1) Two equal spherical masses with mass $M$ and radius $r$ are held at rest a distance $6r$ apart (surface to surface). There are far from any other objects with appreciable mass.

a) If you are on the surface of one mass and along the line that connects the two centers, how fast does it appear that other mass is moving when it lands on your head? (Assume your height is zero.)

b) What value of $r$ would be necessary for that speed to be 200 m/s if each of these masses has a uniform density of $5 \times 10^{17}$ kg/m$^3$ (a value typical for a neutron star).
An object of mass 2 kg undergoes an elliptical orbit about a “star” (of mass $3.0 \times 10^{11}$ kg) as shown. At point A the object’s velocity is 20 m/s (and perpendicular to the gravitation force on the object). ($G = 6.67 \times 10^{-11}$ N m$^2$/kg$^2$)

a) What is velocity of the object at point B (the furthest point)?
b) Assuming the velocity at point C is 10 m/s, what is the change in potential energy from point A?
c) Assume that now a force acts at point A to now initiate a circular orbit with a velocity of 4 m/s, what would be the object’s orbital period?
3) You are given two identical bottles filled with equal amounts of whole milk (about 3.5% fat). In the bottle on the left the milk is homogenized so that the cream is uniformly distributed. In the bottle on the right the cream has separated and floats to the top of the bottle. Each bottle is connected to a pressure sensor at the bottom of the bottle. Is the pressure in the left bottle the same as that in the right bottle? If not then which one is higher. Explain your answer.

3) A large tub is half full of water. A mass M=25 kg, which has a density of 2.5 gm/cm³, is attached to the right-hand side of the tub, out of the water. The density of the water is 1.0 gm/cm³. The entire apparatus balances perfectly horizontally on a fulcrum at F, as in (A). The tub is clamped in place while the mass, M, is lowered to the bottom of the tub and it becomes completely submerged. This is shown in (B). When the clamp is released does the tub remain balanced or does it tip (and, if so, which way). Explain your reasoning.