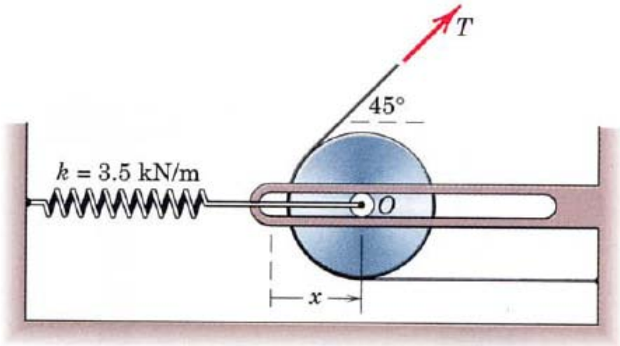
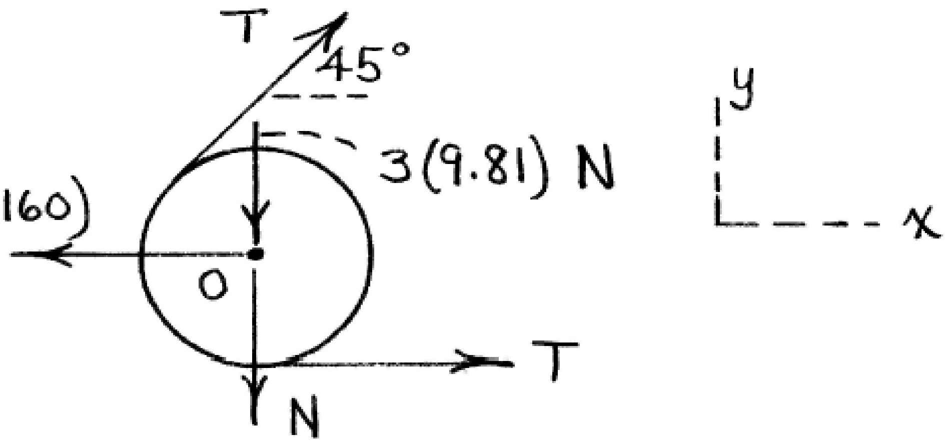
1) The spring of modulus k = 3.5 kN/m is stretched 10 mm when the disk center O is in the left most position x = 0. Determine the tension T required to position the disk center at x = 150 mm. A that position, what force N is exerted on the horizontal slotted guide? The mass of the disk is 3 kg.



Solution

$kx = 3500(0.160)$
$= 560\text{ N}$



$$\Sigma F_x = 0: \quad T(1 + \cos 45^\circ) - 560 = 0$$

$$T = 328 \text{ N}$$

$$\Sigma F_y = 0: \quad 328(\sin 45^\circ) - 3(9.81) - N = 0$$

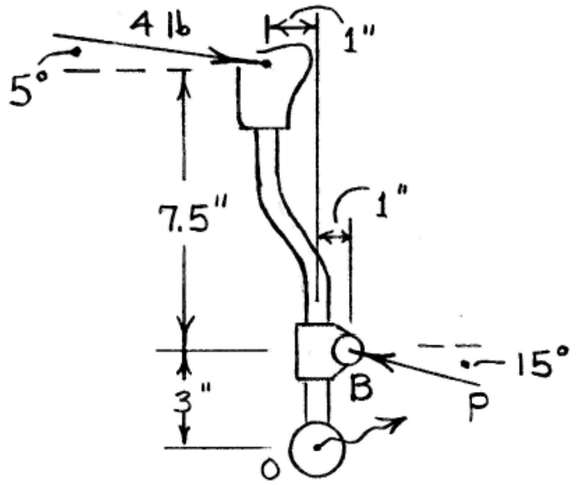
$$N = 203 \text{ N} \quad \text{(down)}$$

