Why is the Neptunian "year" so long?!

Version 2

How fast do the planets orbit the Sun?

A "year" on Earth is about 365 days long. In astronomical terms, that means it takes about 365 days for the Earth to come back to the same spot in its orbit around the Sun. On Mars, a "year" is about 697 days long – almost two Earth years! We refer to the length of the "year" on a particular planet as its "orbital period." The Earth has an orbital period of about 365 days, Mars has an orbital period of about 697 days, etc. The furthest major planet, Neptune, has an orbital period of over 60,000 days – almost 165 Earth *years*! Think about that for a second: in the time it takes the Earth to circle the Sun over 164 times (which is several human lifetimes), Neptune travels around the Sun *once*. Why is this?!

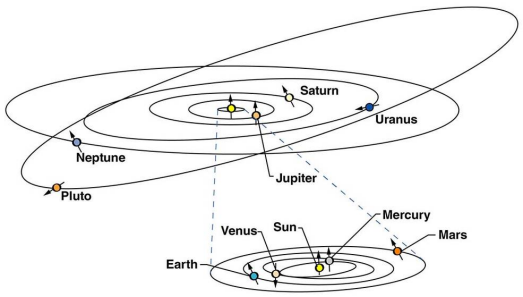


Figure 1. The orbits of the eight major planets (and one dwarf planet, Pluto) in the Solar System. Ellipses show approximate orbits, and arrows on each planet show the direction of that planet's axis ("North"). Image source: NASA.

Calculating planetary orbital velocities

The attached dataset shows the distance from the Sun to each planet's orbit (the "orbital radius"), and the orbital period for each major planet. Your job is to calculate how fast each planet is traveling around the Sun, and then see if you can spot patterns in the data.

We call the speed at which something is traveling its "velocity," which is how long it takes for an object to travel a certain distance. For example, we often talk about cars traveling at velocities of "miles per hour" or "kilometers per hour," while our fingernails grow at "centimeters per year."

Distances in space are very large, with just our Solar System spanning *billions* of kilometers. Those numbers are very inconvenient to work with, so we have

defined an "astronomical unit" (AU) to make things more convenient. We call the Earth's orbital radius 1 AU, equal to about 149,600,000 km (1.496×10^8 km). Throughout the rest of this activity, you will be working with distances (orbital radius, circumference, orbital velocity) in AU. For reference, a velocity of "1 AU per year" is about 17,000 km per hour, or 170 times the velocity of a car on the highway! That's *fast*!

Use the attached data table to calculate the orbital velocity for your assigned planet. Write the name of the planet, the planet's orbital radius in AU, the planet's orbital period in years, the planet's orbital velocity in AU per year, and the "eccentricity" (roundness) of the planet's orbit on your round piece of paper (representing the planet). If you have extra time, decorate your paper to look like the planet, then post it (in order with the other planets) on the wall.

After everyone's planets are displayed, look at all of the data. Look carefully for patterns; can you spot any trends in the data?

Graphing orbital velocities

Fill in the missing values of your data table from the information on each planet *(if you have time, double-check the calculations!)* Use the attached graph paper to plot the orbital velocity of each planet.

On your graph, plot the orbital velocity in AU per year on the Y-axis, and the orbital radius for each planet on the X-axis. Label each point with the planet's name. **Think carefully about the scale and range of your axes before plotting your dataset!**

Guiding questions (record your answers in your notebook!)

