Exoplanet Names: ___________________

Solar System Size and Scale Lab

Each member of the lab group should attach their individual introductory page to the back of this lab.

Background – Scale Factors

A scale factor is a number that tells us how many times smaller a model is than the real thing. If you've ever looked closely at a map, you may be familiar with a scale factor. For example, 1:10,000 is a common scale factor for a hiking map and you would find it written at the bottom. In fact, every (decent) map should have a scale factor written on it somewhere in the form of 1:X, where X is some large number (generally a round power of 10 like 1,000 or 1,000,000, but sometimes not).

A scale factor of 1:10,000 means that the true terrain is 10,000 times larger than that represented on your map, or that if you were to blow up your map by a factor of 10,000, it would be the same size as the real terrain. Obviously this would be impractical and would defeat the purpose of having the portable map in the fist place, so the scale factor is important in telling you the true distance between points. If you don't know whether the scale factor of your map is 1:1,000 or 1:10,000, then you don't know whether it should take you 10 minutes or several hours to walk a distance on the map.

Scale factors are always **unitless** which makes sense if you think about it. It shouldn't matter if you measure distances on a map in inches (US) or in cm (Europe), the factor by which you have to multiply your measurement to get the true distance should be the same. If you measured in inches and multiply by your unitless scale factor, you'll get the true (probably very large) distance also in inches. This also goes for cm, m, ft or any other unit of length you could use to measure.

Part 1: Establish the Scale Factor for our Model

1. By selecting a certain object to represent the sun in our model, we've established a scale factor between the model and the real solar system. Use the scale model's "sun", which is 8in in diameter, to establish that scale. In other words, determine a conversion from real physical distance units in the solar system to distance units in the model. (Hint: 8in (rather, 8in converted to cm) is our model's equivalent to the real physical diameter of the sun, 1,391,000km). Show your work below and then fill in the scale factor.

Model Scale factor: ____________ cm = ____________ km (use scientific notation!)

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2. Scale factors are usually represented as a translation from **one** model unit (in our case 1 cm in the model) to a much larger number of real physical units (in our case km in the real solar system). To find out how many real kilometers one centimeter in our model represents, simply divide both sides of the scale factor you wrote above by the *number* of centimeters you filled in on the lefthand side. Fill in this equivalent scale factor below.

Model Scale factor: 1 cm = ____________ km

Part 2: Interpret the Scale Factor

3. One nice thing about having converted into cm for question 1 is that we know have both the model and real distance in metric system units, which are simple to convert between. Compute the fraction (or percentage) of the true size of the solar system that our model represents. To do this, you will first need to make the units equal (by either converting cm to km or vice versa). Show your work below.
Hint: You should work with both numbers in either cm or km (one of them will be very small or very large, depending on which way you went). In ether case, divide the smaller number by the larger and round to one significant figure. For example, if you had ended up with the answer 8 x 10^{-3}, or 0.008, that is equivalent to 8/1000. This would mean that our model was eight one-thousandths the size of the true solar system!

Part 3: Determine Sizes and Distances Between Objects in the Model

4. To make a full scale model of the solar system in size and relative spacing of the planets both the sizes of the real planets and the real distances between them need to be multiplied by this scale factor to determine the correct distance from and size relative to the model "sun" that sets the scale. The real sizes and distances to the planets in our solar system are given in the table at the end of this lab, together with blank columns for you to fill in the number in model units. Compute sizes for the model planets in units of cm and distances in units of feet. Record them in the table with no more than two significant figures.

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5. When we actually walk this model out, which we will do later on in the class, it will be most convenient for us to measure distances in "paces" rather than feet so that we don't have to use a tape measure. Using the meter sticks at the front of the classroom, determine the average "pace" for the members of your group. Record your data and describe your procedure below.

6. Convert the distances between objects in the scale model to paces using your answer to question 5 and record them in the table in the column provided.

7. Finally, using the sizes that you computed for the objects in the scale model and the objects provided at the front of the room, choose an appropriate type of object for each planet and fill in what you've chosen in the table. Record the sizes of candidate objects that you measure below.

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Object	Diameter (in km)	Distance from sun (in 10^6 km)	Object in our model	Model diameter (in cm)	Model distance (in ft)	Model distance (in paces)
Sun	1,391,000	0	ball	8in	0	0
Mercury	4879	57.9				
Venus	12,104	108.2				
Earth	12,756	149.6				
Mars	6792	227.9				
Jupiter	142,984	778.6				
Saturn	120,536	1433.5				
Uranus	51,118	2872.5				
Neptune	49,528	4495.1				
Pluto	2930	5906.4				