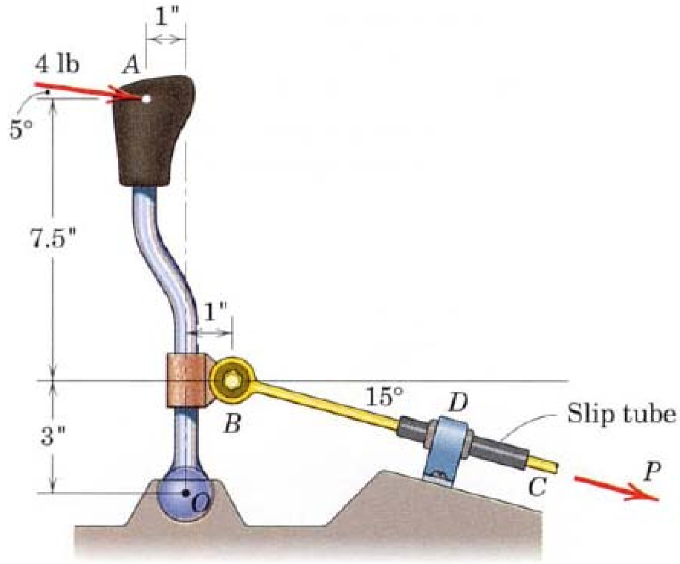
The force on the guide is then

$$N = 203 \text{ N} \quad \text{up}$$

2) A portion of the shifter mechanism for a manual car transmission is shown in the figure. For the 4 Ib force exerted on the shift knob, determine the corresponding force p exerted by the shift link BC on the transmission (not shown). Neglect friction in the ball and socket joint at o, in the joint at B and in the slip tube near support D. note that a soft rubber bushing at D allows the slip tube to self align with link BC.

Solution





$$\circlearrowleft^{+} \sum M_O = 0: \; -4\cos 5^\circ(10.5) + 4\sin 5^\circ(1)$$

$$+ P\cos 15^\circ(3) + P\sin 15^\circ(1) = 0$$

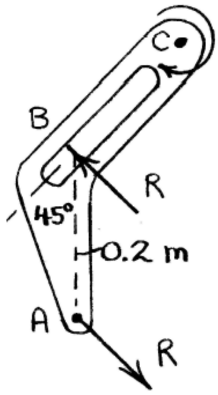
$$P = 13.14 \text{ lb}$$

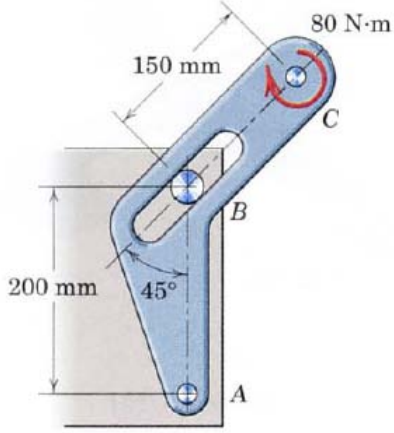
3) The light bracket ABC is freely hinged at A and is constrained by the fixed pin in the smooth slot at B. calculate the magnitude r of the force supported by the pin at A under the action of the 80 N.m applied couple.

Forces at A and B must constitute a couple.

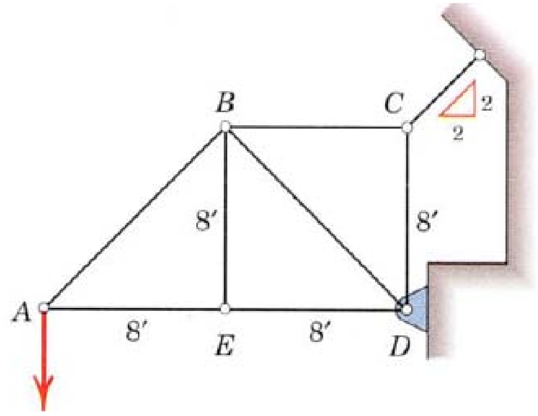
$$\circlearrowright^{+} \sum M = 0: \; 80 - R(0.2\cos 45^\circ) = 0$$

$$R = 566 \text{ N}$$



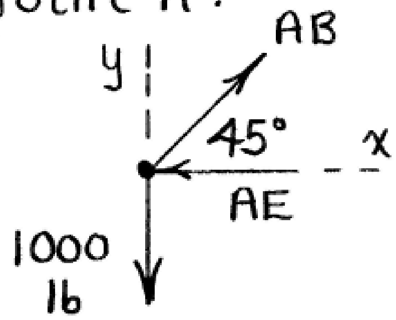


4) Calculate the forces in members BE and BD of the loaded truss.



Solution

Joint A :



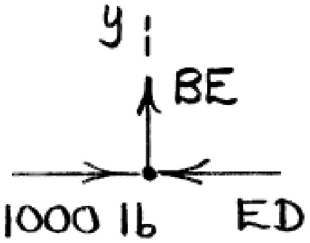
$$\Sigma F_y = 0: \quad AB \sin 45^\circ - 1000 = 0$$

$$AB = 1414 \text{ lb} \quad T$$

$$\Sigma F_x = 0: \quad 1414 \cos 45^\circ - AE = 0$$

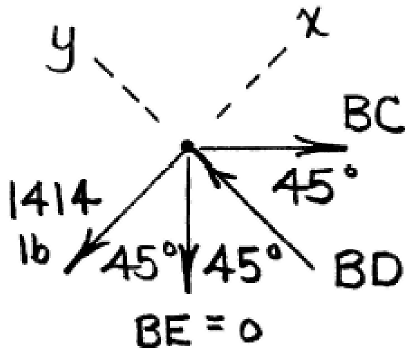
$$AE = 1000 \text{ lb} \quad C$$

Joint E :



$$\Sigma F_y = 0: \quad \underline{BE = 0}$$

Joint B:



