Q_1

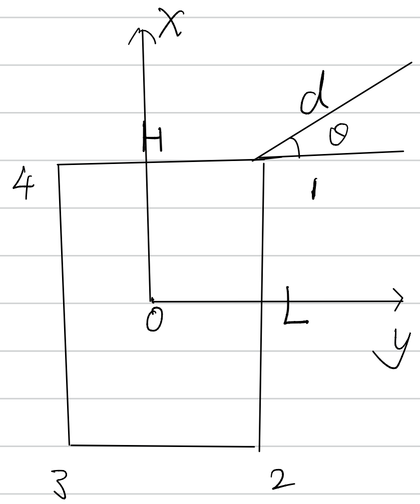
(1) For point O we can get (ignore the couples M_1 M_2 M_3 M_4)

$\Sigma F_z = 0 \Rightarrow F_1 + F_2 + F_3 + F_4 = G$

$\Sigma M_x = 0 \Rightarrow (F_3+F_4)(\frac{H}{2}+d\cos\theta) - (F_1+F_2)(\frac{H}{2}+d\cos\theta) = 0$

$\Sigma M_y = 0 \Rightarrow (F_1+F_4)(\frac{L}{2}+d\sin\theta) - (F_2+F_3)(\frac{L}{2}+d\sin\theta) = 0$

$\Rightarrow F_1 = F_3 = N \quad F_2 = F_4 = \frac{G}{2} - N = 0.02\,kgf - N$ (For all N is OK)



For example you can get $F_1 = F_2 = F_3 = F_4 = 0.01\,kgf$ (

(2). For point O we can get (ignore the grave)

$F_x = 0$

$F_y = 0 \quad \Rightarrow \quad \vec{F} = (0\vec{i} + 0\vec{j} - 0.208\vec{k})\,kgf$

$F_z = F_1 + F_2 + F_3 + F_4 = -0.208\,kgf$

$M_x = (F_3+F_4)(\frac{H}{2}+d\cos\theta) - (F_1+F_2)(\frac{H}{2}+d\cos\theta) = (0.06+0.064-0.04-0.044)\times(150+125\sqrt{3})$
$= (6+5\sqrt{3})\,kgf\cdot mm = 14.66\,kgf\cdot mm$

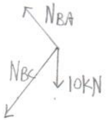
$M_y = (F_1+F_4)(\frac{L}{2}+d\sin\theta) - (F_2+F_3)(\frac{L}{2}+d\sin\theta) = 0$

$M_z = (M_2+M_4) - (M_1+M_3) = (0.11+0.16) - (0.1+0.15) = 0.02\,kgf\cdot mm$

$\Rightarrow \vec{M} = (14.66\vec{i} + 0\vec{j} + 0.02\vec{k})\,kgf\cdot mm$

2. two force bar

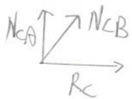
point B



$$\begin{cases} \Sigma F_x = 0 & \frac{0.75}{0.85} N_{BA} + \frac{0.75}{1.25} N_{BC} = 0 \\ \Sigma F_y = 0 & \frac{0.4}{0.85} N_{BA} = 10 + \frac{1}{1.25} N_{BC} \end{cases}$$

$$\begin{cases} N_{BC} = -\frac{125}{14} kN = -8.93 kN & (C) \\ N_{BA} = \frac{85}{14} kN = 6.07 kN & (T) \end{cases}$$

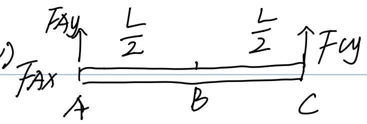
point C



$\Sigma F_y = 0$ $\quad N_{CA} + \frac{1}{1.25} N_{CB} = 0$

$$N_{CA} = \frac{50}{7} kN = 7.14 kN \quad (T)$$

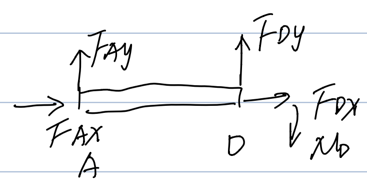
3. (a)



$$\begin{cases} \sum F_x = 0: & F_{Ax} = 0 \\ \sum F_y = 0: & F_{Ay} = -F_{cy} \\ \sum M_{(B)} = 0: & F_{Ay} \cdot \frac{L}{2} + M_0 = F_{cy}\left(\frac{L}{2}\right) \end{cases}$$

