Astronomy 421 – Problem set 1

Due Thursday, Sept 1

1. (a) Determine the Julian date for 16:15 UT on July 14, 2006. (Hint: be sure to include any leap years in your calculation). (b) What is the corresponding MJD?
2. Proxima Centauri (alpha Centauri C) is the closest star to the Sun and part of a triple star system. It has J2000 coordinates RA=14h29m42.95s, Dec=-62d40m46.1s. The brightest member of the system (alpha Centauri A) has J2000 coordinates RA=14h39m50s,
   Dec=-60d50m02.3s.
   (a) What is the angular separation between alpha Centauri A and C?
   (b) If the distance to Proxima Centauri is 4.0 x 10^16 m, what is the physical distance between these two stars?
3. Derive equation 2.25 from the sum of the kinetic and potential energy terms for the masses m1 and m2 in a binary system.
4. Consider two stars in orbit around a mutual center of mass. If a1 is the semimajor axis of the orbit of a star with mass m1 and a2 is the semimajor axis of the orbit of a star with mass m2, prove that the semimajor axis of the orbit of the reduced mass is given by a = a1 + a2. Hint: review section 2.3 and recall that r = r2 – r1.
5. Assuming that the Sun interacts only with Jupiter:
   (a) calculate the total orbital angular momentum of the Sun-Jupiter system. The semimajor axis of Jupiter's orbit is a=5.2AU, its orbital eccentricity e=0.048, and its period is P=11.86 years.
   (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 zero (e=0). Hint: first find the distance of the center of the Sun from the center of mass.
6.
   (c) Making the assumption that the orbit of Jupiter is a perfect circle (e=0), estimate the contribution that it makes to the total orbital angular momentum. Compare your answer with the difference to parts (a) and (b).
   (d) The moment of inertia of a solid sphere of mass m and radius r is given by I = 0.4 mr^2, which is related to the rotational angular momentum by L = Iw, where w is the angular frequency measured in radians/s. Assuming (incorrectly) that the Sun and Jupiter rotate like solid spheres, calculate approximate values for the rotational angular momentum of the Sun and Jupiter. The rotation periods of the Sun is 26 days, and for Jupiter is 10 hours. The radius of the Sun is 6.96 X 10^8m and the radius of Jupiter is 6.9 x 10^7 m.
   (e) What part of the Sun-Jupiter system makes the largest contribution to the total angular momentum?
7. Using the data contained in problem (5&6) above, and in Chapter 2:
   (a) calculate the escape velocity at the surface of Jupiter.
   (b) calculate the escape velocity from the Solar System, starting from Earth's orbit. Assume that the Sun contains essentially all of the mass in the Solar System.
8. Cometary orbits usually have very large eccentricities, often approaching (or even exceeding) unity. Halley's comet has an orbital period of 76 years, and e=0.9673.
   (a) calculate the semimajor axis of Comet Halley's orbit.
   (b) Use the orbital data of Comet Halley to estimate the mass of the Sun.
9.
   (c) Calculate the distance of Comet Halley from the Sun and perihelion and aphelion.
   (d) Determine the orbital speed of the comet at perihelion, aphelion and on the semiminor axis of its orbit.
   (e) How many times larger is the kinetic energy of the comet at perihelion compared to aphelion?
10. The Hubble Space Telescope is in Low Earth Orbit (LEO) with a height of 540 km, and is in a nearly circular orbit with a period of 95.42 minutes. Show that it obeys the virial theorem.