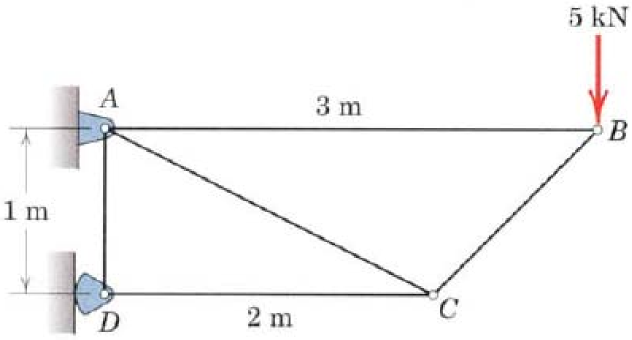
$$\Sigma F_x = 0: \quad BC \cos 45^\circ - 1414 = 0$$

$$BC = 2000 \text{ lb} \quad T$$

$$\Sigma F_y = 0: \quad BD - 2000 \cos 45^\circ = 0$$

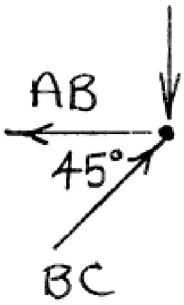
$$\underline{BD = 1414 \text{ lb} \quad C}$$

5) Determine the force in each member of the truss.



Solution

Joint B:

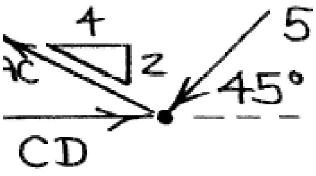


$\Sigma F_y = 0: \; BC\frac{\sqrt{2}}{2} - 5 = 0$

$\underline{BC = 5\sqrt{2} \text{ kN } C}$

$\Sigma F_x = 0: \; -AB + 5\sqrt{2}\frac{\sqrt{2}}{2} = 0, \quad \underline{AB = 5 \text{ kN } T}$

Joint C:



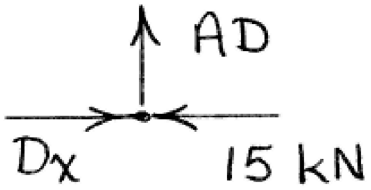
$\Sigma F_y = 0: \; -5\sqrt{2}\frac{\sqrt{2}}{2} + AC\frac{2}{2\sqrt{5}} = 0$

$\underline{AC = 5\sqrt{5} \text{ kN } T}$

$\Sigma F_x = 0: \; CD - 5\sqrt{5}\frac{4}{2\sqrt{5}} - 5\sqrt{2}\frac{\sqrt{2}}{2} = 0$

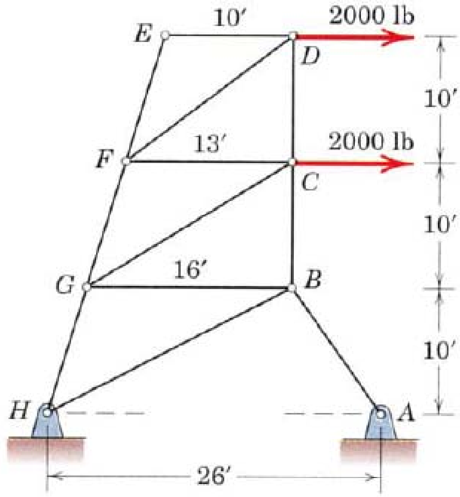
$\underline{CD = 15 \text{ kN } C}$

Joint D:



From $\Sigma F_y = 0$, $\underline{AD = 0}$

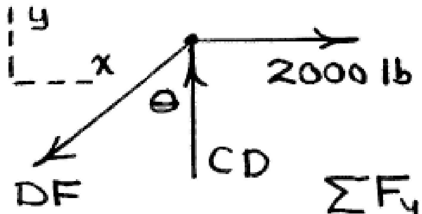
6) Calculate the forces in members CF, CG, and EF of the loaded truss.



