FALL 2015 EXAM II FOR ME 104

INSTRUCTIONS:

- NO electronic devices, notes, etc., are allowed.
- NEATNESS COUNTS. DRAW VERY PRECISE DIAGRAMS FOR EACH PROBLEM.
- Write on only the sheets provided to you.
- Make sure that your full name (not nickname) is on each sheet.
- Make sure that all of your sheets are stapled together.
- Box your answers. Be as concise as possible.
- Optimize your time and first set up all the problems.

The only "nonstandard" equations that you may need are

$$\boxed{\begin{aligned} &\boldsymbol{r} = r\boldsymbol{e}_r \\ &\boldsymbol{v} = \dot{r}\boldsymbol{e}_r + r\dot{\theta}\boldsymbol{e}_\theta \\ &\boldsymbol{a} = (\ddot{r} - r\dot{\theta}^2)\boldsymbol{e}_r + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\boldsymbol{e}_\theta \\ &\boldsymbol{a} = \dot{v}\boldsymbol{e}_t + \frac{v^2}{\rho}\boldsymbol{e}_n \end{aligned}}$$

Out of plane moment of inertias:

- Thin Disk: $\bar{I}_{cg} = \frac{1}{2}mr^2$,
- Thin rod: $\bar{I}_{cg} = \frac{1}{12}mL^2$.

- PROBLEM 1: 20
- PROBLEM 2: 20
- PROBLEM 3: 30
- PROBLEM 4: 30

PROBLEM 1 (20 POINTS)

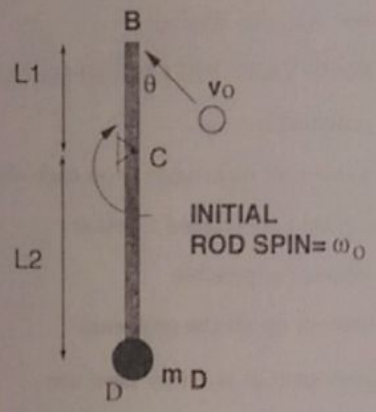

Figure 1: Figure for PROBLEM 1.

The point mass m_b is projected (at an angle) against the end of the rod BD as shown with an initial speed v_0. The rod also has an initial spin ω_0. Rod BD has mass m_r and a disc mass (of radius R) welded on the end of m_D. The rod is attached to a pin support at C. The impact time Δt is known, and the coefficient of restitution is $e = e^*$, where $0 < e^* < 1$.

Denoting the velocity of the point mass, just before impact by v_o, determine, IGNORING GRAVITY:

- (a) Draw a neat freebody MOMENTUM diagram (BEFORE-IMPACT-AFTER).
- (b) Determine the components of the velocity of the point mass immediately after impact
- (c) Determine the angular velocity of the rod immediately after impact

PROBLEM 2 (20 POINTS)

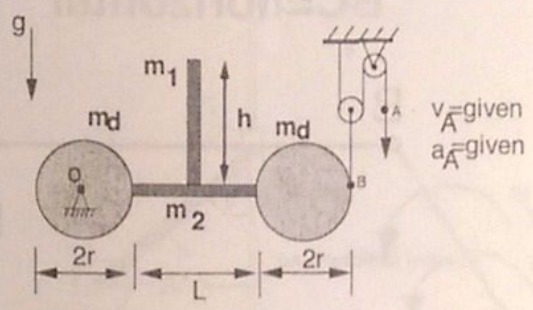

Figure 2: Figure for PROBLEM 2.

For the assembly shown, the cord, at point A, is pulled downwards with a velocity of v_A and an acceleration a_A. The disks are welded to the rod. The mass of the vertical thin rod of length h is m_1. The mass of the horizontal thin rod of length L is m_2 (it is in the middle of the structure). The mass of each thin disk of radius r is m_d. *The pulleys are massless.*

- (a) Draw a neat freebody and effective force diagram.
- (b) Determine the kinematic relationship between the velocity and acceleration the point A and that of point B.
- (c) Determine the angular velocity and acceleration of the disk-rod-disk assembly.
- (d) Derive the equations of dynamic motion for the disk-rod-disk assembly as one entire structure which can be solved for the unknown reaction forces at O and the tension in the string.

