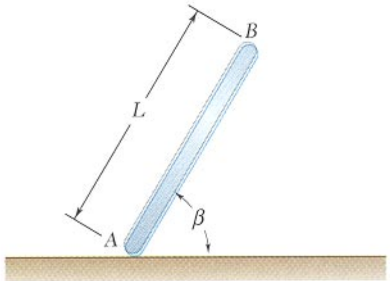


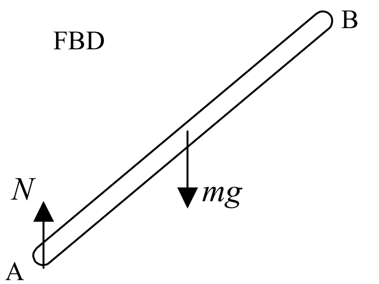
Problem 16.158

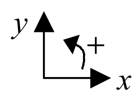
The uniform rod AB of weight W is released from rest when $\beta = 70^\circ$. Assuming the friction force is zero between end A and the surface, determine immediately after release

a) the angular acceleration of the mass center of the rod
b) the acceleration of the mass center of the rod
c) the reaction at A

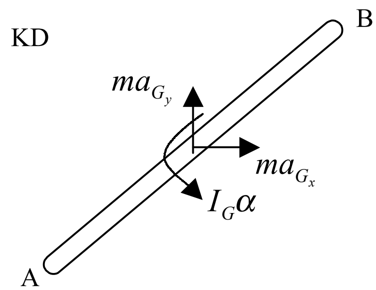
Step 1 : **Identify System**: *The Rod*
Step 2 : **Identify Form of Equations Required**: *need acceleration and force, therefore use Rate Form*
Step 3 : **Draw system diagrams** according to choice of equation form **and identify unknowns** : *FBD and KD*

FBD





KD



unk	eqs
α	
a_{Gx}	
a_{Gy}	
N	

Step 4 : **Kinetics**

COLM(RF) in x-dir $$0 = ma_{G_x} \quad (1)$$

COLM(RF) in y-dir $$N - mg = ma_{G_y} \quad (2)$$

COAM(RF) about point G $$-N\frac{l}{2}\cos(70^\circ) = I_G\alpha \quad (3)$$

Step 5 : **Kinematics**

Relative acceleration of G wrt A

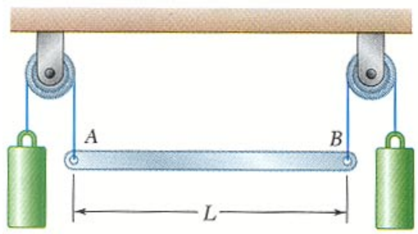
$$\begin{aligned} \bar{a}_G &= \bar{a}_A + \bar{a}_{G/A} \\ &= \bar{a}_A + \bar{\alpha}\times\bar{r}_{G/A} - \omega^2\bar{r}_{G/A} \\ &= a_{A_x}\hat{i} + a_{A_x}\hat{j} + (\alpha\hat{k})\times\left(\frac{l}{2}\cos(70^\circ)\hat{i} + \frac{l}{2}\sin(70^\circ)\hat{j}\right) - 0 \end{aligned}$$

Collecting i and j components (a_{Ay}=0!)

i components $$a_{G_x} = a_{A_x} - \frac{l}{2}\cos(70^\circ)\alpha \quad (4)$$

j components $$a_{G_y} = a_{A_y} + \frac{l}{2}\sin(70^\circ)\alpha \quad (5)$$

Step 6: **Solve in Maple**



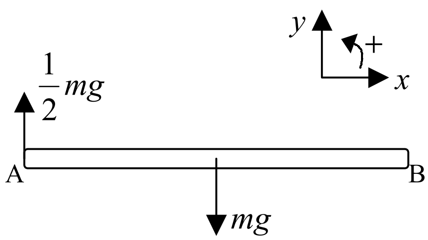
Problem 16.160

The slender rod AB of weight W is held in equilibrium by two counterweights each of mass 1/2W. If the wire at B is cut, determine the acceleration at that instant

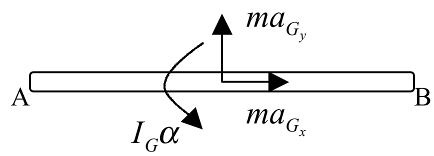
a) of point A
b) of point B

Step 1 : **Identify System**: *The Rod*
Step 2 : **Identify Form of Equations Required**: *need acceleration and force, therefore use Rate Form*
Step 3 : **Draw system diagrams** according to choice of equation form **and identify unknowns** : *FBD and KD*

