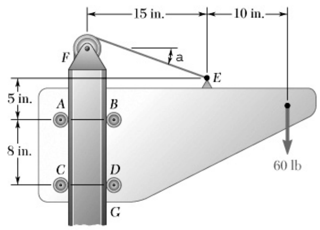
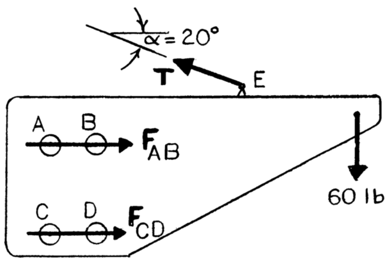


PROBLEM 4.43

A movable bracket is held at rest by a cable attached at E and by frictionless rollers. Knowing that the width of post FG is slightly less than the distance between the rollers, determine the force exerted on the post by each roller when $\alpha = 20^o$.

SOLUTION



f.b.d.

From f.b.d. of bracket

$$+\uparrow \Sigma F_y = 0: \quad T \sin 20° - 60 \text{ lb} = 0$$

$$\therefore \quad T = 175.428 \text{ lb}$$

$$T_x = (175.428 \text{ lb}) \cos 20° = 164.849 \text{ lb}$$

$$T_y = (175.428 \text{ lb}) \sin 20° = 60 \text{ lb}$$

Note: T_y and 60 lb force form a couple of

$$60 \text{ lb}(10 \text{ in.}) = 600 \text{ lb} \cdot \text{in.} \circlearrowleft$$

$$+\circlearrowleft \Sigma M_B = 0: \quad 164.849 \text{ lb}(5 \text{ in.}) - 600 \text{ lb} \cdot \text{in.} + F_{CD}(8 \text{ in.}) = 0$$

$$\therefore \quad F_{CD} = -28.030 \text{ lb}$$

or $$\mathbf{F}_{CD} = 28.0 \text{ lb} \longleftarrow$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad F_{CD} + F_{AB} - T_x = 0$$

$$-28.030 \text{ lb} + F_{AB} - 164.849 \text{ lb} = 0$$

$$\therefore \quad F_{AB} = 192.879 \text{ lb}$$

or $$\mathbf{F}_{AB} = 192.9 \text{ lb} \longrightarrow$$

Rollers A and C can only apply a horizontal force to the right onto the vertical post corresponding to the equal and opposite force to the left on the bracket. Since $\mathbf{F}_{AB}$ is directed to the right onto the bracket, roller B will react $\mathbf{F}_{AB}$. Also, since $\mathbf{F}_{CD}$ is acting to the left on the bracket, it will act to the right on the post at roller C.

PROBLEM 4.43 CONTINUED

$$\therefore \quad \mathbf{A} = \mathbf{D} = 0$$

$$\mathbf{B} = 192.9 \text{ lb} \longrightarrow$$

$$\mathbf{C} = 28.0 \text{ lb} \longleftarrow$$

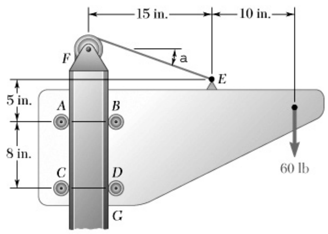
Forces exerted on the post are

$$\mathbf{A} = \mathbf{D} = 0 \blacktriangleleft$$

$$\mathbf{B} = 192.9 \text{ lb} \longleftarrow \blacktriangleleft$$

$$\mathbf{C} = 28.0 \text{ lb} \longrightarrow \blacktriangleleft$$

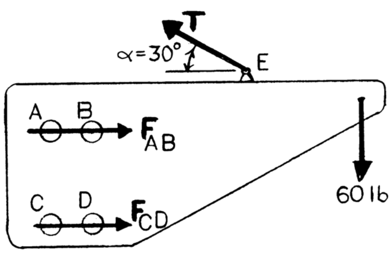
PROBLEM 4.44



Solve Problem 4.43 when $\alpha = 30^{\circ}$.

P4.43 A movable bracket is held at rest by a cable attached at *E* and by frictionless rollers. Knowing that the width of post *FG* is slightly less than the distance between the rollers, determine the force exerted on the post by each roller when $\alpha = 20^{\circ}$.

SOLUTION



f.b.d.

