10 pts 1. A mass m slides without friction along a horizontal guide as shown in figure 1. Motion is restrained by a linear spring of stiffness k and unstretched length $L/2$. Determine the equation of motion for the mass using its horizontal displacement x as a generalized coordinate.

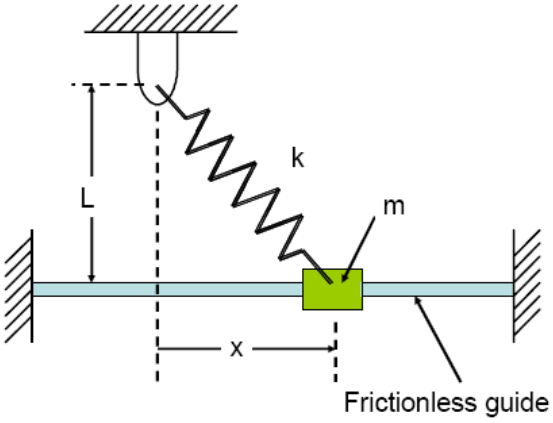

Figure 1:

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10 pts 2. A uniform rod of length L and mass m_2 is attached by way of a frictionless pin to a sliding collar of mass m_1 (figure 2). The collar slides without friction on a horizontal guide and is further restrained by two identical springs of stiffness $k/2$ (x is the extension/compression of the left/right springs respectively). A force of magnitude F is applied to the rod in such a way that it is always perpendicular to the rod. Derive the equations of motion.

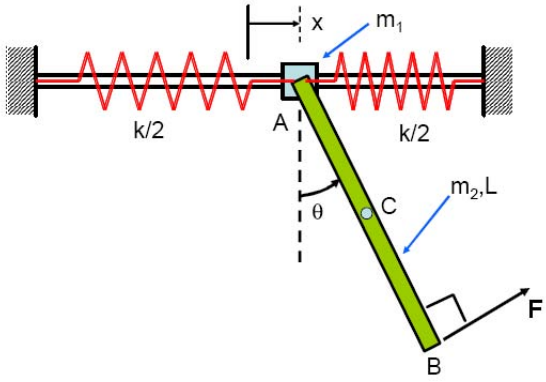

Figure 2:

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10 pts 3. A uniform rod of length L and mass m_1 is attached to a cart of mass m_2 by means of a spring with spring constant k (figure 3). There is a constant force F that is always applied perpendicular to the free end. The nonlinear equations of motion for this system in terms of the generalized coordinates θ and x are:

$$\theta : I_0\ddot{\theta} + m_1 g\frac{L}{2}sin\theta - k\frac{L}{2}cos\theta(x - \frac{L}{2}sin\theta) = FL \tag{7}$$

$$\mathbf{x} : m_2\ddot{x} + k(x - \frac{L}{2}sin\theta) = 0 \tag{8}$$

Identify the equilibria and derive the linearized equations for small perturbations about the equilibria (you do not have to solve these equations).

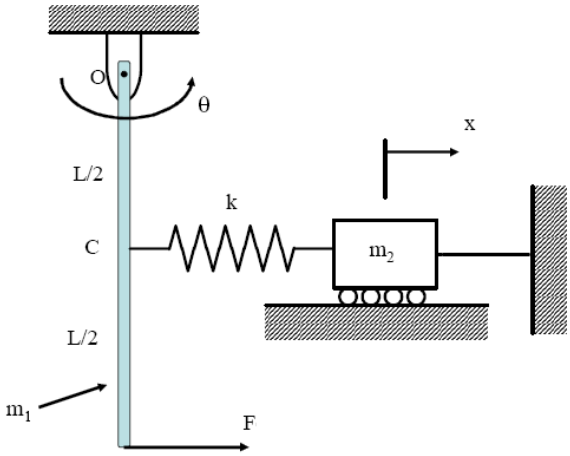

Figure 3:

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