Solution

Joint E: $DE = \underline{EF = 0}$

Joint D: $\left(\theta = \tan^{-1}\frac{13}{10} = 52.4°\right)$

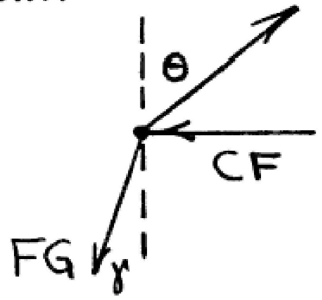


$\Sigma F_x = 0: \; DF \sin\theta - 2000 = 0$

$DF = 2520 \text{ lb } T$

$\Sigma F_y = 0: \; CD - 2520 \cos\theta = 0, \; CD = 1538 \text{ lb}, C$

Joint F: $\left(\gamma = \tan^{-1}\frac{3}{10} = 16.70°\right)$



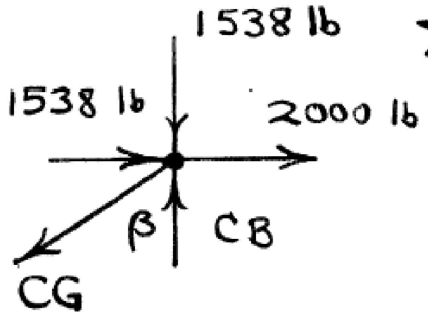
$\Sigma F_y = 0: \; 2520 \cos\theta - FG \cos\gamma = 0$

$FG = 1606 \text{ lb } T$

$\Sigma F_x = 0: \; 2520 \sin\theta - CF - 1606 \sin\gamma = 0$

$\underline{CF = 1538 \text{ lb } C}$

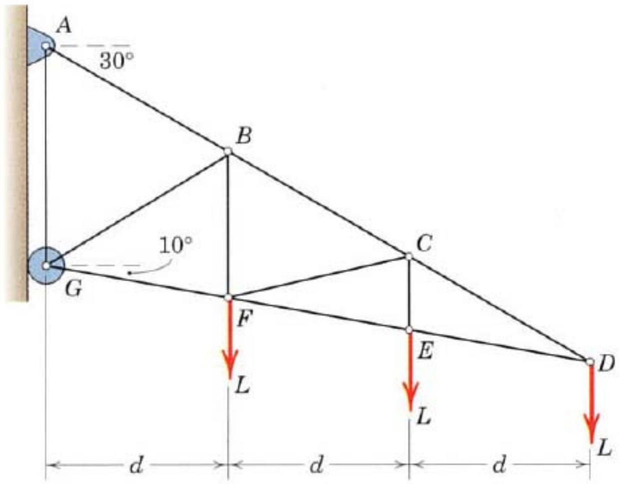
Joint C: $\left(\beta = \tan^{-1}\frac{16}{10} = 58.0°\right)$



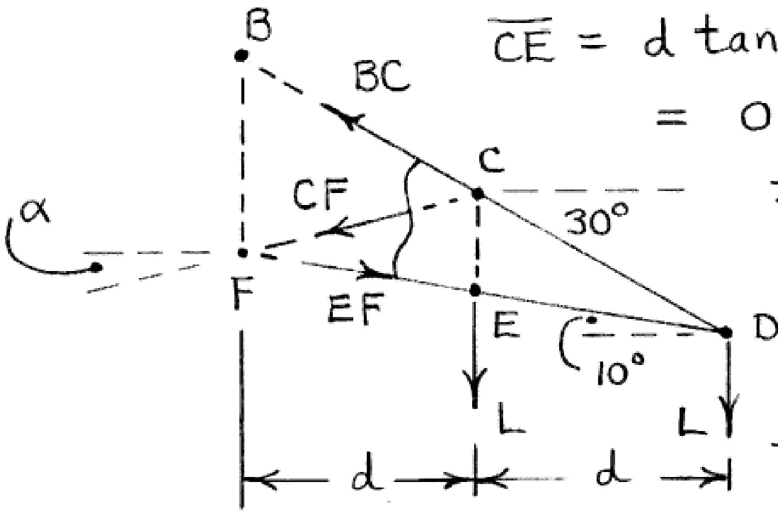
$\Sigma F_x = 0: \; 1538 + 2000 - CG \sin\beta = 0$

$\underline{CG = 4170 \text{ lb } T}$

7) Determine the forces in members BC, CF and EF of the loaded truss.