From f.b.d. of bracket

$$+\uparrow \Sigma F_y = 0: \quad T\sin 30^{\circ} - 60 \text{ lb} = 0$$

$$\therefore \quad T = 120 \text{ lb}$$

$$T_x = (120 \text{ lb})\cos 30^{\circ} = 103.923 \text{ lb}$$

$$T_y = (120 \text{ lb})\sin 30^{\circ} = 60 \text{ lb}$$

Note: T_y and 60 lb force form a couple of

$$(60 \text{ lb})(10 \text{ in.}) = 600 \text{ lb}\cdot\text{in.} \circlearrowleft$$

$$+\circlearrowright \Sigma M_B = 0: \quad (103.923 \text{ lb})(5 \text{ in.}) - 600 \text{ lb}\cdot\text{in.} + F_{CD}(8 \text{ in.}) = 0$$

$$\therefore \quad F_{CD} = 10.0481 \text{ lb}$$

or $$\mathbf{F}_{CD} = 10.05 \text{ lb} \longrightarrow$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad F_{CD} + F_{AB} - T_x = 0$$

$$10.0481 \text{ lb} + F_{AB} - 103.923 \text{ lb} = 0$$

$$\therefore \quad F_{AB} = 93.875 \text{ lb}$$

or $$\mathbf{F}_{AB} = 93.9 \text{ lb} \longrightarrow$$

Rollers *A* and *C* can only apply a horizontal force to the right on the vertical post corresponding to the equal and opposite force to the left on the bracket. The opposite direction apply to roller *B* and *D*. Since both $\mathbf{F}_{AB}$ and $\mathbf{F}_{CD}$ act to the right on the bracket, rollers *B* and *D* will react these forces.

$$\therefore \quad \mathbf{A} = \mathbf{C} = 0$$

$$\mathbf{B} = 93.9 \text{ lb} \longrightarrow$$

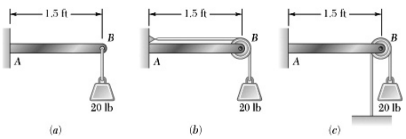
$$\mathbf{D} = 10.05 \text{ lb} \longrightarrow$$

Forces exerted on the post are

$$\mathbf{A} = \mathbf{C} = 0 \blacktriangleleft$$

$$\mathbf{B} = 93.9 \text{ lb} \longleftarrow \blacktriangleleft$$

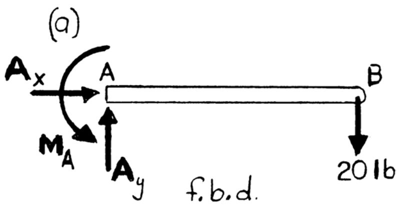
$$\mathbf{D} = 10.05 \text{ lb} \longleftarrow \blacktriangleleft$$



PROBLEM 4.45

A 20-lb weight can be supported in the three different ways shown. Knowing that the pulleys have a 4-in. radius, determine the reaction at *A* in each case.

SOLUTION



(*a*) From f.b.d. of *AB*

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

$$+\uparrow \Sigma F_y = 0: \quad A_y - 20 \text{ lb} = 0$$

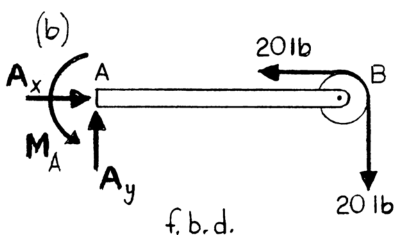
or $$A_y = 20.0 \text{ lb}$$

and $$\mathbf{A} = 20.0 \text{ lb} \uparrow \blacktriangleleft$$

$$+\circlearrowleft \Sigma M_A = 0: \quad M_A - (20 \text{ lb})(1.5 \text{ ft}) = 0$$

$$\therefore M_A = 30.0 \text{ lb}\cdot\text{ft}$$

or $$\mathbf{M}_A = 30.0 \text{ lb}\cdot\text{ft} \circlearrowleft \blacktriangleleft$$



(*b*) Note: $$4 \text{ in.}\left(\frac{1 \text{ ft}}{12 \text{ in.}}\right) = 0.33333 \text{ ft}$$

From f.b.d. of *AB*

$$\xrightarrow{+} \Sigma F_x = 0: \quad A_x - 20 \text{ lb} = 0$$

or $$A_x = 20.0 \text{ lb}$$

$$+\uparrow \Sigma F_y = 0: \quad A_y - 20 \text{ lb} = 0$$

or $$A_y = 20.0 \text{ lb}$$

Then $$A = \sqrt{A_x^2 + A_y^2} = \sqrt{(20.0)^2 + (20.0)^2} = 28.284 \text{ lb}$$

$$\therefore \quad \mathbf{A} = 28.3 \text{ lb} \measuredangle 45° \blacktriangleleft$$