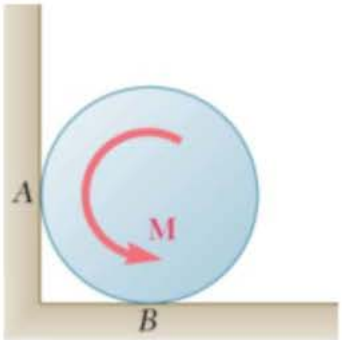
$$\begin{cases} F_{Ax} = 0 \\ F_{Ay} = -\frac{M_0}{L} \\ F_{cy} = \frac{M_0}{L} \end{cases}$$

(b)



$$\begin{cases} \sum F_x = 0: & F_{Ax} = F_{Dx} = 0 \\ \sum F_y = 0: & F_{Dy} = -F_{Ay} = \frac{M_0}{L} \\ \sum M_{(D)} = 0: & M_D + F_{Ay} \cdot \frac{L}{4} = 0 \end{cases}$$

$$\begin{cases} F_{Dx} = 0 \\ F_{Dy} = \frac{M_0}{L} \\ M_D = \frac{M_0}{4} \end{cases}$$

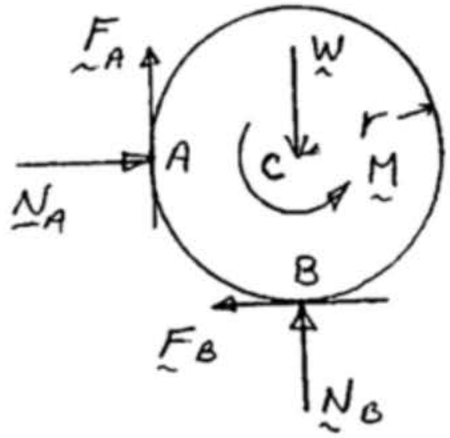


PROBLEM 8.22

The cylinder shown is of weight W and radius r, and the coefficient of static friction μ_s is the same at A and B. Determine the magnitude of the largest couple **M** that can be applied to the cylinder if it is not to rotate.

SOLUTION

FBD cylinder:



For maximum M, motion impends at both A and B

$$F_A = \mu_s N_A$$

$$F_B = \mu_s N_B$$

$$\xrightarrow{} \Sigma F_x = 0: \quad N_A - F_B = 0$$

$$N_A = F_B = \mu_s N_B$$

$$F_A = \mu_s N_A = \mu_s^2 N_B$$

$$\uparrow \Sigma F_y = 0: \quad N_B + F_A - W = 0$$

$$N_B + \mu_s^2 N_B = W$$

or

$$N_B = \frac{W}{1+\mu_s^2}$$

and

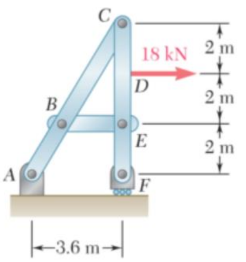
$$F_B = \frac{\mu_s W}{1+\mu_s^2}$$

$$F_A = \frac{\mu_s^2 W}{1+\mu^2}$$

$$\circlearrowleft \Sigma M_C = 0: \quad M - r(F_A + F_B) = 0$$

$$M = r\left(\mu_s + \mu_s^2\right)\frac{W}{1+\mu_s^2}$$

$$M_{\max} = Wr\mu_s \frac{1+\mu_s}{1+\mu_s^2} \blacktriangleleft$$

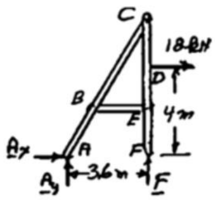


PROBLEM 6.79

For the frame and loading shown, determine the components of all forces acting on member *ABC*.

