Welcome to astronomy. This summer, you will hone your scientific skills by completing some graphical analysis. This assignment is due the first day of class in September.

Kepler's Third Law of Planetary Motion

In this activity, you will use graphs of the average distance an orbiting object is from the Sun (mean distance) and the time it takes to make one complete orbit (orbital period) to test Kepler's third law of planetary motion.

Kepler's three Laws of Planetary Motion state the following:

1. The orbit of every planet is an ellipse with the sun as a focus.

2. A line joining the planet and the sun sweeps out equal areas in equal time.

3. The square of the period of the orbit is equal to the cube of the average radius of its orbit.

The following table lists planetary data you will use to construct a graph to test Kepler's third law of planetary motion.

Planet	**R** mean distance from the Sun (10^6 km)	Distance from the Sun in AU	**T** period, the time to complete one orbit (Earth-years)	$\frac{T^2}{R^3}$
Mercury	57.9		0.241	
Venus	108.2		0.615	
Earth	149.6		1.0	
Mars	227.0		1.88	
Jupiter	778.6		11.86	
Saturn	1433.5		29.42	
Uranus	2872.5		83.75	
Neptune	4495.1		163.72	

Graphing instructions

1. The independent variable goes on the x-axis, and the dependent variable goes on the y-axis. In your first graph, R, mean distance from the Sun is the independent variable, and, T, orbital period, is the dependent variable.

2. Title the graph by saying “The dependence of (insert the dependent variable here) versus (insert the independent variable here).

3. Always label the axis and place the units on them (for example: Period, T (Earth-years).

4. The data in the graph should fill the graph (so scale the axis).

5. Label each data point on the graph with the name of the planet it represents.

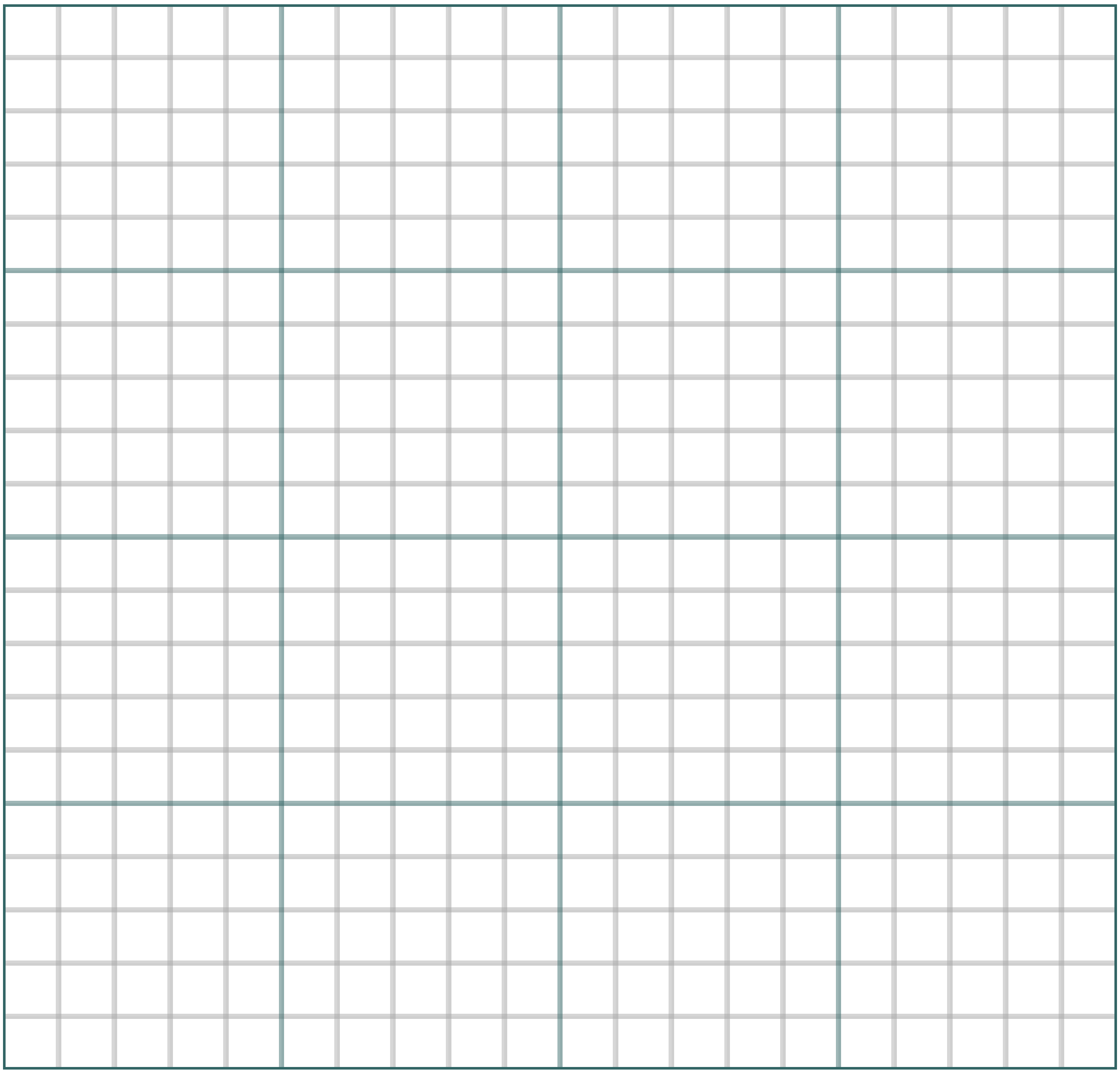
6. Draw the best straight line through the data points

The data for the mean distance from the Sun is reported in 10^6 (million) kilometers. Astronomers generally express these distances in astronomical units (AU) where an AU is defined as the average distance the Earth is from the Sun,
1 AU= 149.6 x 10^6 km. To perform this conversion divide the distance the planets are from the Sun by Earth’s distance from the Sun.

For example: $$Mercury = \frac{57.9 \times 10^6 km}{149.6 \times 10^6 km} = 0.387\ AU.$$

Calculate distance data in AU and fill in the appropriate column in the table. You should use AU to indicate distance on your graph.

You will construct two graphs, the first you will graph mean distance from the Sun (R) versus orbital period (T) , and the second you will graph the cube of mean distance from the Sun (R^3) versus the square of the period (T^2).



Questions

1. Which graph is a straight line?

2. For each planet calculate the ratio $\frac{T^2}{R^3}$ and enter these values on the above table.

3. How do the values compare for different planets? Are these values similar? Compute the average value for this data.

4. What is the slope of the T^2 versus R^3 graph? How does it compare to the value in question 3?

5. The minor planet Pluto has an orbital period of 247.93 Earth-years. Calculate Pluto's distance from the Sun. Use the value generated in question 3.

6. Finally, suppose an asteroid is found between Mars and Jupiter and has an orbit at a distance = 2 AU. Predict how long it will take this asteroid to orbit the Sun. Use the value generated in question 3.