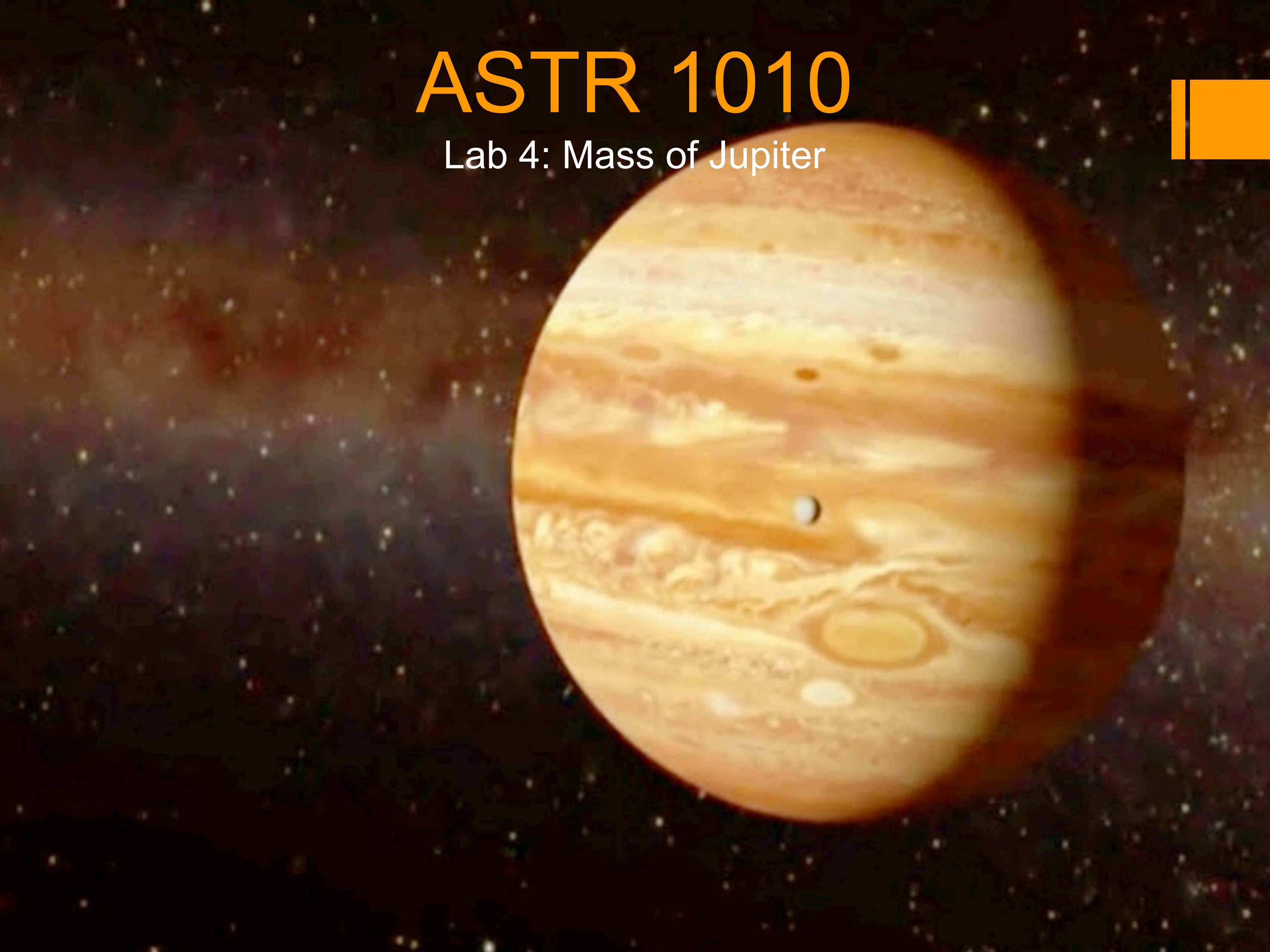
ASTR 1010

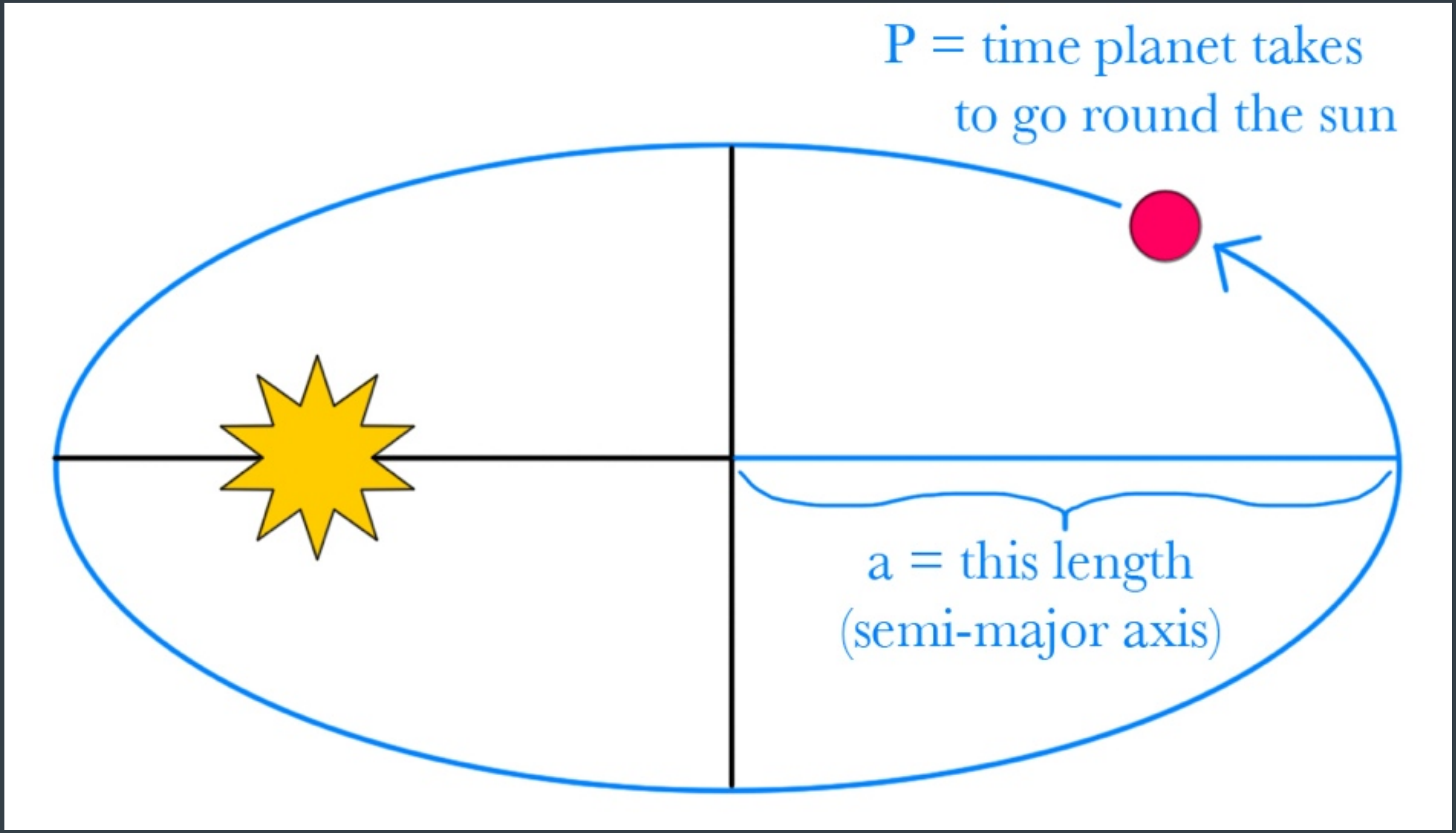
Lab 4: Mass of Jupiter



Kepler's 3rd Law

The size of an orbit (given by semimajor axis a) and the time it takes for an object to complete the orbit (period P) are related via total mass in the system:

$$M_{tot} = \frac{a^3}{P^2}$$



Kepler's 3rd Law

Jupiter is MUCH more massive than its moons: $M_J >> M_{moons}$. Thus, adding M_{moons} to M_J hardly changes the total. Therefore, $M_{tot} \approx M_J$, and we get the following equation:

