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)
- 4. (a) Estimate the minimum rotation period of a star, in hours, by equating gravity with the centrifugal force at the equator. (3 pts)
 - (b) How would your answer differ for a planet? (3 pts)
 - (c) Calculate the spin angular momentum of the Sun, the spin angular momentum of Jupiter, and the orbital angular momentum of Jupiter. Assume the moment of inertia for a uniform sphere. (5 pts)
 - (d) If Jupiter were to be absorbed by the Sun, how fast would the Sun spin? What would happen? Assume that the angular momentum vectors are parallel, that the total angular momentum is conserved, and that the radius of the Sun would not change. (5 pts)
 - (e) Now consider a 1 M_{\odot} spherical cloud of gas with uniform density and radius 1 light year. How fast does it spin if it has the same angular momentum as the Sun-Jupiter system? (5 pts)
- 5. Calculate the effective potential at the Earth-Moon Lagrange Point L4 and from this determine its x and y coordinates relative to the center of mass of the system, in units of cm. (Do not assume that the Earth, the Moon, and L4 form a triangle with 60° angles, nor that any of the distances between the Earth, the Moon, and L4 are equal. You will show these things by evaluating the potential.) (8 pts)

