

Due in section the week of May 9<sup>th</sup>

Problems are based off lecture and readings - Show all work - Don't forget units - 10pts total

**Q1) Roche limits**

(1 pts) The Roche limit sets the minimum distance at which an object can orbit around a planet without being torn apart by tidal force. Calculate the Roche limits for Jupiter and Saturn using the following equation:

$$d \approx 2.44R \left( \frac{\rho_M}{\rho_m} \right)^{1/3}$$

where  $R$  is the planet's radius,  $\rho_M$  is the planet's density and  $\rho_m$  is the moon's density, which we will assume  $0.5 \text{ g/cm}^3$ . Give your answers in units of  $R$ .

**Q2) Resonance and Tidal Heating in Io (0.5 each x2 = 1 pts)**

Io, Europa and Ganymede are locked together in a 1:2:4 orbital resonances. Give an observable consequence of this for two of the moons (one consequence for each).

**Q3) Comets (0.5 pts)**

Describe the two types of tails found in comets.

**Q4) Saturn's rings: solid or not? How can you prove this?**

a) Assume that the rings of Saturn are in circular orbits with a radius of 87,000 [km] and 137,000 [km] for the inner and outer rings, respectively. Given that the mass of Saturn is  $5.68 \times 10^{26}$  [kg]. Calculate the orbital speeds at the inner and outer edges of the rings for the following cases:

i) (2 pts) If the rings are made of individual particles which obey Kepler's laws. (Note that the mass of a particle is much smaller than the mass of Saturn)

ii) (1 pts) If the rings were solid and rotate with the same period as calculated for the inner edge in part (i).

b) (2pts) How much of a shift in wavelength would a spectrograph operating at 500 nanometers need to be sensitive to in order to distinguish between these two types of motion for the rings (i.e., to detect the relative motion between the inner and outer edges of the ring, as viewed from an observer on Earth; review Doppler shift)?

**Q5) True/False (2.5 pts total)**

- (a) Titan is the only moon in the solar system to have a thick atmosphere. T/F
- (b) The sunlight reflected from a bright, smooth region indicates the presence of a lake or sea on Titan. T/F
- (c) Infrared and radar observations revealed more lakes near the north pole than the south pole. T/F
- (d) The liquid in the lakes of Titan is composed of Methane, Ethane, and water. T/F
- (e) Voyager detected approximately 30 active volcanoes on Io. T/F