1 (20%) Consider a round uniform body of mass M and radius R rolling smoothly down a ramp at angle θ, along x axis (see Fig. 1). Let I_{com} denote the rotational inertia at the center of mass of the round body, $\vec{F}_g$ the gravitational force on the body, $\vec{F}_N$ the normal force perpendicular to the ramp, and $\vec{f}_s$ the static frictional force acting at the contact point P. Please prove that the linear acceleration at the center of mass is

$$a_{com,x} = -\frac{g \sin\theta}{1 + I_{com}/MR^2}$$

(Remark: g: gravitational acceleration)

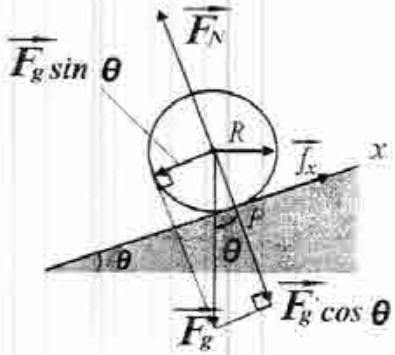

Figure 1

2 In Figure 2, particle A moves along the line y = 40 m with a constant velocity $\vec{v}$ = 4.0 m/s and parallel to the x axis. At the instant particle A passes the y axis, particle B leaves the origin with initial speed 1.0 m/s and constant acceleration $\vec{a}$ = 0.60 m/s.

(a) What is the angle θ between $\vec{a}$ and the positive direction of the y axis would result in a collision? (15%)

(b) When will the collision take place? (10%)

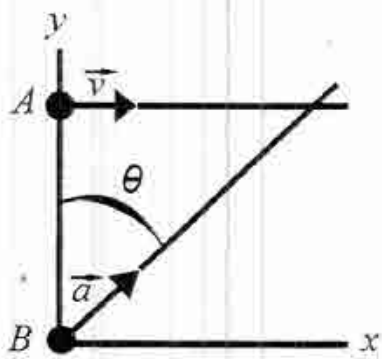

Figure 2

3 A save, of mass M = 400 kg, hanging by a rope from a boom with dimensions a = 1.9 m and b = 2.5 m. The boom consists of a hinged beam and a horizontal cable. The uniform beam has a mass m of 100 kg; the masses of the cable and rope are negligible.

(a) What is the tension T_c in the cable? (14%)

(b) What are the magnitudes of the net horizontal force F_h and net vertical force F_v on the beam from the hinge. (16%)

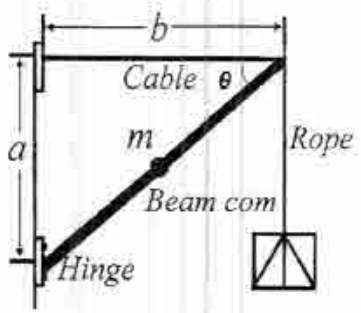

Figure 3

4 Let $\vec{E}$: electric field, $\vec{B}$: magnetic field, q_{enc}: net electric charge enclosed by surface, i_{enc}: current encircled by closed loop, Φ_B: magnetic flux, Φ_E: electric flux, μ_0: magnetic permeability constant, ε_0: electric permittivity constant. Please write down the following Maxwell's equations:

(a) Gauss's law for electricity? (6%)

(b) Gauss's law for magnetism? (6%)

(c) Faraday's law? (6%)

(d) Ampere-Maxwell law? (7%)