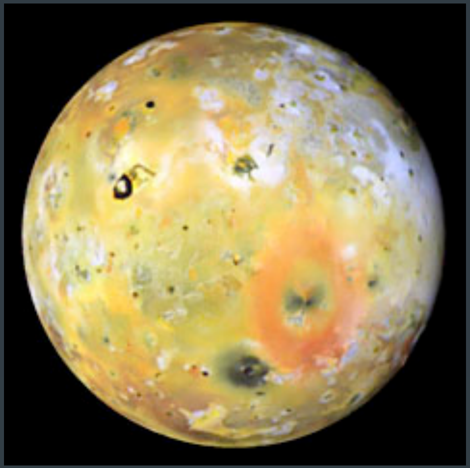
$$M_J = \frac{a^3}{P^2}$$

Thus we can deduce Jupiter's mass by studying the orbits of Jupiter's moons!

Tour of Moons

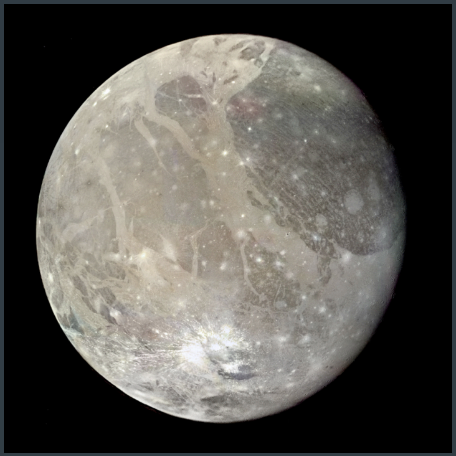
These are Jupiter's four largest moons. You can pick any one of them for today's activity. They'll all give you a similarly good estimate of Jupiter's mass.

