Lab 1 – Scale Sizes of the Solar System

ASTR 1010

Name: _____

Overview

In this activity you will compare the physical properties of objects within the Solar System to better understand the relative scale of the planets. You will also explore the scale of planetary orbits in relation to each other.

Objectives

After completing this activity students will be able to:

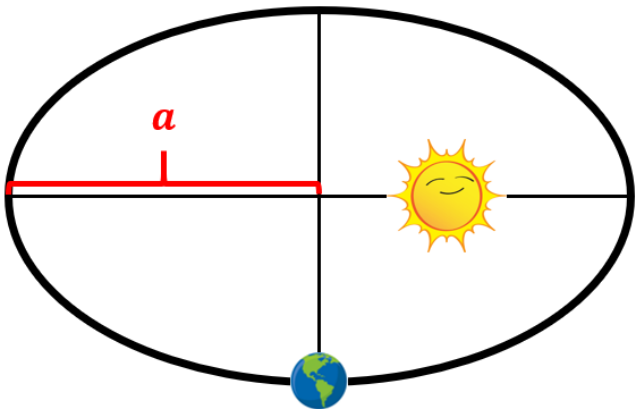
- Calculate a spherical volume and density for a given planetary size and mass
- Compare volumes and radii to demonstrate planetary sizes in relation to the Earth
- Interpret given data and perform unit conversions
- Order the planets in increasing distance from the Sun
- Identify the planets at the appropriate relative orbital locations on a diagram

Definitions

Here are some terms that we will be using today in lab:

- **Planet** – an object that orbits the Sun, is massive enough for its own gravity to make it round and has cleared its orbital region of smaller objects. This does not include Pluto…
- **Spherical Volume**: $\mathbf{V = \frac{4}{3}\pi R^3}$ where R is the radius of the sphere and V is the volume of the sphere. Volume has units of length cubed, such as km^3. (km - kilometers)
- **Density**: $\mathbf{D = \frac{Mass}{Volume} = \frac{M}{V}}$ where D is the density of the object and M is the mass of the object. Density has units of mass divided by length cubed, such as $\frac{\mathrm{kg}}{\mathrm{km}^3}$. (kg – kilograms)
- **Astronomical Unit** – the average distance between the Earth and Sun, noted as the unit **AU**. $1\ \mathrm{AU} \approx 1.5 \times 10^8\ \mathrm{km}$
- **Semi-major Axis** – half of the major-axis length of an ellipse or elliptical orbit. Noted with the variable $\boldsymbol{a}$, and often given in units of AU or km. Approximately the same as the distance from the Sun for planets in the Solar System.

  Note: diagram not to scale.



Part 1. Relative Sizes of the Planets

1. Fill in Table A above by calculating the diameter of each object relative to the Earth. (divide diameter of object by diameter of Earth)

Table A. Solar System Data

Object	Mass (kg)	Diameter (km)	Diameter relative to Earth	Semi-major Axis (AU)
Sun	1.99×10^{30}	1.38×10^{6}		0.00
Mercury	3.30×10^{23}	4.84×10^{3}		0.39
Venus	4.87×10^{24}	1.21×10^{4}		0.72
Earth	5.97×10^{24}	1.27×10^{4}	1.00	1.00
Mars	6.42×10^{23}	6.78×10^{3}		1.52
Jupiter	1.90×10^{27}	1.41×10^{5}		5.20
Saturn	5.68×10^{26}	1.20×10^{5}		9.54
Uranus	8.68×10^{25}	5.10×10^{4}		19.18
Neptune	1.02×10^{26}	4.94×10^{4}		30.06

2. List the planets in order of <u>increasing size</u>.

3. Which planet, other than Earth, is closest in diameter to Earth?

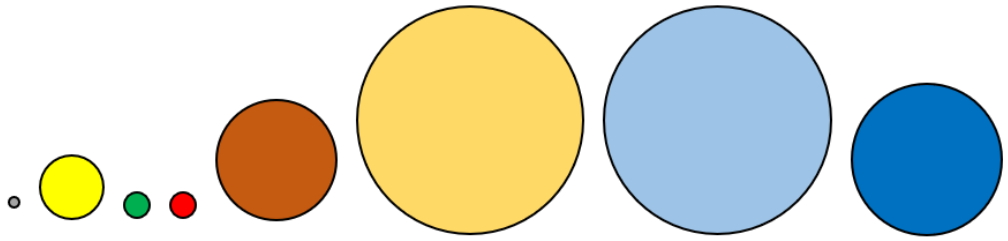
4. Are the ice giants (Uranus and Neptune) larger or smaller than the gas giants (Jupiter and Saturn)?

5. How many Earths could fit end-to-end from one side of the Sun to the other side? Hint: Think about the Sun's diameter relative to Earth.

