A simple pendulum of mass $m$ and length $\ell$ is suspended from a block of mass $M$ that slides horizontally without friction.

a) Choose suitable generalized coordinates for this system and write down the Lagrangian.

b) Find the generalized momentum conjugate to each of the generalized coordinates.

c) Find from the Lagrangian the equations of motion for this system and identify any cyclic coordinates and conserved momenta. In the case of each conserved momentum, explain what it is physically.

d) Find a second-order differential equation for the angle $\theta$ of the pendulum in terms of the masses, the pendulum length, and the acceleration of gravity. That is, all other generalized coordinates and their derivatives should be eliminated.