1. A box of mass $M$ is on a rough incline that makes an angle $\theta$ with the horizontal. The coefficient of kinetic friction between the box and the incline is $\mu$. The box is placed against a spring whose other end is secured to a wall at the lower end of the incline. The block is used to compress the spring a distance $D$ and is then released from rest.

Derive an expression for the minimum spring constant $k$ necessary to ensure that the box reaches a distance $L$ up the incline from the equilibrium position of the spring. (Treat the box as a point mass.)

2. Object $A$ of mass $M$ is initially at rest on a flat, smooth frictionless surface. Object $B$, which has twice the mass of $A$, is traveling with speed $V$ before it collides elastically with $A$. Immediately after the collision, both objects move off at angles $\theta > \theta$ with respect to the original direction of $B$.

Calculate the value of the angle $\theta$. [Hint: Note that the collision is elastic.]

3. Scientists on a planet of mass $4M$ and radius $2R$ launch a satellite. Their moon has mass $2M$, radius $R$, and its center is a distance of $10R$ from the center of the planet. The satellite of mass $m$ is shot out of a cannon from the side of the planet facing away from the moon. It follows the dashed path to point $O$ which is on the line connecting the centers of planet and moon, a distance $4R$ away from the moon, as shown in the figure. Ignore the orbital motion of the moon about the planet.

a) Derive an expression for the difference in kinetic energies, $\Delta K$, between point $O$ and the launch point in terms of relevant system parameters.

b) Derive an expression for the net force on the satellite at point $O$ in terms of relevant system parameters.