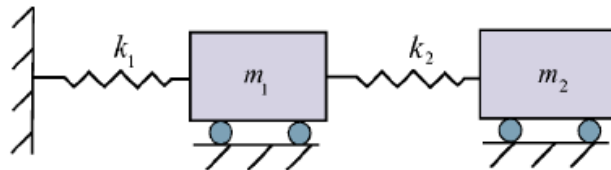# 2.003/1.053 Dynamics and Controls I
Spring 2007
Problem Set 10

Issued on Tuesday, May 8th
Optional/practice problem set

1 Carts

Find the equations of motion of the system shown below. Find the natural frequencies and mode shapes of the system for $k_1 = k_2 = k$ and $m_2 = \frac{2}{3}m_1$, $m_1 = m$.

2 Double mass and spring pendulum revisited

Using symmetry or otherwise find the natural frequencies and mode shapes of this system (small motions). The spring is unstretched in the equilibrium position shown.
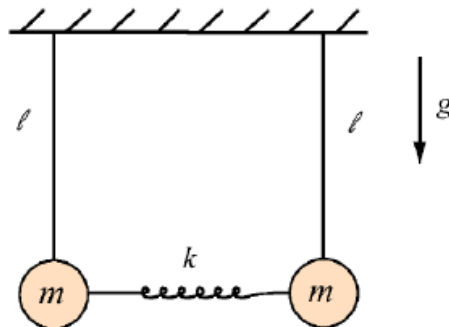
3 Suspension

i. Derive the equation of motion for the system shown below using x, the elevation of the mass above the base, as generalized coordinate. The unstretched length of the spring is l.

ii. Derive the equation for small motions about x_0, the static equilibrium location of the mass.

iii. Find the steady-state response (amplitude of oscillations about x_0) of the system due to $F(t)$. Evaluate this response at $\omega/\omega_n = 0.3, 1.0, 3.0$ for $\zeta = 0.05$.

iv. Let the total force transmitted to the base be given by $F_B = F_D + F_g$ where F_D is the "dynamic part" (due to $F(t)$) and F_g is the part due to gravity. Derive an expression for the transmission ratio $T = F_D/F_0$. Sketch $|T|$ for $\zeta = 0.05$ and $\zeta = 1$ as a function of ω/ω_n.