Solution



$$\overline{CE} = d\tan 30° - d\tan 10° = 0.401d$$

$$\overline{BF} = 2\,\overline{CE} = 0.802d$$

$$\alpha = \tan^{-1}\left(\frac{0.401d - d\tan 10°}{d}\right) = 12.66°$$

$$\curvearrowleft + \sum M_C = 0: \quad -Ld + EF\cos 10°(0.401d) = 0$$

$$\underline{EF = 2.53L \quad C}$$

$$\curvearrowleft + \sum M_F = 0: \quad -Ld - L(2d) + BC\cos 30°(0.802d) = 0$$

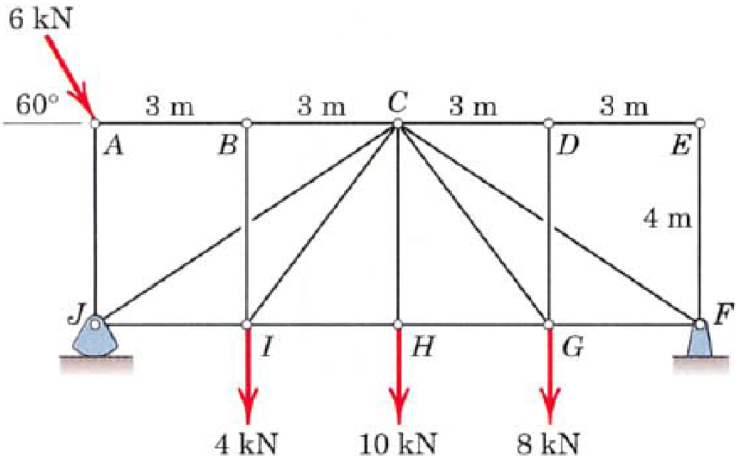
$$\underline{BC = 4.32L \quad T}$$

$$\curvearrowleft + \sum M_D = 0: \quad Ld + CF\cos 12.66°(d\tan 30°)$$

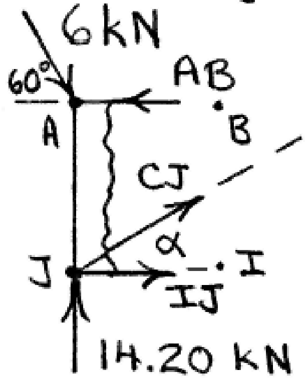
$$+ CF\sin 12.66°(d) = 0 \qquad CF = -1.278L$$

or $\underline{CF = 1.278L \quad C}$

8) The members CJ and CF of the loaded truss cross but are not connected to members BI and DG. Compute the forces in members BC, CJ, CI, and HI.



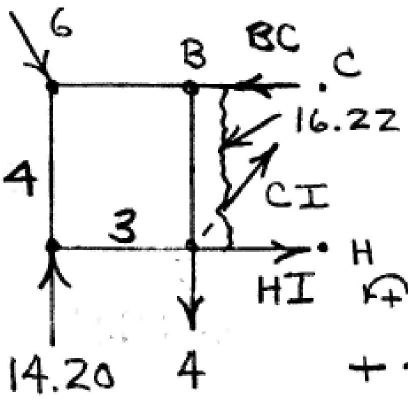
Solution From truss as a whole and $\Sigma M_F = 0$, $J = 14.20$ kN.



$\Sigma F_y = 0: 14.20 - 6 \sin 60° + CJ \sin\alpha = 0$

where $\alpha = \tan^{-1}\left(\frac{4}{6}\right) = 33.7°$

$\therefore$ $CJ = -16.22$ kN C



$\Sigma F_y = 0: -6 \sin 60° + 14.20 - 4$

$-16.22 \sin\alpha + CI \frac{4}{5} = 0$

$CI = 5.00$ kN T

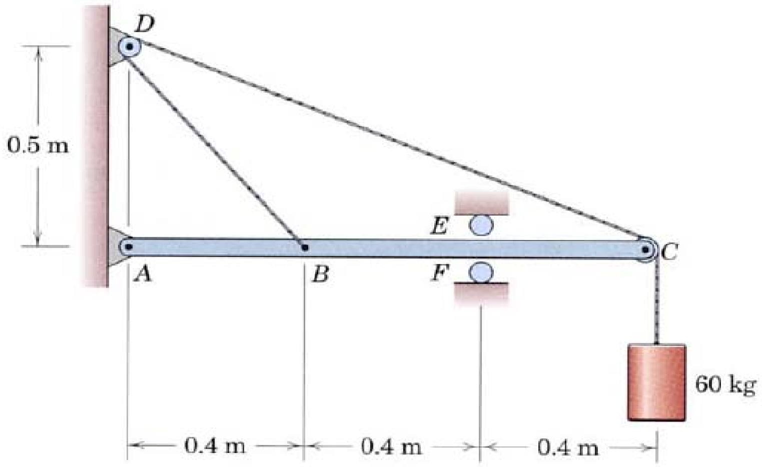
$\Sigma M_C = 0: (6 \sin 60°)\, 6 - (14.20)\, 6$

