1. The size of the gravitational force between any two spherically-symmetric masses in the Universe is given by $F_G = G\frac{m_A m_B}{r^2}$; $r$ is the separation distance between the masses.

a. Star $A$ is twice as massive as star $B$; no other masses are nearby. No information about their motions is given. Make a FBD on each star, drawing the force arrows to scale.


b. Draw a labeled acceleration arrow below each star, once again to scale. Explain the selected length of your acceleration arrows.

2. The gravitational PE stored in a system of two spherically-symmetric masses, $M$ and $m$, separated by a distance $r$, is most conveniently written as $U_G(r) = -G\frac{Mm}{r}$.

a. Find the expression that results from taking $-\frac{d}{dr}U_G(r)$. For $M$ at the origin (a reasonable choice if we let $M >> m$), what is the physical significance of your result?

b. Show that, given this choice of $U_G(r)$, if a projectile was fired from the surface of a planet of mass $M$ and radius $R$ with a launch speed of $\sqrt{2GM/R}$, then the planet-projectile system would have a total mechanical energy of zero! What would happen to such a projectile launched vertically from the surface of an airless world?

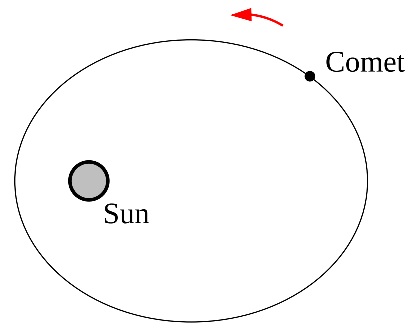
c. Consider a 100-kg projectile to be launched from the surface of an airless world having $M = 6.0 \times 10^{24}$ kg and $R = 6500$ km. Find the launch speed needed to create $K + U = 0$ (as in (b)), and calculate each of $K$ and $U$ at the instant of launch.

d. For the launch of part (c), what would be the system KE when the projectile has achieved an altitude equal to twice the radius of the planet (*i.e.* $r = 3R$)?

3. Comets have highly elliptical orbits with the Sun at one focal point of the ellipse.

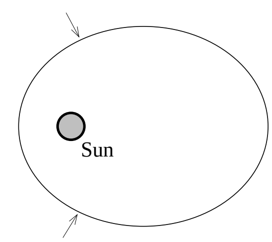
a. Make a FDB on the comet, and a FBD on the Sun, drawing the force vectors to scale.

b. Based on your FBD, what is the direction of the torque on the comet about the point at the center of the Sun? Or is the torque zero? Explain.




c. What is the direction of the angular momentum of the comet about the point at the center of the Sun? Or is the angular momentum zero? Explain.

d. When the comet has moved to a location which is half as far from the Sun (possible locations marked with arrows), how will the size of the force on the comet by the Sun have changed, and how will the comet's angular momentum have changed?




e. For the possible comet locations marked as *A*-*D*, draw and label arrows on the comet to indicate the direction of the velocity of the comet and the direction of the net force on the comet. Use a different color for the two different arrows.

f. For locations *A*-*D*, determine whether the comet is speeding up, slowing down, or moving at constant speed. Explain your reasoning both in terms of the W-K theorem and using conservation of mechanical energy.