Io

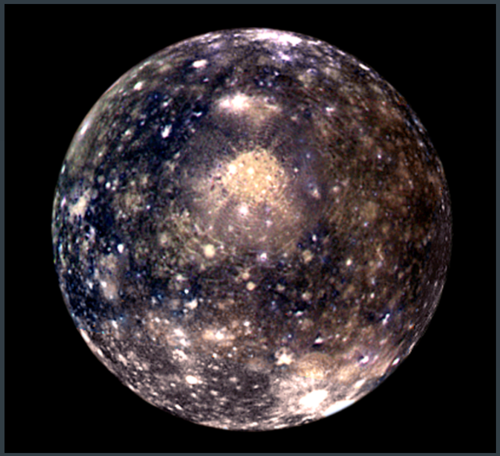


Europa

Ganymede



Callisto

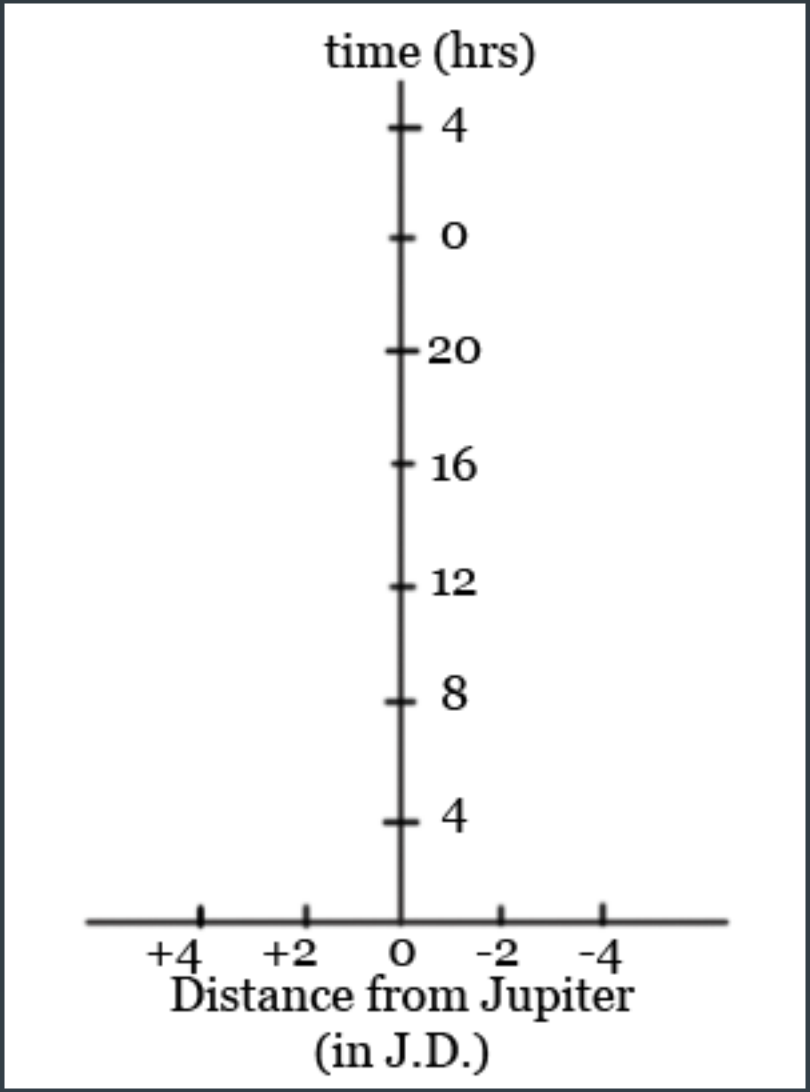


How to Plot

Plotting on our distance from Jupiter vs. time grid is just like plotting x and y. Distance from Jupiter gives the horizontal location, and time in hours gives the vertical location.

Note that 0 hr = 24 hr.

Example: Plot (10, -3.5).



