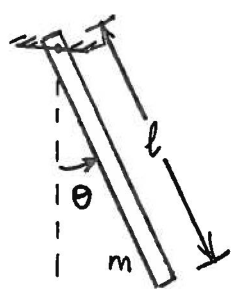
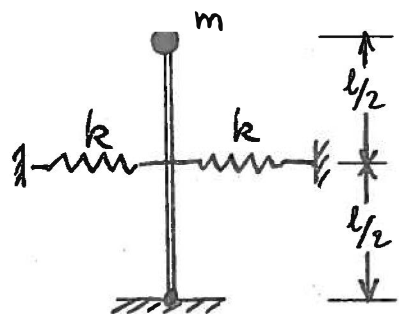
MECH463 -- Tutorial 3

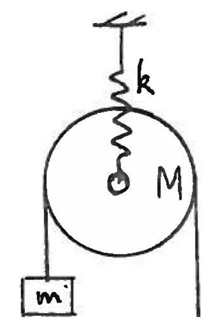
1. Draw free body diagrams for each of the three vibrating systems shown in the diagrams. Formulate the equations of motion and identify the natural frequencies.

   Component (a) is a compound pendulum made of a uniform bar of length ℓ, mass M, and centroidal polar moment of inertia $J = m\ell^2/12$, that pivots around its upper end. Component (b) is an inverted pendulum with a mass m attached at the upper end of a light, stiff rod. The rod, which has length ℓ and pivots at the bottom, is supported by horizontal springs of stiffness k at its midpoint. Component (c) is a circular pulley of mass M, radius r, $J = \frac{1}{2}Mr^2$, supported by a spring of stiffness k at its centre. A light, stiff string passes around the pulley and secures a mass m. (Hint: Remember to include the inertia forces and couples in your FBDs based on the centres of mass.)





(b)



(c)

2. A shock absorber is required that will have an overshoot of not more than 15% of its initial displacement when released. Determine the needed damping factor.

3. A spring-damper system consisting of a spring k = 40N/mm in parallel with a damper c = 10N.s/mm is installed at the end of a railway siding. A freight car of mass 2000kg rolls along the siding and hits the spring-damper at speed 10 m/s. Determine (a) the maximum displacement of the spring-damper, and (b) the time taken to reach the maximum displacement.

4. A machine with a total mass m = 50 kg contains a shaft mechanism of effective mass m_0 that rotates at 1800 rpm. The machine rests on springs of combined stiffness k = 200 kN/m, but the damping constant c is unknown. Due to an imbalance in the shaft, there is a steady-state vibration with amplitude 1 mm. The amplitude of the vibration force transmitted to the floor is 278N. Determine (a) the damping constant c, and (b) the unbalanced moment $m_0\epsilon$.