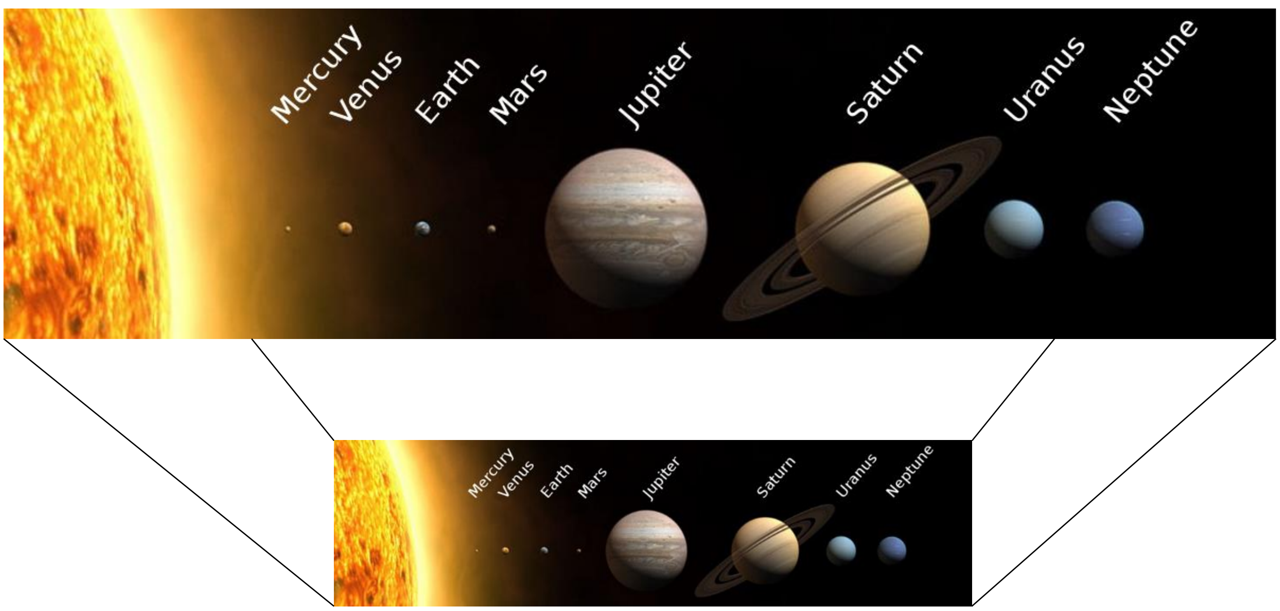
Scale of the Solar System Lab Guide *Experiment A06*

Part A: First Estimate

The idea of this lab is to realize just how large our solar system is – really, how large our *universe* is. On Earth, the distances we are limited by are so small in comparison to the sales of the universe that we do not give a second thought to (for example) the speed of light. We shine a flashlight and it seems to us that the object we are illuminating becomes lit *instantaneously* – the speed of light is so fast that we cannot discern the time difference between when we turn on the light and when the photons reach what we are aiming at because the distances are relatively *small* while the speed of light is so *large*. Experiencing this, it humbles us thinking that it takes *8 whole minutes* for the light from the sun to reach the Earth! Then, of course, you have light traveling between stars taking *years* to get to their destinations – sometimes *millions* between galaxies. It really gives you an idea of how small we really are.

In this part A you will be giving me your estimates on how close you think all our planets are to each other. Since we do not have a length of paper the size of the solar system to work with, we will be doing something called *scaling*. In this case, we can imagine taking the entire solar system and shrinking it to fit on some length of paper. This is exactly what Microsoft Word does when you shrink an object using one of the corner buttons:



See that we made the entire image smaller, but *everything in the image got smaller by the same factor* – the distances represented are not *physically* the same between planets (i.e., measuring distances with a ruler will obviously give you a larger number in the top picture compared to the bottom), but how distances in the picture relate to other distances *in the same picture will stay the same* (i.e., if, for example, one planet was twice as far as another from the sun, you will still see that as being true in *both* of the images above).

So, what we will be doing is scaling down the entire solar system to fit on a long piece of paper – this could be almost anything, but for the best effect it is recommended you use something (or tape things together) so that you have a one long sheet of paper that is as wide as your wingspan. At one edge of this long piece of paper will be the sun, and the other end will be Pluto. Just like in the pictures above, you have taken the *true* distance of the solar system

(5.91×10^{12} m; the real distance between the Sun and Pluto) and scaled it down to fit on something that is only about 1 m (now our *scaled* distance between the small sun and small Pluto on our paper).

For part A, you will be drawing on your piece of paper where *you believe all the planets are in the solar system relative to each other*. If one side of the paper is the sun and the other is Pluto, then you need to draw and label where you think the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune are in between (also include where you think the asteroid belt is between Mars and Jupiter). So, if you think all these objects are the same distance from each other in the solar system, then you would draw and label each one of these planets on your piece of paper at equal distances from each other. If you think some planets are closer while others are spread apart more, then you will have to illustrate this idea.

The only incorrect answer is a blank answer – We will be seeing in the next section just how correct (or incorrect) our assumptions were. Notice that the lab manual asks for you to include a selfie of you (or one or more of your group members together) with the strip of paper – best to snap a picture with your phone, email it to the user writing your lab manual, and copy/paste it in the lab manual as an image.

Part B: Scale Model

Now as we said before, when (for example) Microsoft word scales down an image (like I did above), it scales every length in the image by the same factor. In our experiment, we can determine this factor since we've already scaled the total horizontal distance of the solar system to fit on our sheet of paper (i.e., when we shrunk the distance from the sun to Pluto to fit on the strip of paper, we shrunk all the other distances – the distances between the other planets – also by the same factor). We already know how large the true distance is from the sun to Pluto (5.91×10^9 km), so we just need the *new length* to find the scale factor. All you have to do is measure to distance from the small sun to the small Pluto on your paper (the full length of the paper if you have followed instruction) ***in centimeters*** and divide that by the true distance ***in kilometers***. This is the factor in which every *true* distance must be multiplied by in order to shrink it and fit on your strip of paper! Thus, if you take the *true* distance of a planet from the sun (in km and given to you as semi-major axis values in the table in your lab manual) and multiply by this *scale factor,* then it will give you the distance to the shrunk planet (in cm) from your small sun. Then all you need to do is measure this distance on your strip of paper and mark this location, ideally in a different color than you did your estimate.

In the table in your lab manual, all you need to do once you calculate your individual *scale factor* is to multiply all the semi-major axis values by this *scale factor* in order to get your scaled distance values (in cm). On your strip of paper, make sure you include these new (and correct) locations of the planets and take another selfie photo. Again, add this image to your lab manual. Finally, compare your estimate to these true scaled distances you just calculated and answer the remaining analysis questions

In summary, for full points you need to (1) **(20 points)** include a selfie with your *estimates*, (2) **(15 points)** find the *scale factor* for your specific strip of paper, (3) **(20 points)** fill out all the scaled distance values in the table using this *scale factor*, (4) **(30 points)** include another selfie with these new distances, and finally (5) **(5 points ea.)** compare these new distances to the ones you predicted and answer the other two remaining analysis questions.