Introductory Astronomy Lab – **Distance & Scales** – V1.1

NAME:

Figure 1: The *NASA* illustration above is beautiful! Is it also accurate?

Introduction: Size matters! Travelling from Midtown Atlanta to Buckhead is very different than traveling from country to country. Knowing the size and scale of an object allows us to determine not only how to get from point A to point B, but also how long the journey will take. From an astronomical point of view, in the next decade or so, we hope to (finally) return people to the Moon as well as land on the planet Mars! In such cases it is vital to know what the distances are to a fine degree. Aside from travel, understanding the scale of our Solar System also helps us understand our own significance and place in this vast cosmos.

Learning Objectives:

▶ Science Process Skills: Measuring length, volume, etc.

→Better visualization of the size and scale of our Solar System.

→Understanding of scaling relations.

→Be able to manipulate and use formulas.

→Calculate circumference, area, and volume.

Materials: In your lab station you will find the following: basketball, measuring tape, marble, golf ball, large plastic ball, and a pin ★ careful not to stick yourself ★

Pre-Lab Exercises

1)Take a look at the NASA illustration on the previous page. Based on the illustration, about how much larger is Jupiter compared to the Earth? How much larger is the Sun compared to the Earth? You do not need to measure, take your best guess. This "rough estimate" without measuring and just using your eyes is known as **eyeballing**.

2)Based on the illustration, about how much farther is Neptune (the last planet) from the Sun than the Earth? Again, eyeball your answer.

3)Consider the picture below of the Earth. Using your intuition (do not look anything up), draw the Moon next to it so that they are the right size in relation to each other. This is called **scaling**. Scientists often use something called a scale factor which is the dimensions of the "new shape" divided by the "old shape". As an example, Earth is about twice the size of Mars, so we say the **scaling factor** for Mars is 1/2.

Note that scaling and scaling relations is important in numerous fields such as film-making, military, architecture, engineering, and also astronomy. In the following section, we will construct a scale model and learn how it can help us visualize and understand the distances within our own Solar System.

Basketball Sun

Imagine shrinking the Sun so it was the size of a basketball! Take the tape measure and measure the **circumference** of the basketball. The formula for circumference is

$$\mathbf{C = 2\pi R} \tag{1}$$

where π is the irrational number which is about 3.1416 and R is the radius.

The circumference of the basketball = ______________
Hint: Do *not* forget to include the correct units!

4)Calculate the radius of the basketball.
Hint: A great online calculator is: **DESMOS**
Show your work here:

The radius of the basketball = ______________

5)It turns out the radius of the Sun is about 696,000 km. We are going to adopt a value of R_{Sun} = 700,000 km. One inch (of the basketball) represents how many km?
Hint: You will need to divide R_{Sun} by what?
Show your work here:

The scale factor = ______________

6)We can calculate the **area** of a circle by using the formula

$$\mathbf{A = \pi R^2} \tag{2}$$

What is the area of the Sun? Show your work here:

Area of the Sun = ______________

7)We can calculate the **volume** of a sphere by using the formula

$$\mathbf{V = \frac{4}{3}\pi R^3} \tag{3}$$

Calculate the volume of the Sun. Show your work here:

The Sun's volume = ______________

Large Earth? or Small Earth?

In everyday life, it seems obvious when something is "small" or "large" because we use ourselves as a scale. However, that becomes much more difficult when talking about other "things". Hence, it's good to give numbers and to use scaling factors.

8)Take your best guess – Which item do you think is closest to the size of the Earth in our basketball model of the Sun? Is it the large plastic ball, golf ball, marble, or pin?

My guess is = ______________

9)Take your best guess – How far away is the Earth from the Sun in our basketball model?

My guess is = ______________

10) Let's find out how close you were! Complete the table below.
You do *not* need to show your work here.

	Radius (km)	Area (km^2)	Volume (km^3)	R_{Sun}/Radius
Sun				1
Earth	6400			
Moon	1740			

Based on the table you completed above, which item is closest to the size of the Earth in our basketball model of the Sun?

The answer is = ______________

11) It turns out the Sun is 150 million km (1.5×10^8 km) from Earth. This distance is known as an **astronomical unit or AU**. How far is that, in actual feet, in our basketball model? If you do not understand this question please ask.
Hint: This is not as hard as it may seem. Look back at Q5. Show your work here:

The answer = ______________

12) Let us visualize what we have calculated! Have someone from your group take the Sun (basketball) and the Earth (Q10) and walk the appropriate distance (Q11). What do you think – is this what you expected it to be in your mind? How does it compare to Figure 1? Answer here:

What about Jupiter?

13) Jupiter, is a giant planet! In fact, we believe that except under special circumstances, planets do not get much larger. Jupiter's radius is about 11 times that of Earth. With that in mind, which item (plastic ball, golf ball, marble, pin) do you think is closest to the size of Jupiter in our basketball model?

The answer is = ______________

14) How many Earths could fit inside Jupiter?
Show your work here:

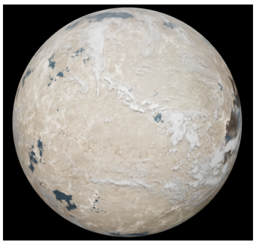
______________ Earths could fit inside Jupiter!

15) How many Jupiters could fit inside the Sun?
Show your work here:

______________ Jupiters could fit inside the Sun!

16) Planets that are found outside our Solar System, are called **exoplanets**. It turns out the nearest known exoplanets, have been detected in the nearest star to our own Sun which is called Proxima Centauri. Proxima Centauri is about 4.2 light-years from the Sun/Earth. There are about 63,000 AUs in a light-year. With this in mind, how many *miles* is the distance to Proxima Centauri in our basketball model?
Show your work here:

The distance to Proxima Centauri is ______________



https://exoplanets.nasa.gov/resources/2211/proxima-b-3d-model/

Putting Things Together

The distances between stars and planets is unfathomably large, as you hopefully saw by answering the previous questions. Visualizing even the size of the Solar System can be a challenge. That said, fortunately people have proven up to the task. Go here:
https://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html
Explore the site for a few minutes.

17) What are your personal thoughts about the sizes and scales we explored in this lab? What truly surprised you? Did it give you a new perspective? Any final thoughts?
Answer here:

Questions, suggestions? – **Dr. Idan Ginsburg** – iginsburg@gsu.edu