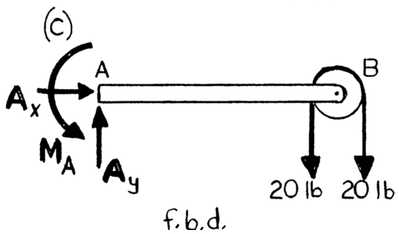
$$+\circlearrowleft \Sigma M_A = 0: \quad M_A + (20 \text{ lb})(0.33333 \text{ ft})$$

$$-(20 \text{ lb})(1.5 \text{ ft} + 0.33333 \text{ ft}) = 0$$

$$\therefore \quad M_A = 30.0 \text{ lb}\cdot\text{ft}$$

or $$\mathbf{M}_A = 30.0 \text{ lb}\cdot\text{ft} \circlearrowleft \blacktriangleleft$$

PROBLEM 4.45 CONTINUED



(*c*) From f.b.d. of *AB*

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

$$+\uparrow \Sigma F_y = 0: \quad A_y - 20 \text{ lb} - 20 \text{ lb} = 0$$

or

$$A_y = 40.0 \text{ lb}$$

and $\mathbf{A} = 40.0 \text{ lb} \uparrow$ ◀

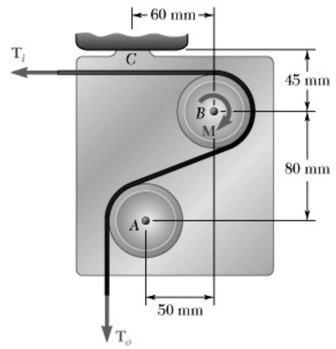
$$+\circlearrowright \Sigma M_A = 0: \quad M_A - (20 \text{ lb})(1.5 \text{ ft} - 0.33333 \text{ ft})$$

$$-(20 \text{ lb})(1.5 \text{ ft} + 0.33333 \text{ ft}) = 0$$

$$\therefore \quad M_A = 60.0 \text{ lb}\cdot\text{ft}$$

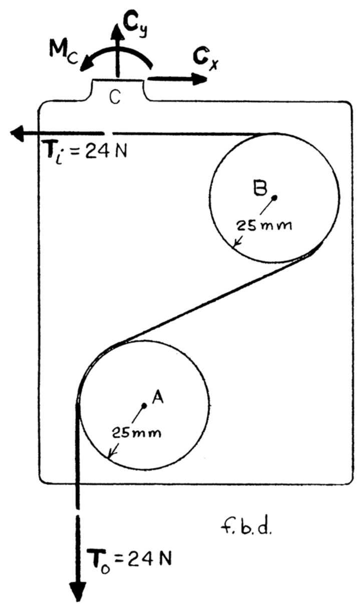
or $\mathbf{M}_A = 60.0 \text{ lb}\cdot\text{ft} \circlearrowright$ ◀

PROBLEM 4.46



A belt passes over two 50-mm-diameter pulleys which are mounted on a bracket as shown. Knowing that $M = 0$ and $T_i = T_O = 24$ N, determine the reaction at C.

SOLUTION



From f.b.d. of bracket

$$\xrightarrow{+} \Sigma F_x = 0: \quad C_x - 24 \text{ N} = 0$$

$$\therefore \; C_x = 24 \text{ N}$$

$$+\uparrow \Sigma F_y = 0: \quad C_y - 24 \text{ N} = 0$$

$$\therefore \; C_y = 24 \text{ N}$$

Then $$C = \sqrt{C_x^2 + C_y^2} = \sqrt{(24)^2 + (24)^2} = 33.941 \text{ N}$$

$$\therefore \; \mathbf{C} = 33.9 \text{ N} \measuredangle 45.0° \blacktriangleleft$$

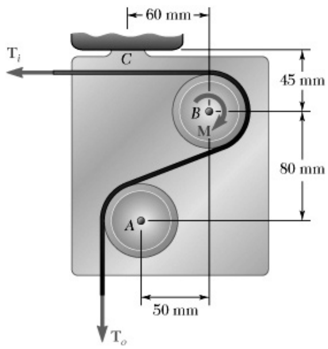
$$+\circlearrowleft \Sigma M_C = 0: \quad M_C - (24 \text{ N})\left[(45 - 25) \text{ mm}\right]$$

