1. Potential energy of a particle is given by $U(r, \theta, \phi) = a \cdot r \cdot \sin \theta \cdot \cos \phi$.

   a) what is the force on the particle?
   b) what work need to be done on the particle to move it from a point $(1, \pi/4, \pi/4)$ to $(2, \pi/2, \pi)$?

2. A metal ball (mass $m$) with a hole through it is threaded on a frictionless vertical rod. A massless string (length $L$) attached to the ball runs over a small, massless, frictionless pulley and supports a block of mass $M$. Horizontal distance between the rod and the pulley is $b$ (see the figure). The position of the two masses can be uniquely specified by the one angle $\theta$.

   a) write down gravitational potential energy of the system $U(\theta)$. (It is given easily in terms of heights shown in $H$ and $h$ in the figure. Express $H$ and $h$ in terms of $\theta$, $L$ and $b$)
   b) By differentiating $U(\theta)$ find whether the system has an equilibrium position, and for what values of $m$ and $M$ equilibrium can occur. Discuss stability of any equilibrium positions.

3. A box of height $H$ and width $W$ is dropped from small height on a conveyer belt that runs with speed $V$. The friction coefficient between the box and the belt is $\mu$. The box will slip right after it’s dropped, but may or may not tumble (obviously if $H$ is much larger then $W$ the box will tumble). For a given $H$ and $\mu$, find the minimum $W$ for which the box does not tumble.