Astronomy 405: Homework #5 (Rotational Mechanics)

1. **Carroll & Ostlie, Problem 2.8**:

   (a) The Hubble Space Telescope is in a nearly circular orbit, approximately 610 km above the surface of Earth. Estimate its orbital period. (2 pts)

   (b) Communications and weather satellites are often placed in *geosynchronous* "parking" orbits above Earth. These are orbits where satellites can remain fixed above a specific point on the surface of Earth. At what altitude must these satellites be located? (3 pts)

   (c) Is it possible for a satellite in a geosynchronous orbit to remain "parked" over any location on the surface of Earth? Why or why not? (2 pts)

2. The energy of a planet traveling at velocity v around the Sun can be expressed as

$$\frac{1}{2}mv^2 - \frac{GM_\odot m}{r} = Cm,$$

   where C is a constant.

   (a) Show that $C = -GM_\odot/2a$ for an arbitrary orbit, where a is the semi-major axis of the orbital path. (5 pts) *Hint: Since the total energy is constant along the entire orbit, evaluate it at a convenient point.*

   (b) Use your result from (a) to obtain an expression for the speed of a planet at an arbitrary point along its orbit. What are the maximum and minimum speeds for the Earth, for Mars, and for Jupiter? (5 pts)

3. You are orbiting the Earth in your spacecraft at an altitude of 100 km, and receive clearance from Houston to fire the spacecraft engines and produce a tangential velocity which will take you to the Moon. (Assume that the spacecraft's orbit is always in the Moon's orbital plane.)

   (a) In a two-body approximation (Earth, spacecraft) how much extra velocity (in km $\sec^{-1}$) must be added to put the spacecraft onto an orbit whose apocenter is at the Moon? (5 pts)

   (b) How much extra velocity would you need to escape from the Earth altogether? (5 pts)