Astronomy 45

Introduction to Astrophysics

Problem Set 5 - Due March 24

1. Encke's comet has a period of 3.30 years. At perihelion it is at distance of 0.338 AU from the Sun. What is the eccentricity of its orbit?

2. Titan is a satellite moon of Saturn. The period of its orbit is 15.945 days and the radius is 1.221 x 10^6 km. The gravitational constant G is 6.67 x 10^{-8} cm^3 g^{-1} s^{-2}. What is the mass of Saturn?

3. a) In a family of elliptical orbits, all of which have the same energy, show that the circular orbit has the greatest angular momentum.

   b) In a family of elliptical orbits, all of which have the same angular momentum, show that the circular orbit is the most bound.

4. **Sun-Jupiter System**

   Jupiter is the largest planet in the solar system with mass M_J = 0.95 x 10^{-3} $M_\odot$ and radius R_J = 7.14 x 10^9 cm. The semimajor axis of Jupiter's orbit is a = 5.2 AU, its orbital eccentricity is ε = 0.048, and its orbital period is P = 11.86 yr.

   a) Calculate the total orbital angular momentum of the Sun-Jupiter system.

   b) Estimate the contribution the Sun makes to the total orbital angular momentum of the Sun-Jupiter system. For simplicity, assume that the Sun's

orbital eccentricity is $\varepsilon = 0$. (First find the distance of the center of the Sun from the center of mass.)

c) Estimate the contribution that the orbit of Jupiter makes to the total angular momentum, also assuming that $\varepsilon = 0$.

d) Recall that the moment of inertia of the solid uniform sphere of mass m and radius r is given by $I = \frac{2}{5} mr^2$. Assuming that both the Sun and Jupiter rotate as solid uniform spheres, calculate approximate values for the rotational angular momentum of the Sun and Jupiter. Take the rotation periods of the Sun and Jupiter to be 26 days and 10 hours respectively.

e) What part of the Sun-Jupiter system makes the largest contribution to the *total* angular momentum (total orbital angular momentum + total rotational angular momentum)?