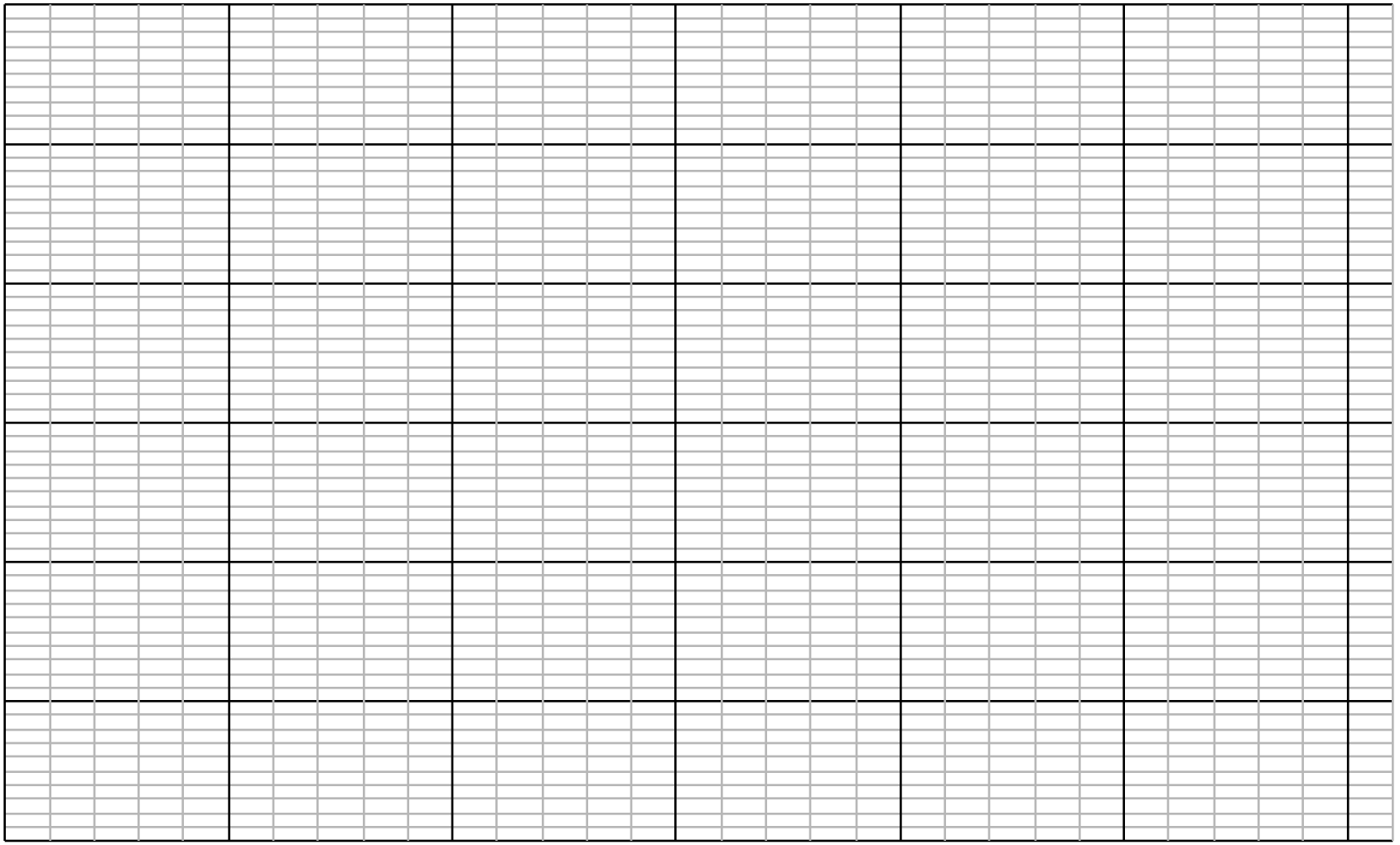
- Which planet has the highest orbital velocity? Which planet has the lowest?
- Is there a consistent trend in orbital velocities? Describe the trend.
- Looking at the data table, is there a trend in orbital eccentricity (the "roundness" of a planet's orbit)? Describe the trend.
- What forces are acting on the planets?
- Can you think of possible explanations for the trends you observe in the data? How are orbital radius, orbital period, orbital velocity linked? Do they have anything to do with the forces acting on the planets?

Orbital properties of the planets

Planet	Orbital radius (AU)	Orbital period (y)	Orbital circumference (AU)	Orbital velocity (AU/y)	Eccentricity
Mercury	0.39	0.24			0.206
Venus	0.72	0.61			0.007
Earth	1.00	1.00			0.017
Mars	1.52	1.88			0.093
Jupiter	5.20	11.9			0.048
Saturn	9.58	29.5			0.054
Uranus	19.20	84.0			0.047
Neptune	30.05	164.8			0.009

Hint for completing the table: What is the formula for the circumference of a circle?

Planetary Velocities



Velocity (AU/year)

Orbital radius (AU)