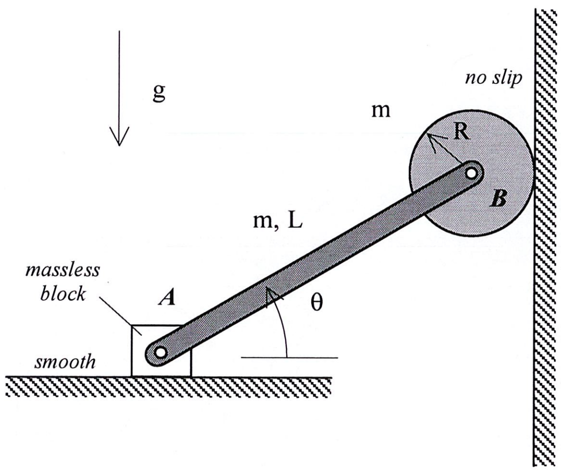
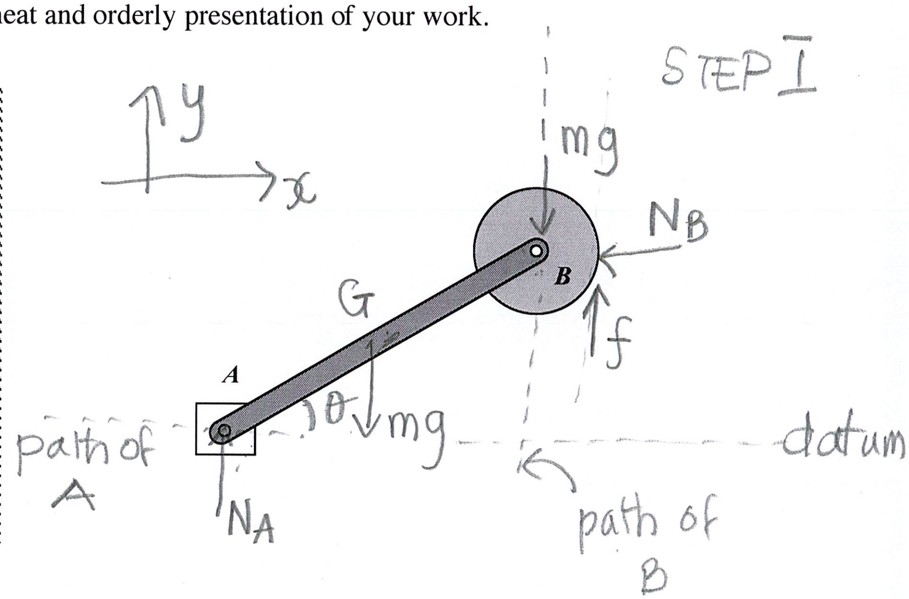
ME 274 – Summer 2010 **Name** ______________________________
Examination No. 2
PROBLEM NO. 1

Given: System released from rest with $\theta = 36.87°$. Consider the bar and the disk to be homogeneous.

Find: Determine the *angular velocity* of the bar when $\theta = 0$. Use: $m = 100\ kg$, $L = 2\ meters$ and $R = 0.4\ meters$.

Please clearly indicate the four steps in a neat and orderly presentation of your work.





Step II

Work - Energy

$$\cancel{T_1}^{0} + V_1 + \cancel{U_{1\to 2}^{(nc)}}^{0} = T_2 + \cancel{V_2}^{0}$$

B and G are at datum in pos ②. $\theta = 0$.

$$\cancel{m}g\frac{L}{\cancel{2}}\sin\theta + \frac{2}{1}L\sin\theta\cdot\cancel{m}g$$

want this

BAR

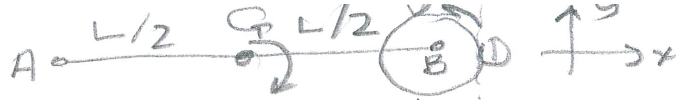
$$= \frac{1}{\cancel{2}}\cancel{m}v_{G_2}^2 + \frac{1}{\cancel{2}}\frac{I_G}{m}\omega_{BAR_2}^2 + \frac{1}{\cancel{2}}\cancel{m}v_{B_2}^2 + \frac{1}{\cancel{2}}\frac{I_{DISK}}{m}\omega_{DISK_2}^2$$

? ? ?

$$3gL\sin\theta = v_{G_2}^2 + \frac{I_G}{m}\omega_{BAR_2}^2 + v_{B_2}^2 + \frac{I_{DISK}}{m}\omega_{DISK_2}^2$$

1

Step II



Use kinematics to express v_{G_2}, v_{DISK_2} and v_{B_2} interms of ω_{BAR_2}

BAR pt. O to pt. B $\quad \bar{\omega}_{BAR} = -\omega_{BAR}\hat{k}$ (assume CW)

$\bar{v}_B = -v_A\hat{i} + (-\omega_{BAR})\hat{k} \times r_{B/A} = -v_A\hat{i} - \omega_{BAR} L\hat{j}$

$-v_B\hat{j} = -v_A\hat{i} - \omega_{BAR} L\hat{j} \quad \therefore \hat{j}: \quad \underline{v_B = \omega_{BAR} L}$ (*)

down $\quad$ CW

$\therefore$ and $\hat{i}$: $\underline{v_A = 0}$ at this instant

DISK pt. D to point B

$\bar{v}_B = \cancel{\bar{v}_D}^{0} + \underbrace{\bar{\omega}_{DISK}}_{\omega_{DISK}\hat{k}} \times \underbrace{\bar{r}_{B/D}}_{-R\hat{i}} \Rightarrow -v_B\hat{j} = -\omega_{DISK} R\hat{j}$

noslip

CCW assumed

$\therefore \underline{v_B = \omega_{DISK} \cdot R}$ (**) $\qquad \underline{\bar{v}_B = -\omega_{DISK} R\hat{j}}$

From (*) and (**)

$\omega_{BAR} L = \omega_{DISK} R$

$\therefore \quad \omega_{DISK} = \omega_{BAR} \cdot \dfrac{L}{R}$ $\qquad$ 2

$\bar{v}_G = \bar{v}_A + \bar{\omega}_{BAR} \times r_{G/A} = \vec{0} + -\omega_{BAR}\hat{k} \times (\frac{L}{2}\hat{i})$

$\bar{v}_G = -\frac{L}{2}\omega_{BAR}\hat{j}$ $\qquad$ 3

$\bar{v}_B = -\omega_{BAR}\dfrac{L}{R} \cdot R\hat{j} = -\omega_{BAR} L\hat{j}$ $\qquad$ 4

STEP (IV)

Substitute kinematics results into 1

$$3gL\sin\theta = \frac{L^2}{4}\omega^2_{BAR_2} + \frac{1}{12}L^2\omega^2_{BAR_2} + L^2\omega^2_{BAR_2}$$

$$+ \left(\frac{1}{2}\cancel{R^2}\right)\left(\frac{\omega_{BAR_2}L}{\cancel{R}}\right)^2$$

$$36g\cancel{L}\sin\theta = [\underbrace{3L^{\cancel{2}} + L^{\cancel{2}} + 12L^{\cancel{2}} + 6L^{\cancel{2}}}]\,\omega^2_{BAR_2}$$

$$\bar{\omega}_{BAR} = -\sqrt{\frac{36g\sin\theta}{22L}}\ \hat{k}\ \text{rad/s}$$

Clockwise motion.

ANS.