Name: ______________________________
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Physics 222 - Spring 2020
★ Homework 1 ★
Chapter 13

1) 13.2
2) 13.4
3) 13.5
4) 13.7
5) 13.9
6) 13.10

7) The velocity of a small planet of mass, m, in orbit around the Sun of mass, M, is given by:

$$\mathbf{v} = \frac{GMm}{L}(-\sin\theta\hat{\mathbf{i}} + (\cos\theta + \epsilon)\hat{\mathbf{j}}),$$

where, L, is the magnitude of the planetary angular momentum and ϵ is a constant (eccentricity). From this relation:

a) Derive the kinetic energy, K, for the orbiting planet in terms of L, ϵ and θ.
b) Derive the total energy, E, in terms of L, and ϵ.
c) Use b) to derive an expression for ϵ, in terms of L, and E.
d) Confirm that $L^2 = -\frac{G^2M^2m^3}{2E}$ for a circular orbit.

8) A black hole has an event horizon (point-of-no-return) corresponding to the radius where the escape velocity is equal to c, $R_{EH} = \frac{2GM}{c^2}$.

a) Calculate the tidal force between ones head and feet, at the radius of the event horizon of a 1 $M_\odot$ black hole (2.0×10^{30} kg). Assume for numerical simplicity that ones head and feet each have a mass of 10 kg and are 1 m apart. Compare the force to the maximum bodily tissue can support (lets say $\sim 10^4$ N). Is spaghettification likely?
b) Repeat a) for a $4 \times 10^6 M_\odot$ black hole (like the one that is at the center of the Milky Way).