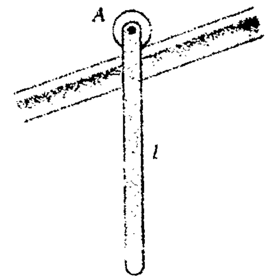
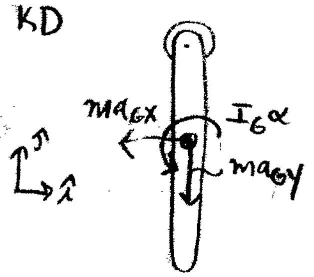
6/97 The slender rod of mass m and length l is released from rest in the vertical position with the small, i.e. negligible, roller at end A resting on the incline. Determine the initial acceleration of A. (*taken from Dynamics, 4th Edition by Meriam & Kraige*)



Strategy: CLM rate
CAM rate $\quad I_G = \frac{1}{12} m l^2$
Kinematics

unknowns	eqns
α	1
N	2
a_{GX}	3
a_{GY}	4
a_A	5

KD



FBD

sys = rod + roller

small roller = massless; pick it as your system and try CAMrate about the center; since m = 0, $I_G = 0$, and $\Sigma \vec{M} = 0$; thus $F_{fr} = 0$

CAMrate (⟲+, con) $\quad \frac{d}{dt}(\vec{L}_{sys,G}) = \Sigma \vec{M}_G$

(1) $\quad I_G\alpha = N \, l/2 \sin\theta$

CLMrate ($\hat{\imath}$) $\quad \frac{d}{dt}(\vec{P}_{sys,x}) = \Sigma F_x$

(2) $\quad -ma_{GX} = -N\sin\theta$

CLMrate ($\hat{\jmath}$) $\quad \frac{d}{dt}(\vec{P}_{sys,Y}) = \Sigma F_y$

(3) $\quad -ma_{GY} = N\cos\theta - mg$

Kinematics of bar

$$\vec{a}_A = \vec{a}_G + \vec{\alpha} \times \vec{r}_{A/G} - \omega^2 \vec{r}_{A/G}$$

$$\vec{a}_A = -a_A\cos\theta\,\hat{\imath} - a_A\sin\theta\,\hat{\jmath}$$

$$\vec{\alpha} = \alpha\hat{k}$$

$$\vec{r}_{A/G} = \frac{l}{2}\hat{\jmath}$$

$$\omega = 0 \quad \text{(starts from rest)}$$

(4) $\hat{\imath}$) $\quad -a_A\cos\theta = a_{GX} - \alpha\frac{l}{2}$

(5) $\hat{\jmath}$) $\quad -a_A\sin\theta = a_{GY}$

solve for $\vec{a}_A = \dfrac{4g\sin\theta}{\cos^2\theta + 4\sin^2\theta}$

at θ to horizontal

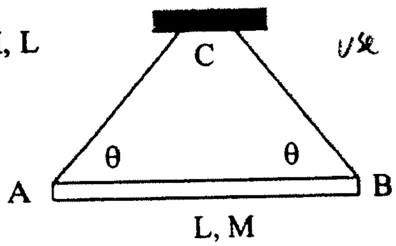
In groups

Name ____ 30 pts

ES204 Examination III **Problem 3** Feb. 14, 1997

A uniform steel beam is L long and has a mass M. If the supporting cable CB is cut, determine the equations necessary to find the tension T in the remaining cable AC an instant after the cut occurs. The beam may be treated as a slender bar. Clearly number your equations as you derived them and list your unknowns in the table provided. DO NOT SOLVE THE EQUATIONS.

knowns: θ, M, L



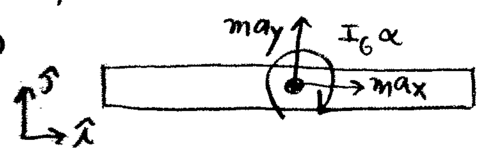
use $I_G = \frac{1}{12} m L^2$

Unknowns

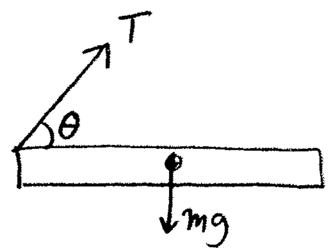
sys = beam

Strategy : CLMrate, CAMrate , Kinematics

KD



FBD



CLMrate ($\hat{i}$) $\frac{d}{dt}(P_{sys,x}) = \sum F_x$

① $m a_x = T\cos\theta$

CLMrate ($\hat{j}$) $\frac{d}{dt}(P_{sys,y}) = \sum F_y$

② $m a_y = T\sin\theta - mg$

CAMrate (com, $\hat{k}$) $\frac{d}{dt}(\vec{L}_{sys,G}) = \sum \vec{M}_G$

③ $I_G \alpha = T \frac{L}{2} \sin\theta$

UNK

a_x

T

a_y

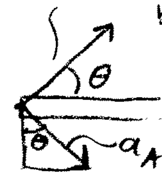
α

a_A

of the com

Kinematics $\vec{a}_A = \vec{a}_G + \vec{\alpha} \times \vec{r}_{A/G} - \omega^2 \vec{r}_{A/G}$

Normal accel is zero b/c $\omega = 0$



use $\vec{a}_A = a_A \sin\theta\, \hat{i} - a_A \cos\theta\, \hat{j}$

$\vec{a}_G = a_x \hat{i} + a_y \hat{j}$

$\vec{\alpha} = -\alpha \hat{k}$, $\omega = 0$ (at rest when cut)

$\vec{r}_{A/G} = -\frac{L}{2} \hat{i}$

gets ④ $\hat{i}$) $a_A \sin\theta = a_x$

⑤ $\hat{j}$) $-a_A \cos\theta = a_y + \frac{L}{2}\alpha$

if you solve, you get

$$T = \frac{mg\sin\theta}{1 + 3\sin^2\theta}$$