$+ 4(3) + HI(4) = 0$, $HI = 10.50$ kN T

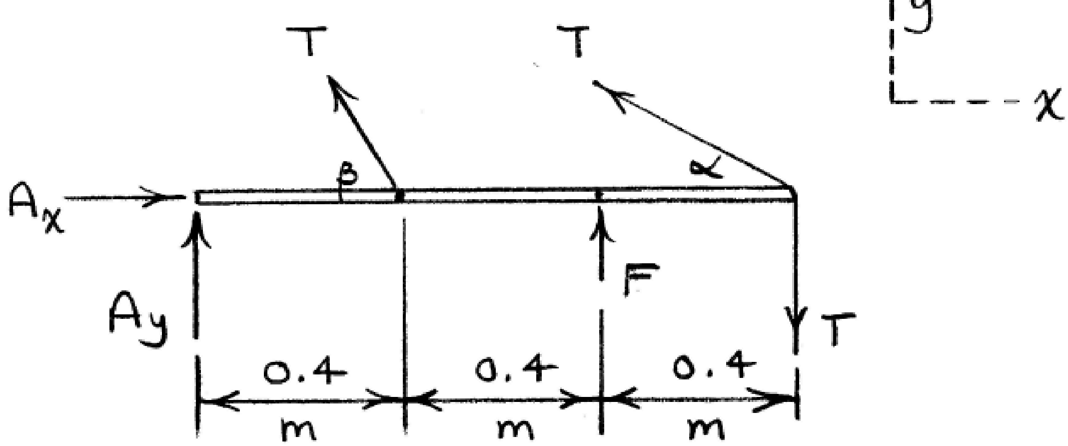
$\Sigma F_x = 0:$ $6 \cos 60° - 16.22 \cos\alpha + 5\left(\frac{3}{5}\right) + 10.5$

$- BC = 0$, $BC = 3.00$ kN C

9) Determine the magnitude of the pin reaction at A and the magnitude and direction of the force reaction at the rollers. The pulleys at C and D are small.



Solution



$$\begin{cases} T = 60(9.81) = 589 \text{ N} \\ \alpha = \tan^{-1}\left(\frac{0.5}{1.2}\right) = 22.6^\circ \\ \beta = \tan^{-1}\left(\frac{0.5}{0.4}\right) = 51.3^\circ \end{cases}$$

$\circlearrowleft + \Sigma M_A = 0: \; T\sin\beta(0.4) + T\sin\alpha(1.2)$

$\quad - T(1.2) + F(0.8) = 0, \quad \underline{F = 314 \text{ N}}$

(Contact at bottom roller)

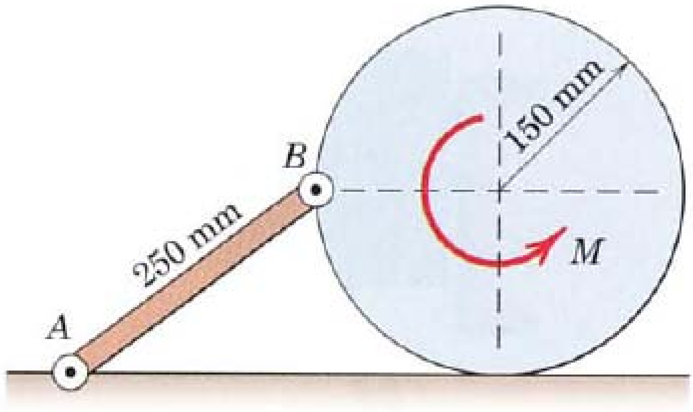
$\Sigma F_x = 0: \; A_x - T\cos\beta - T\cos\alpha = 0, \; A_x = 911 \text{ N}$

$\Sigma F_y = 0: \; A_y + T\sin\beta + T\sin\alpha - T + F = 0$

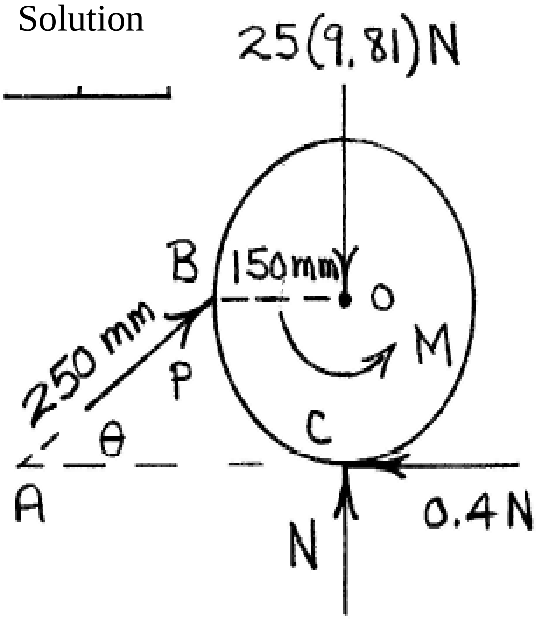
$A_y = -411 \text{ N}$

$A = \sqrt{A_x^2 + A_y^2} = \underline{999 \text{ N}}$

10) The setrut AB of negligible mass is hinged to the horizontal surface at A and to the uniform 25 kg wheel at B. determine the minimum couple M applied to the wheel which will cause it to slip if the coefficient of static friction between the wheel and the surface is 0.4.