PROBLEM 3 (30 POINTS)

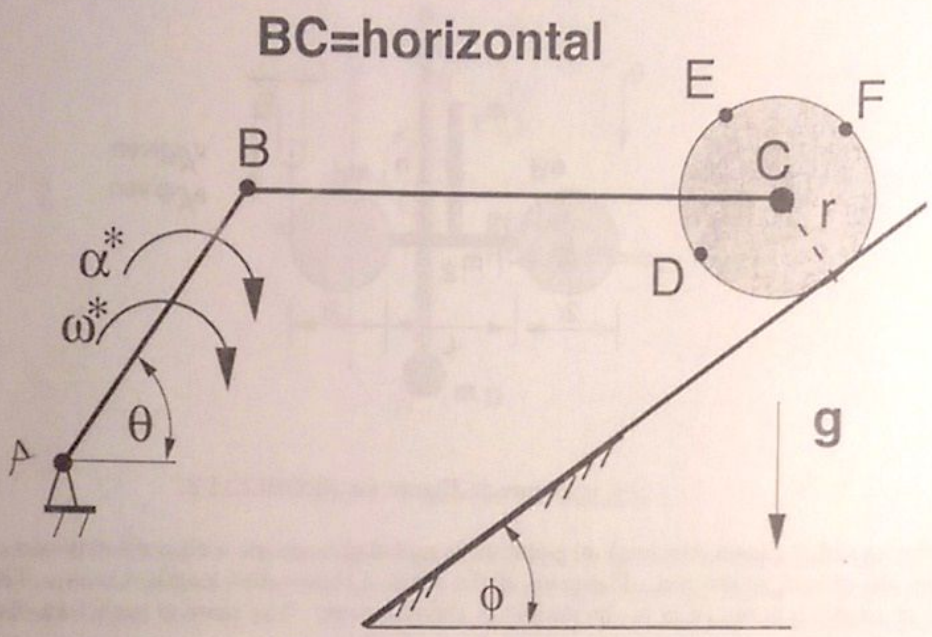

Figure 3: Figure for PROBLEM 3.

The mechanical device shown consists of two rods linked together, which drive the disk. The disk (mass m_d) rolls (radius R without slipping. The rod (AB), of length L_{ab} and mass m_{ab}, has a controlled angular velocity of ω^* (clockwise) and a controlled angular acceleration of α^* (clockwise). The rod (BC) is of length L_{bc} and mass m_{bc}. Consider only the instant shown

- (a) Draw a neat freebody diagram and effective force diagram for each component (2 rods, 1 disk).
- (b) Draw the instant center for the rod (BC) and the instant center for the disk.
- (c) Determine the angular velocity of rod (BC) and the angular velocity of the disk. For each, make sure to indicate whether the angular velocity is clockwise or counterclockwise.
- (d) Determine the angular acceleration of rod (BC) and the angular acceleration of the disk. For each, make sure to indicate whether the angular acceleration is clockwise or counterclockwise.
- (e) Determine the accelerations of points D, E and F on the disk.
- (f) Determine the total kinetic energy in the system.

PROBLEM 4 (30 POINTS)

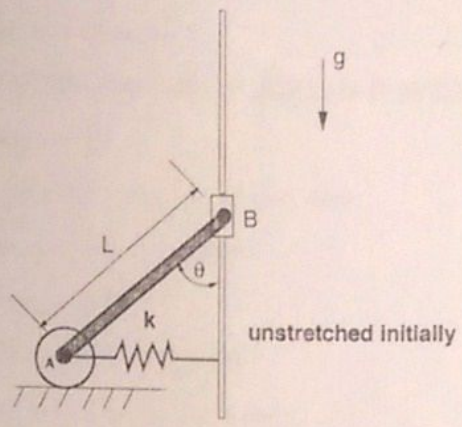

Figure 4: Figure for PROBLEM 4.

The rod AB of mass m_r and length L is pinned to thin disk (mass m_d and radius R) that rolls, without slipping, on the flat surface at point A, while end B is attached to a heavy collar of mass m_c which may slide along the (frictionless) vertical rod as shown.

- (a) Draw a neat freebody diagram and effective force diagram for the assembly (disk-rod-collar).
- (b) Determine, IMMEDIATELY after release, the angular acceleration of the rod and the reactions at points A and B.
- (c) Determine, IMMEDIATELY after release, the angular acceleration of the disk,
- (d) Using work energy principles, determine the angular velocity of 1)the rod and 2) the disk when point B falls to become the same height as A.