FBD



KD



unk	eqs
a_{Ax}	
a_{Ay}	
a_{Bx}	
a_{By}	
a_{Gx}	
a_{Gy}	
α	

Step 4 : **Kinetics**

COLM(RF) in x-dir
$$0 = ma_{G_x} \quad (1)$$

COLM(RF) in y-dir
$$\frac{1}{2}mg - mg = ma_{G_y} \quad (2)$$

COAM(RF) about point G
$$-\frac{1}{2}mg\frac{l}{2} = I_G\alpha \quad (3)$$

Step 5 : **Kinematics**

Relative acceleration of A wrt G

$$\bar{a}_A = \bar{a}_G + \bar{a}_{A/G}$$
$$= \bar{a}_G + \bar{\alpha} \times \bar{r}_{A/G} - \omega^2 \bar{r}_{A/G}$$
$$= a_{G_x}\hat{i} + a_{G_x}\hat{j} + (\alpha\hat{k}) \times \left(-\frac{l}{2}\hat{i} + 0\hat{j}\right) - 0$$

Collecting i and j components

i components
$$a_{A_x} = a_{G_x} \quad (4)$$

j components
$$a_{A_y} = a_{G_y} - \alpha\frac{l}{2} \quad (5)$$

Relative motion of B wrt G

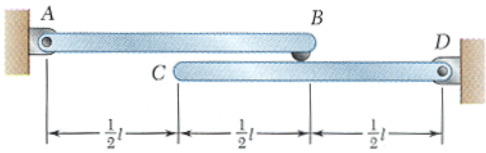
$$\begin{aligned} \bar{a}_B &= \bar{a}_G + \bar{a}_{B/G} \\ &= \bar{a}_G + \bar{\alpha} \times \bar{r}_{B/G} - \omega^2 \bar{r}_{B/G} \\ &= a_{G_x}\hat{i} + a_{G_x}\hat{j} + \left(\alpha\hat{k}\right) \times \left(\frac{l}{2}\hat{i} + 0\hat{j}\right) - 0 \end{aligned}$$

Collecting i and j components

i components $$a_{B_x} = a_{G_x} \qquad (6)$$

j components $$a_{B_y} = a_{G_y} + \alpha\frac{l}{2} \qquad (7)$$

Step 6: Solve in Maple



Problem 16.162

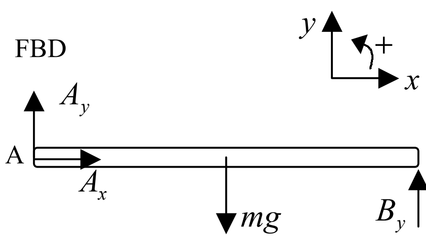
Two slender rods of length l and mass m, are released from rest in the positions shown. Knowing that a small knob at end B of rod AB bears on rod CD, determine immediately after release

a) the acceleration of end C of the rod CD
b) the force exerted on the knob

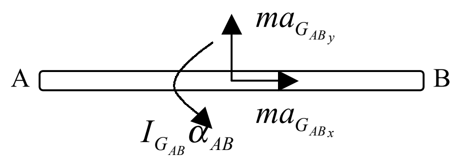
Step 1 : **Identify System**: *Both Rod*
Step 2 : **Identify Form of Equations Required**: *need acceleration and force, therefore use Rate Form*
Step 3 : **Draw system diagrams** according to choice of equation form **and identify unknowns** : *FBD and KD*

Rod AB

FBD



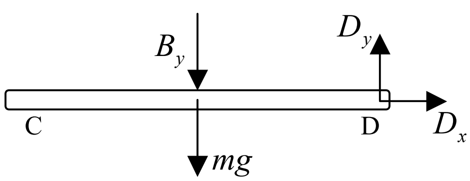
KD



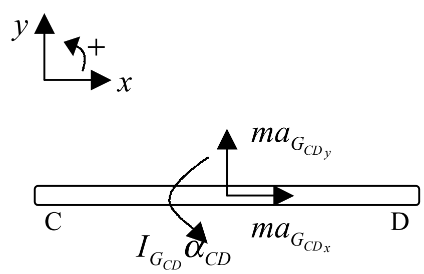
unk	eqs
a_{Cx}	
a_{Cy}	
B_y	
A_x	
A_y	
D_x	
D_y	
a_{GABx}	
a_{GABy}	
α_{AB}	
a_{GCDx}	
a_{GCDy}	
α_{CD}	