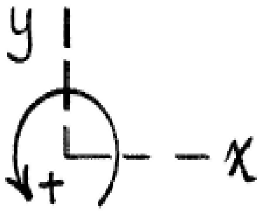
Solution



$$\sin\theta = \frac{150}{250} = 0.6$$

$$\cos\theta = 0.8$$

$$\overline{AC} = 0.8(0.25) + 0.15 = 0.35\,m$$

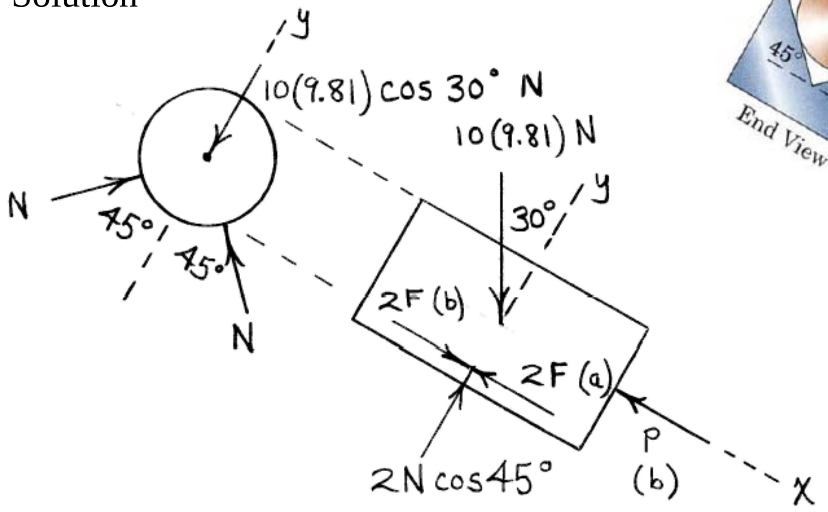


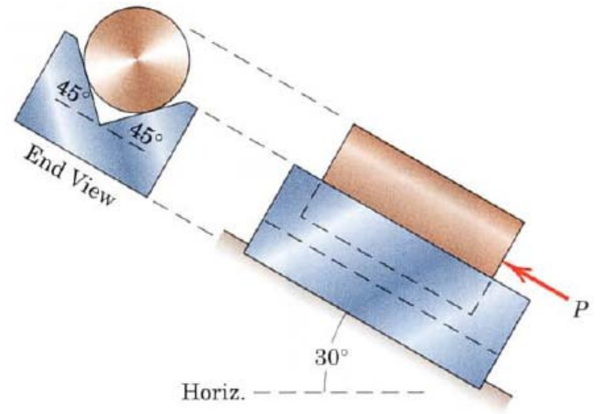
$$\begin{cases} \Sigma F_x = 0: \; 0.8P - 0.4N = 0 \\ \Sigma F_y = 0: \; N + 0.6P - 25(9.81) = 0 \\ \Sigma M_A = 0: \; M + (N - 25(9.81))(0.35) = 0 \end{cases}$$

Solution: $N = 188.7\,N$, $P = 94.3\,N$, $\underline{M = 19.81\ N\cdot m}$

11) The 10 kg solid cylinder is resting in the inclined V-block. If the coefficient of static friction between the cylinder and the block is 0.5, determine (a) the friction force F acting on the cylinder at each side before force P is applied and (b) the value of p required to start sliding the cylinder up the incline.

Solution





$\Sigma F_y = 0: \; 2N\cos 45° - 10(9.81)\cos 30° = 0, \quad N = 60.1 \text{ N}$

(a) $P = 0$

$\Sigma F_x = 0: -2F + 10(9.81)\sin 30° = 0, \quad \underline{F = 24.5 \text{ N}}$

Check: $F_{max} = \mu_s N = 0.5(60.1) = 30.0 \text{ N} > F = 24.5 \text{ N}$

So we indeed have static equilibrium.