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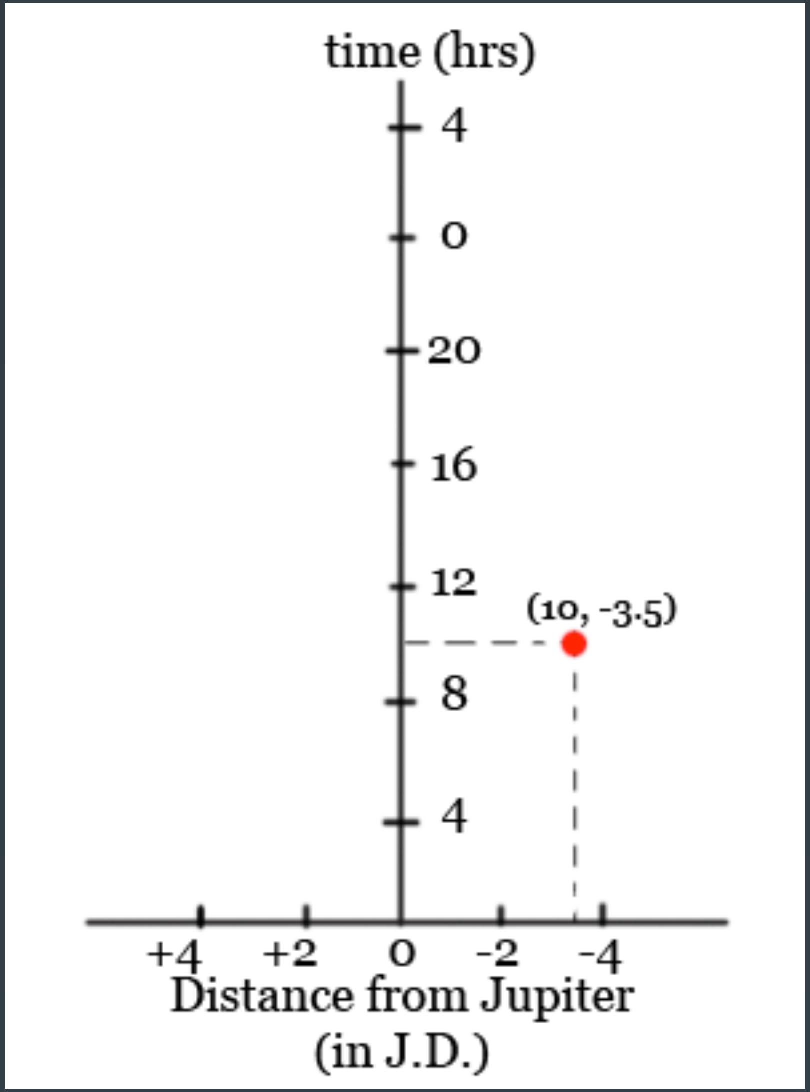
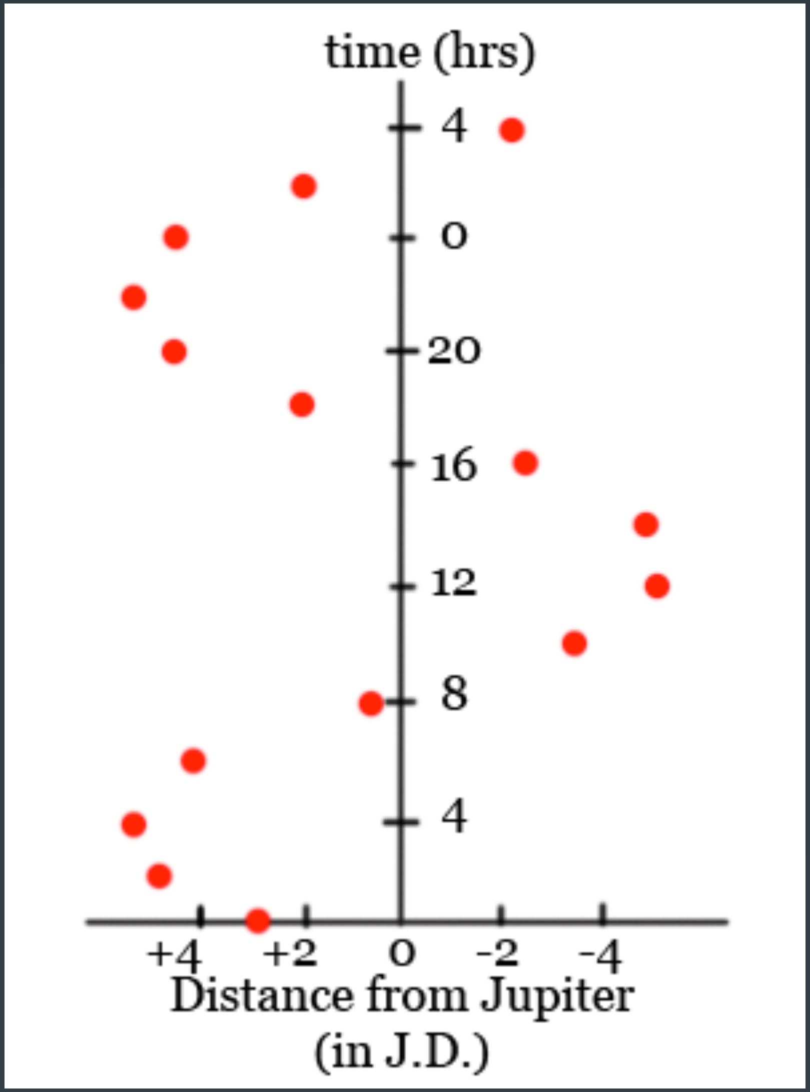


