ME Dept., IIT Delhi

MEL 832: Multibody Systems and Vibration Design
Major (April 30, 2010; Fri)

Duration: 2 hours **Marks: 30**

1. Figure 1 shows a roller of mass m is moving on an inclined plane without slipping. Answer the following:

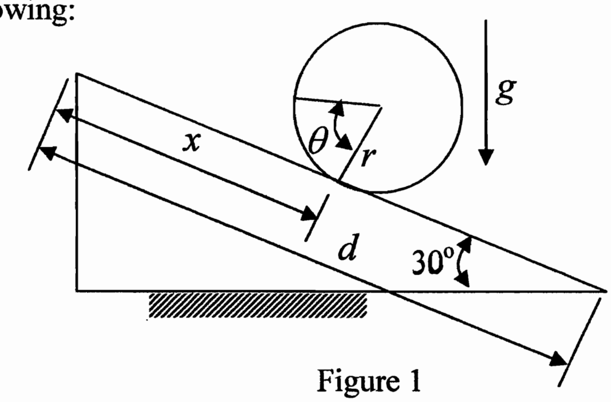

Figure 1

a) What is the degree of freedom of the system?
b) Prove that it is a holonomic system
c) If x and θ are the two generalized coordinates, derive the Euler-Lagrange equations of motion.
d) Perform forward dynamics for the above system.
e) Using Euler's integration formula, find out numerically the position of the roller, x and θ, at time, $t = 1$ sec for the time step of $h = 0.5$ sec. Assume, $m = 5$ kg, $d = 5$ m, $r = 0.5$ m, and the initial conditions at $t = 0$ are all zeros.
f) Verify the position results of e) using the kinematic constraints.

[1+1+5+3+5+1 = 16]

2. The dynamics of a two-dimensional beam is modeled using three elastic coordinates. The shape function of the beam is assumed to be

$$\mathbf{S} = \begin{bmatrix} \sin(\pi\xi) & 0 & 0 \\ 0 & \sin(\pi\xi) & \sin(2\pi\xi) \end{bmatrix}$$

where $\xi = x/l$, x is the location of an element along the beam, and l is the length of the beam. At a given instant of time, the vector of generalized coordinates of the beam is given by

$$\mathbf{q} \equiv \begin{bmatrix} R_1 & R_2 & \theta & q_{f1} & q_{f2} & q_{f3} \end{bmatrix}^T = \begin{bmatrix} 3 & 2 & \dfrac{\pi}{2} & \dfrac{10^{-3}}{2} & 10^{-3} & 10^{-5} \end{bmatrix}^T.$$

a) Determine the global position of the point at $\xi = 1/2$.

b) If the external force vector at the center of the beam is $\mathbf{F} \equiv \begin{bmatrix} 2.5 & -3 \end{bmatrix}^T N$, determine the generalized forces associated with the generalized coordinates of the flexible beam.

[6+8 = 14]

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