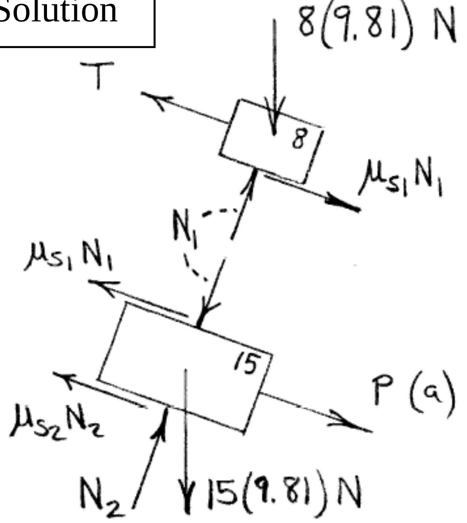
(b) $P \neq 0$

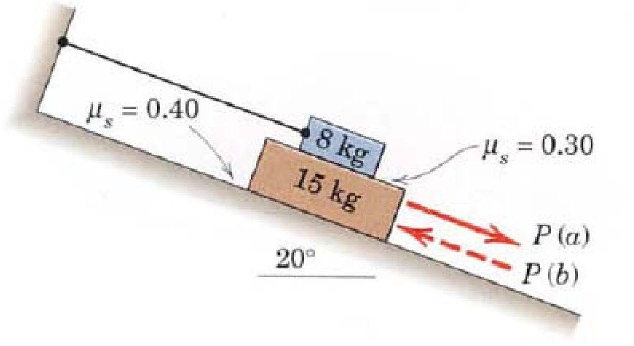
$\Sigma F_x = 0: -P + 10(9.81)\sin 30° + 2(0.5 \cdot 60.1) = 0$

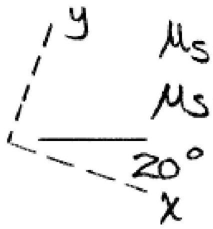
$\underline{P = 109.1 \text{ N}}$

12) The two blocks are placed on the incline with the cable taut. (a) Determine the force P required to initiate motion of the 15 kg block if P is applied down the incline. (b) If P is applied up the incline and slowly increased from zero, determine the value of P which will cause motion and describe that motion.

Solution







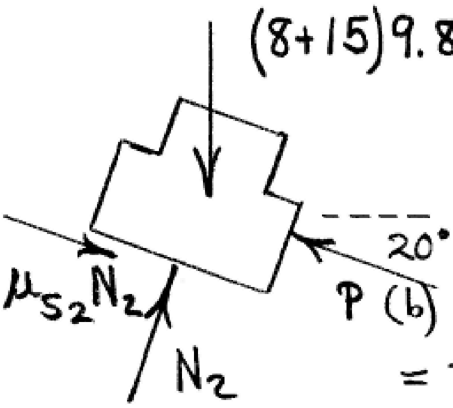
$\mu_{s1} = 0.30$
$\mu_{s2} = 0.40$

(a) $\Sigma F_x = 0$:

$$\left.\begin{aligned} -T + 8(9.81)\sin 20° + \mu_{s1} N_1 &= 0 \\ -\mu_{s1} N_1 - \mu_{s2} N_2 + 15(9.81)\sin 20° + P &= 0 \end{aligned}\right\}$$

Solution: $P = 56.6$ N, $T = 49.0$ N

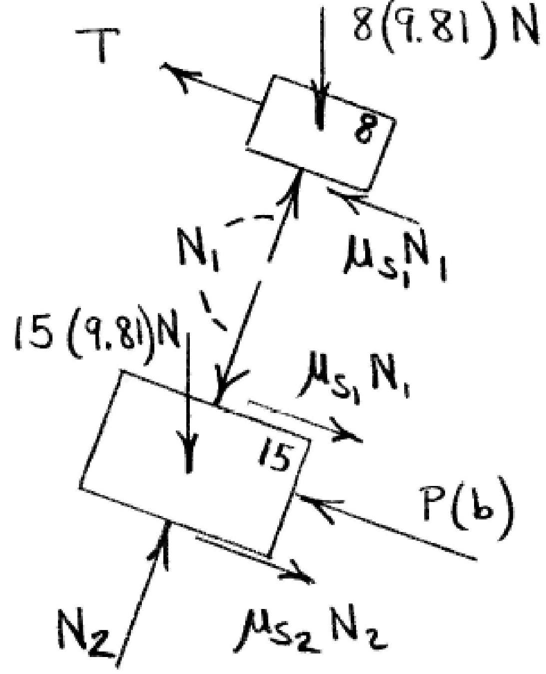
(b) Assume T goes slack and both masses move as one unit.



$\Sigma F_x = 0$: $23(9.81)\sin 20° - P + \mu_s N_2 = 0$, $P = 162.0$ N

(But note that $\theta_{max} = \tan^{-1}\mu_{s1} = \tan^{-1} 0.3 = 16.70°$, so 8-kg block would slip.)

(b), continued. Assume that T does not go slack; 8-kg block remains stationary.



As in (a), all friction forces go to their respective maxima for impending slip.

$\Sigma F_x = 0$:

$$\left.\begin{aligned} -T + 8(9.81)\sin 20^\circ - \mu_{s_1} N_1 &= 0 \\ \mu_{s_1} N_1 + \mu_{s_2} N_2 + 15(9.81)\sin 20^\circ - P &= 0 \end{aligned}\right\}$$

Solution: $\underline{P = 157.3\ \text{N}}$, $T = 4.72\ \text{N}$

The 15-kg block slips up the incline while the 8-kg block remains stationary.