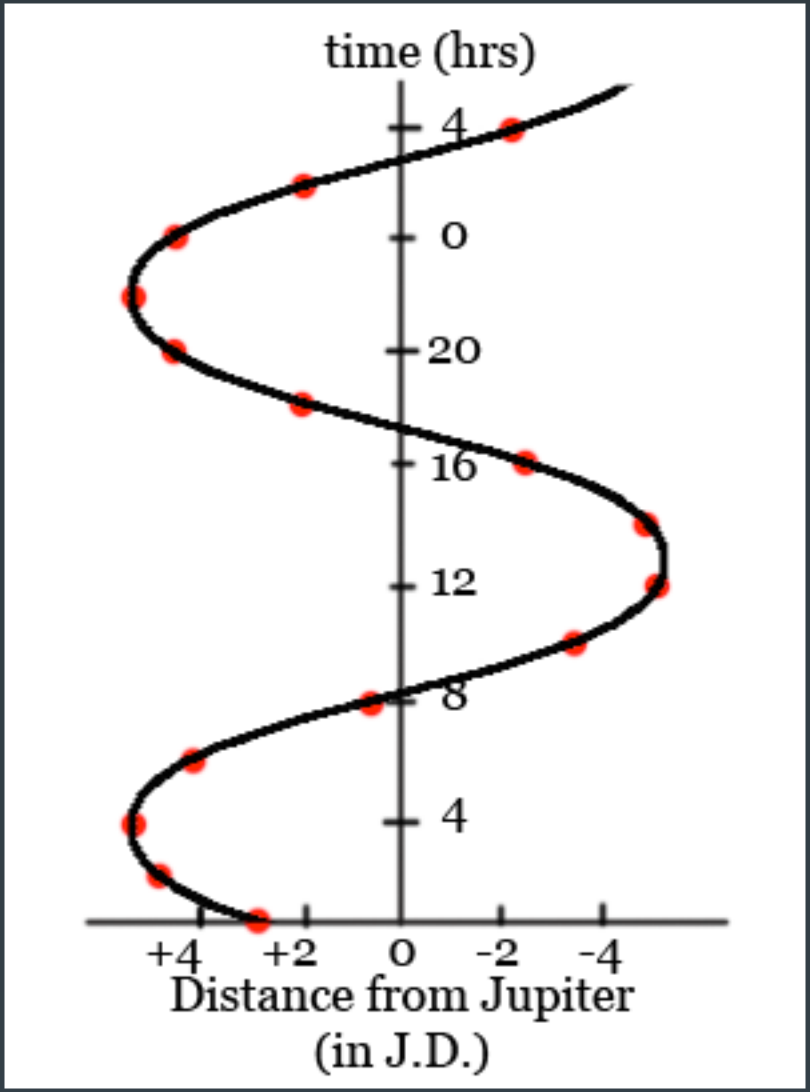
How to Plot

Eventually you'll end up with a set of points. Connect them with a smooth line...



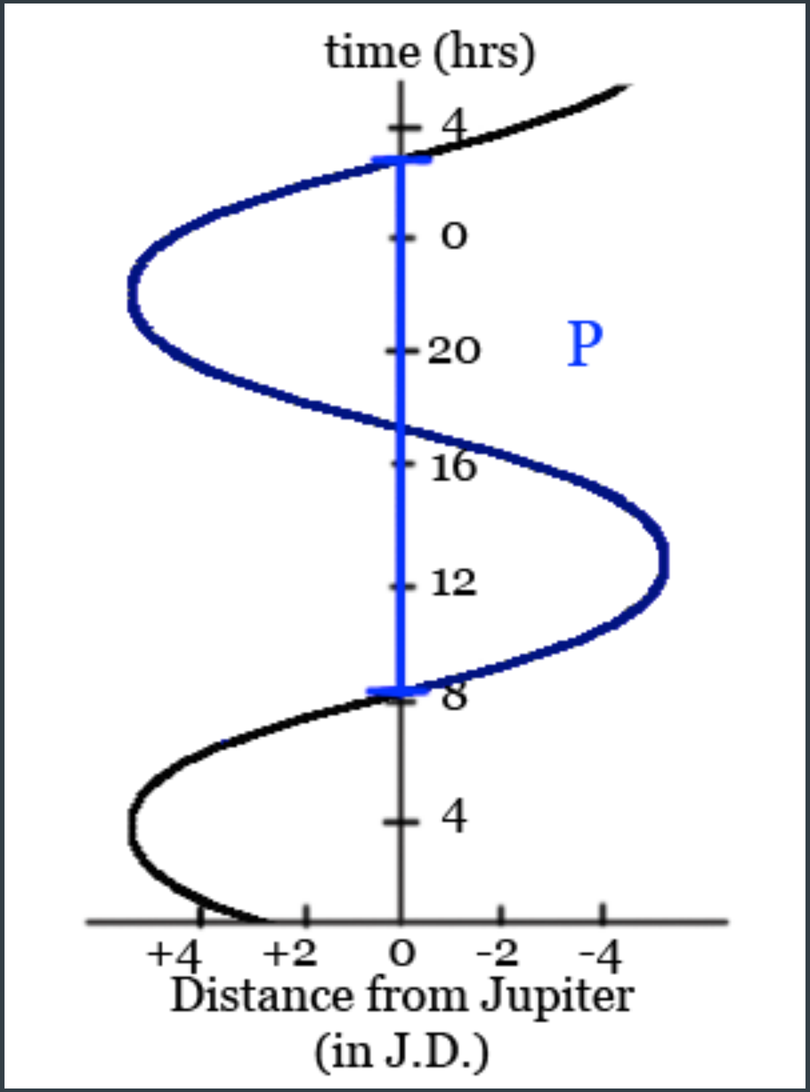
How to Plot

Voila! This is called a sine curve. It plots a moon's position relative to Jupiter over time. A full orbit starts and ends at the same position.