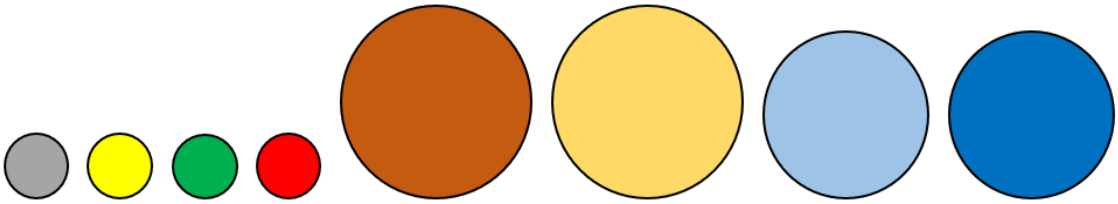
6. Which of the following diagrams most accurately represents the relative sizes of the Solar System planets? (answer A, B, C, or D)

Each diagram represents the planets in order of increasing distance from the Sun.
Mercury – Venus – Earth – Mars – Jupiter – Saturn – Uranus – Neptune

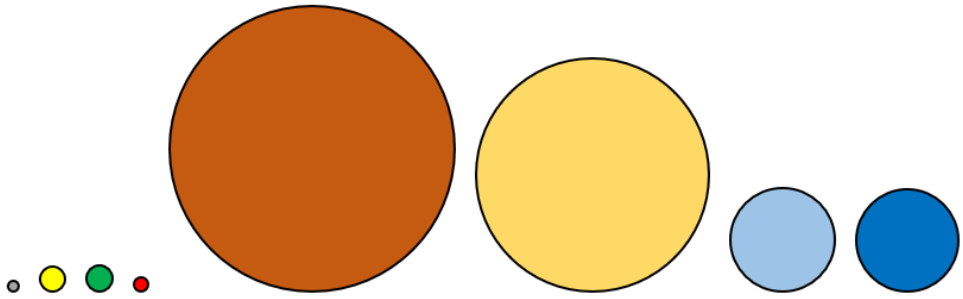
A)



B)



C)



D)

7. Calculate the volume of Saturn and the volume of Earth. Use the equation for volume provided on page 1, with radius R being the diameter divided by 2. The diameters are listed in Table A. Don't forget units. (show or explain your work)

8. How many Earths could fit inside of Saturn? Use the volumes you calculated in the previous question. (show or explain your work)

Part 2. Relative Masses of the Planets

Answer the following questions using the data provided in Table A from Part 1.

1. Calculate the density of Saturn. Use the equation for density provided on page 1, with the mass given in Table A and the volume you calculated in Question 7. Don't forget units. (show or explain your work)

2. Would Saturn sink or float if placed in an ocean? (density of water is $10^{12}\ \frac{\text{kg}}{\text{km}^3}$)

3. Add up the masses of the planets.

4. Divide the mass of the Sun by the total planetary mass to find out how many times more massive the Sun is than all of the planets.

5. What percentage of this total planetary mass is Jupiter? (show or explain your work)

Part 3. Relative Sizes of the Planetary Orbits

Answer the following questions using the data provided in Table A from Part 1.

1. If our spaceship takes 1 month to travel from the Sun to Earth (a distance of 1 AU), how long would it take to travel from the Sun to Neptune?

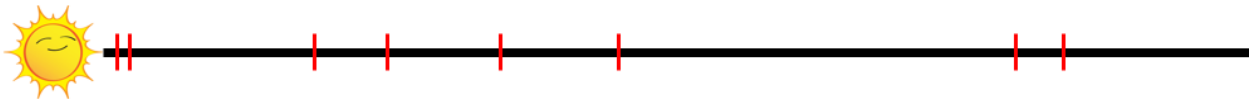
2. The nearest star system to ours is Alpha Centauri, which is 4.13×10^{13} km away. Calculate how far away this is in AU by dividing by the number of km per AU provided on page 1.

3. How long would it take for our spaceship in the previous question to travel from the Sun to Alpha Centauri? Give your answer in years.

4. Which of the following diagrams most accurately represents the relative distances of the planets from the Sun? (answer A, B, C, or D)

Each diagram represents the planets in order of increasing distance from the Sun.
Mercury – Venus – Earth – Mars – Jupiter – Saturn – Uranus – Neptune

A)



B)

C)

D)

5. Add up the diameters of the planets (in km), to determine how far they would extend if put side-by-side in a line.

6. The largest orbital distance between the Moon and Earth is 4.06×10^5 km. Is this distance <u>greater</u> or <u>smaller</u> than the length of the planets side-by-side that you calculated in part 1?

7. Explain what this means, in your own words.

Your answers to Question 4 should demonstrate how small the planetary sizes are in comparison to how far apart they orbit. After all, space is indeed mostly empty space.

<u>To complete this assignment for grading:</u>

- File → Save As… → Rename the file 'YourLastName – ScaleSizesLab'
- Upload to the file to the 'Lab 1 – Scale Sizes of the Solar System' assignment in iCollege (click Add Attachments → Upload → upload renamed saved file → Update).
- Complete the Reflection activity on iCollege