inches). Using this scale, complete the table below:

Planet	True distance from sun (miles)	Scaled feet from your location	Scaled inches from your location
Mercury	36,187,500		
Venus	67,625,000		
Earth	93,000,000		
Mars	142,437,500		
Jupiter	486,437,500		
Saturn	891,875,000		
Uranus	1,793,500,000		
Neptune	2,810,375,000		
Pluto	3,687,500,000		

Once you have completed the above table, go outside with your lab group. Starting at the place your instructor tells you (to represent the position of the sun), measure out the distances you have just scaled, placing the appropriate planet indicator at each point.

Do you now have a better feel for distances within the solar system? Explain.

Compare the planet-to-planet spacing for Mercury, Venus, Earth, and Mars to Jupiter, Saturn, Uranus, Neptune, and Pluto.

In 1905, Albert Einstein proposed that the speed of light ( $c$ ) is the “cosmic speed limit,” i.e. nothing can accelerate up to go faster than this. This has subsequently been confirmed in many experiments. This is a *natural* barrier, not a technological one; that is, it’s not just a matter of building an engine powerful enough one day to accelerate this fast--the very laws of nature forbid such an acceleration.

The speed of light is so phenomenally fast, a beam of light would circumnavigate the Earth seven times in one second! Going this rate, light takes 8.3 minutes to traverse one AU. That is, the light we are getting from the sun is 8.3 minutes old!

How long would it take sunlight to get to Pluto?

## **Activity 2: The Stars**

The nearest star to us (other than the sun) is called Proxima Centauri and is about 300,000 AU away. How many miles would this be?

Does this value, expressed in either miles or AU, mean anything to you intuitively?

If light travels 1 AU in 8.3 minutes, how many minutes would it take for light to go the 300,000 AU to Proxima Centauri?

And since there are about 526,000 minutes in a year, how many years would it take for light to travel to Proxima Centauri?

How many feet away would Proxima Centauri be from the Sun in your scaled model of the solar system?

How many miles?

Does this help put the distances in perspective?

The stars in the galaxy are so far apart that even the AU is of little use to us in understanding the scale of this vast distance. The stars are so distant we have to use a new unit, the *light-year (ly)*, to describe how far away they are efficiently. The light-year is the **distance** light travels in a year. (Note it is a distance unit, not a time unit!)

Thus Proxima Centauri is over 4 *light-years* away. Keep in mind that light goes so fast it would go around the world seven times in the time it takes to snap your fingers, and yet it would still take over 4 years to get to the *closest* star to the sun. The other stars you see at night are even *further* away. And the other galaxies are even *further* out.

Now, keeping in mind Einstein's discovery that there's no way, no matter how technologically advanced a civilization might be, to accelerate up to go faster than light, what do you think is the likelihood that space aliens from other stars and galaxies traverse these humongous distances and visit earth regularly, as many people claim?

### **Activity 3: You Age in Seconds**

Time units in millions or billions of years are common in astronomy. Since we are dealing with large numbers, calculate your age in seconds.

If you live to be 75 years old, how many billion seconds will you have lived?