

Do the following problems and be prepared to discuss them in class.

**1.** Pluto has a semi-major axis of 39.48 AU and an eccentricity of 0.249.

a) Calculate the perihelion and aphelion distances for Pluto.

b) Calculate Pluto's orbital period.

c) Calculate Pluto's speed at perihelion.

**2.** At what semi-major axis value would you expect to find a gap in the asteroid belt corresponding to objects that would be in a 3:1 resonance with Jupiter? In other words, at what orbital  $a$  value would an asteroid have an orbital period that was  $1/3$  the orbital period of Jupiter? Jupiter orbits at  $\sim 5.2$  AU.

**3.** Calculate the synodic period of Jupiter (as seen from the Earth).

The relevant equation is:  $\left| \frac{1}{P_1} - \frac{1}{P_2} \right| = \frac{1}{S}$ .

In this equation,  $P_1$  and  $P_2$  are two sidereal periods, i.e., periods with respect to the stars, and  $1/S$  is the “beat frequency”;  $S$  itself is the synodic period, the time it takes for three objects to come back into alignment (e.g., the Sun–Earth–Jupiter system in this case).

**4.** Another synodic period problem:

a) How long is it between consecutive inferior conjunctions of Jupiter and the Sun as seen from Saturn?

b) How long is it between consecutive oppositions conjunctions of Saturn and the Sun as seen from Jupiter?

**5.** What is the greatest elongation of Mars as seen from Jupiter? Assume circular orbits in the plane of the ecliptic.