$$+ (24 \text{ N})\left[(25 + 50 - 60) \text{ mm}\right] = 0$$

$$\therefore \; M_C = 120 \text{ N}\cdot\text{mm}$$

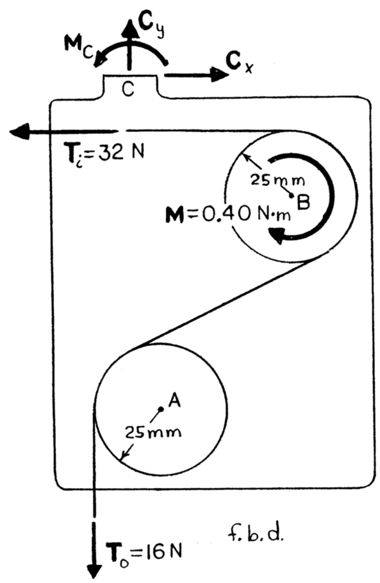
$$\text{or} \;\; \mathbf{M}_C = 0.120 \text{ N}\cdot\text{m} \circlearrowleft \blacktriangleleft$$

PROBLEM 4.47



A belt passes over two 50-mm-diameter pulleys which are mounted on a bracket as shown. Knowing that $M = 0.40$ N·m m and that T_i and T_O are equal to 32 N and 16 N, respectively, determine the reaction at C.

SOLUTION



From f.b.d. of bracket

$$\xrightarrow{+} \Sigma F_x = 0: \quad C_x - 32 \text{ N} = 0$$

$$\therefore \quad C_x = 32 \text{ N}$$

$$+\uparrow \Sigma F_y = 0: \quad C_y - 16 \text{ N} = 0$$

$$\therefore \quad C_y = 16 \text{ N}$$

Then $$C = \sqrt{C_x^2 + C_y^2} = \sqrt{(32)^2 + (16)^2} = 35.777 \text{ N}$$

and $$\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \tan^{-1}\left(\frac{16}{32}\right) = 26.565°$$

or $\mathbf{C} = 35.8$ N $\measuredangle$ 26.6° ◀

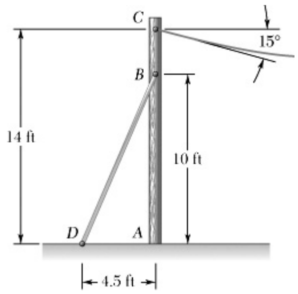
$$+\circlearrowleft \Sigma M_C = 0: \quad M_C - (32 \text{ N})(45 \text{ mm} - 25 \text{ mm})$$

$$+ (16 \text{ N})(25 \text{ mm} + 50 \text{ mm} - 60 \text{ mm}) - 400 \text{ N}\cdot\text{mm} = 0$$

$$\therefore \quad M_C = 800 \text{ N}\cdot\text{mm}$$

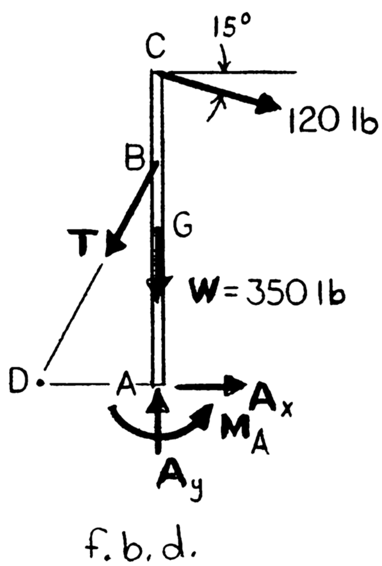
or $\mathbf{M}_C = 0.800$ N·m $\circlearrowleft$ ◀

PROBLEM 4.48



A 350-lb utility pole is used to support at *C* the end of an electric wire. The tension in the wire is 120 lb, and the wire forms an angle of 15° with the horizontal at *C*. Determine the largest and smallest allowable tensions in the guy cable *BD* if the magnitude of the couple at *A* may not exceed 200 lb · ft.

SOLUTION



First note

$$L_{BD} = \sqrt{(4.5)^2 + (10)^2} = 10.9659 \text{ ft}$$

T_{max}: From f.b.d. of utility pole with $\mathbf{M}_A = 200 \text{ lb}\cdot\text{ft}$

$$+\circlearrowleft \Sigma M_A = 0: \quad -200 \text{ lb}\cdot\text{ft} - \left[(120 \text{ lb})\cos 15°\right](14 \text{ ft})$$

$$+\left[\left(\frac{4.5}{10.9659}\right)T_{max}\right](10 \text{ ft}) = 0$$

$$\therefore \quad T_{max} = 444.19 \text{ lb}$$

or $T_{max} = 444 \text{ lb}$ ◀

T_{min}: From f.b.d. of utility pole with $\mathbf{M}_A = 200 \text{ lb}\cdot\text{ft}$