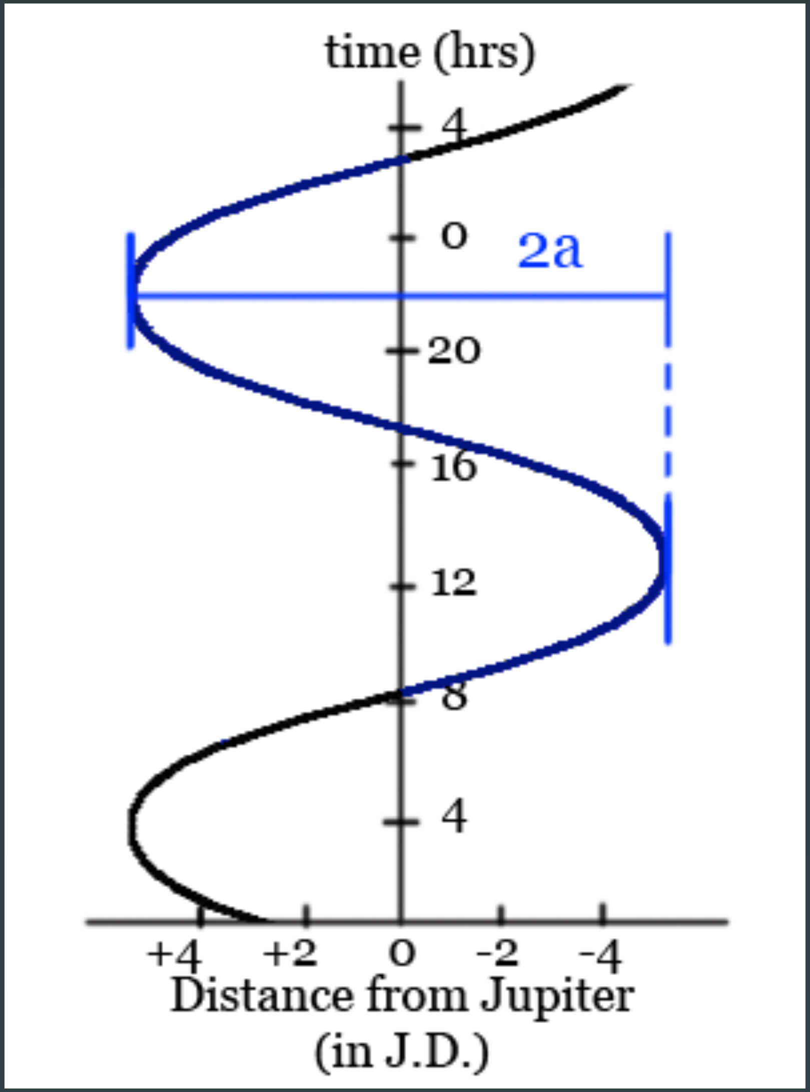
How to Plot

This is the period of a moon's orbit, **P**.



How to Plot

The farthest-left position and farthest-right position basically give you a diameter of the elliptical orbit. The size of the orbit is the farthest-left position minus the farthest-right position divided by two. It's the semimajor axis **a** of the elliptical orbit.



Unit Conversions

You first measure P in hours and a in Jupiter diameters, J.D. The formula we saw earlier works best with time units of years and distance units of AUs (the distance between the Earth and the Sun). Then you'll receive mass units in solar masses. Here's how to convert:

Time units:

hours to days: Divide # hrs by 24.

days to years: Divide # days by 365.25.

Distance units:

J.D. to AUs: Multiply # J.D. by $9.545 * 10^{-4}$.

Mass units:

solar masses to Earth masses: Divide # solar masses by $3.0 * 10^{-6}$.

Fin