SOLUTION

<u>Free body: Entire frame:</u>



$\xrightarrow{+} \Sigma F_x = 0\text{:}\quad A_x + 18\text{ kN} = 0$

$A_x = -18\text{ kN} \qquad \mathbf{A}_x = 18.00\text{ kN} \longleftarrow$ ◀

$+\circlearrowleft \Sigma M_E = 0\text{:}\quad -(18\text{ kN})(4\text{ m}) - A_y(3.6\text{ m}) = 0$

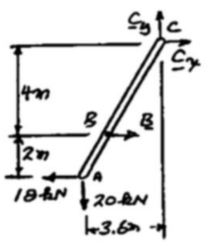
$A_y = -20\text{ kN} \qquad \mathbf{A}_y = 20.0\text{ kN}\downarrow$ ◀

$+\uparrow \Sigma F_y = 0\text{:}\quad -20\text{ kN} + F = 0$

$F = +20\text{ kN} \qquad \mathbf{F} = 20\text{ kN}\uparrow$

<u>Free body: Member *ABC*</u>

Note: *BE* is a two-force member, thus **B** is directed along line *BE*.



$+\circlearrowleft \Sigma M_C = 0\text{:}\quad B(4\text{ m}) - (18\text{ kN})(6\text{ m}) + (20\text{ kN})(3.6\text{ m}) = 0$

$B = 9\text{ kN} \qquad \mathbf{B} = 9.00\text{ kN} \longrightarrow$ ◀

$\xrightarrow{+} \Sigma F_x = 0\text{:}\quad C_x - 18\text{ kN} + 9\text{ kN} = 0$

$C_x = 9\text{ kN} \qquad \mathbf{C}_x = 9.00\text{ kN} \longrightarrow$ ◀

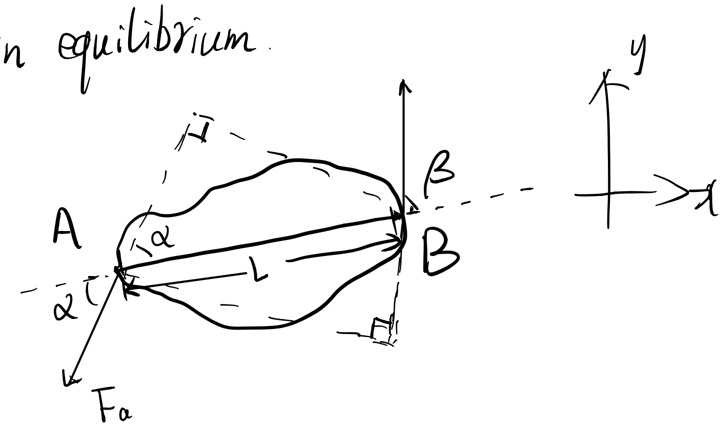
$+\uparrow \Sigma F_y = 0\text{:}\quad C_y - 20\text{ kN} = 0$

$C_y = 20\text{ kN} \qquad \mathbf{C}_y = 20.0\text{ kN}\uparrow$ ◀

Q6. Solution:

(a) $\vec{R} = \dfrac{\sum m_i \vec{r_i}}{\sum m_i}$

(b) for arbitrary two-force member to be in equilibrium.



$\Sigma F_x = 0, \; -F_a \sin\alpha + F_b \cdot \sin\beta = 0.$

$\Sigma F_y = 0, \; -F_a \cos\beta + F_b \cdot \cos\beta = 0.$

$\Sigma M_B = 0, \; F_A \cdot L \cdot \sin\alpha = 0.$

$\Sigma M_A = 0, \; F_B \cdot L \cdot \sin\beta = 0.$

For arbitrary two-force member,

L, F_a, F_b are arbitrary value.

so. $\alpha = \beta = 0.$

$\Rightarrow \Sigma F_y = 0, \; -F_a + F_b = 0.$

$\Rightarrow F_a = F_b.$

Quod Erat Demonstrandum.

or QED.