Rod BC

FBD



KD



Step 4 : **Kinetics**

Rod AB

COLM(RF) in x-dir $$A_x = ma_{G_{ABx}} \tag{1}$$

COLM(RF) in y-dir $$A_y + B_y - mg = ma_{G_{ABy}} \tag{2}$$

COAM(RF) about point G $$-A_y \frac{l}{2} + B_y \frac{l}{2} = I_{G_{AB}} \alpha_{AB} \tag{3}$$

Rod CD

COLM(RF) in x-dir $$D_x = ma_{G_{CDx}} \tag{4}$$

COLM(RF) in y-dir $$D_y - B_y - mg = ma_{G_{CDy}} \tag{5}$$

COAM(RF) about point G $$D_y \frac{l}{2} = I_{G_{CD}} \alpha_{CD} \tag{6}$$

Step 5 : Kinematics

Rod AB

Relative acceleration of G wrt A

$$\bar{a}_G = \bar{a}_A + \bar{a}_{G/A}$$
$$= \bar{a}_A + \bar{\alpha}_{AB} \times \bar{r}_{G/A} - \omega_{AB}^2 \bar{r}_{G/A}$$
$$= 0 + \left(\alpha_{AB}\hat{k}\right) \times \left(\frac{l}{2}\hat{i} + 0\hat{j}\right) - 0$$

Collecting i and j components

i components $$a_{G_{ABx}} = 0 \tag{7}$$

j components $$a_{G_{ABy}} = \alpha \frac{l}{2} \tag{8}$$

Rod CD

Relative acceleration of G wrt D

$$\bar{a}_G = \bar{a}_D + \bar{a}_{G/D}$$
$$= \bar{a}_D + \bar{\alpha}_D \times \bar{r}_{G/D} - \omega_{CD}^2 \bar{r}_{G/D}$$
$$= 0 + \left(\alpha_{CD}\hat{k}\right) \times \left(-\frac{l}{2}\hat{i} + 0\hat{j}\right) - 0$$

Collecting i and j components

i components $$a_{G_{CDx}} = 0 \tag{9}$$

j components $$a_{G_{CDy}} = -\alpha \frac{l}{2} \tag{10}$$

Relative acceleration of C wrt G

$$\bar{a}_C = \bar{a}_G + \bar{a}_{C/G}$$
$$= \bar{a}_G + \bar{\alpha}_{CD} \times \bar{r}_{C/G} - \omega_{CD}^2 \bar{r}_{C/G}$$
$$= \left(a_{G_{CD_x}}\hat{i} + a_{G_{CD_y}}\hat{j}\right) + \left(\alpha_{CD}\hat{k}\right) \times \left(-\frac{l}{2}\hat{i} + 0\hat{j}\right) - 0$$

Collecting i and j components

i components $$a_{Cx} = a_{G_{CDx}} \tag{11}$$

j components $$a_{C_y} = a_{G_{CDy}} - \alpha_{CD}\frac{l}{2} \tag{12}$$

Need one more equation ...

Relating point B - the acceleration of point B must be the same on both rods

Rod AB

Relative acceleration of B wrt G

$$\begin{aligned}\bar{a}_B &= \bar{a}_G + \bar{a}_{B/G} \\ &= \bar{a}_G + \bar{\alpha}_{AB} \times \bar{r}_{B/G} - \omega_{AB}^2 \bar{r}_{B/G} \\ &= a_{G_{AB\,x}} \hat{i} + a_{G_{AB\,y}} \hat{j} + \left(\alpha_{AB} \hat{k}\right) \times \left(\frac{l}{2} \hat{i} + 0 \hat{j}\right) - 0\end{aligned}$$

Collecting i and j components

i components $$a_{B_x} = a_{G_{AB\,x}} \quad (13)$$

j components $$a_{B_y} = a_{G_{AB\,y}} + \alpha_{AB} \frac{l}{2} \quad (14)$$

Rod CD

Relative acceleration of B wrt G

$$\begin{aligned}\bar{a}_B &= \bar{a}_G + \bar{a}_{B/G} \\ &= \bar{a}_G + \bar{\alpha}_{CD} \times \bar{r}_{B/G} - \omega_{CD}^2 \bar{r}_{B/G} \\ &= \left(a_{G_{CD_x}} \hat{i} + a_{G_{CD_y}} \hat{j}\right) + 0 - 0\end{aligned}$$

Collecting i and j components

i components $$a_{B\,x} = a_{G_{CD\,x}} \quad (15)$$

j components $$a_{B_y} = a_{G_{CD\,y}} \quad (16)$$

Step 6: Solve in Maple