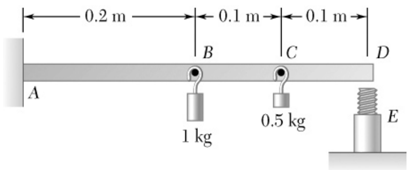
$$+\circlearrowleft \Sigma M_A = 0: \quad 200 \text{ lb}\cdot\text{ft} - \left[(120 \text{ lb})\cos 15°\right](14 \text{ ft})$$

$$+\left[\left(\frac{4.5}{10.9659}\right)T_{min}\right](10 \text{ ft}) = 0$$

$$\therefore \quad T_{min} = 346.71 \text{ lb}$$

or $T_{min} = 347 \text{ lb}$ ◀

PROBLEM 4.49

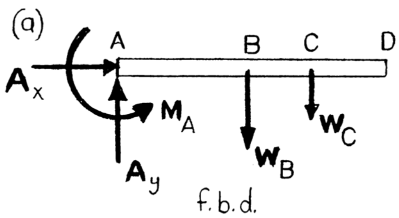


In a laboratory experiment, students hang the masses shown from a beam of negligible mass. (*a*) Determine the reaction at the fixed support *A* knowing that end *D* of the beam does not touch support *E*. (*b*) Determine the reaction at the fixed support *A* knowing that the adjustable support *E* exerts an upward force of 6 N on the beam.

SOLUTION

$$W_B = m_B g = (1\text{ kg})(9.81\text{ m/s}^2) = 9.81\text{ N}$$

$$W_C = m_C g = (0.5\text{ kg})(9.81\text{ m/s}^2) = 4.905\text{ N}$$



(*a*) From f.b.d. of beam *ABCD*

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

$$+\uparrow \Sigma F_y = 0: \quad A_y - W_B - W_C = 0$$

$$A_y - 9.81\text{ N} - 4.905\text{ N} = 0$$

$$\therefore \quad A_y = 14.715\text{ N}$$

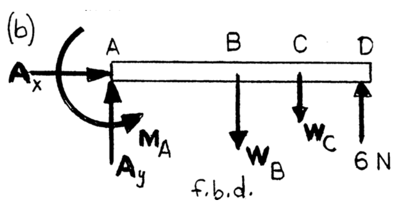
or $\mathbf{A} = 14.72\text{ N} \uparrow$ ◀

$$+\circlearrowleft \Sigma M_A = 0: \quad M_A - W_B(0.2\text{ m}) - W_C(0.3\text{ m}) = 0$$

$$M_A - (9.81\text{ N})(0.2\text{ m}) - (4.905\text{ N})(0.3\text{ m}) = 0$$

$$\therefore \quad M_A = 3.4335\text{ N}\cdot\text{m}$$

or $\mathbf{M}_A = 3.43\text{ N}\cdot\text{m} \circlearrowleft$ ◀



(*b*) From f.b.d. of beam *ABCD*

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

$$+\uparrow \Sigma F_y = 0: \quad A_y - W_B - W_C + 6\text{ N} = 0$$

$$A_y - 9.81\text{ N} - 4.905\text{ N} + 6\text{ N} = 0$$

$$\therefore \quad A_y = 8.715\text{ N}$$

or $\mathbf{A} = 8.72\text{ N} \uparrow$ ◀

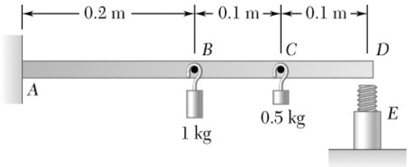
$$+\circlearrowleft \Sigma M_A = 0: \quad M_A - W_B(0.2\text{ m}) - W_C(0.3\text{ m}) + (6\text{ N})(0.4\text{ m}) = 0$$

$$M_A - (9.81\text{ N})(0.2\text{ m}) - (4.905\text{ N})(0.3\text{ m}) + (6\text{ N})(0.4\text{ m}) = 0$$

$$\therefore \quad M_A = 1.03350\text{ N}\cdot\text{m}$$

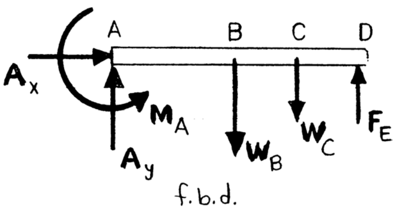
or $\mathbf{M}_A = 1.034\text{ N}\cdot\text{m} \circlearrowleft$ ◀

PROBLEM 4.50



In a laboratory experiment, students hang the masses shown from a beam of negligible mass. Determine the range of values of the force exerted on the beam by the adjustable support E for which the magnitude of the couple at A does not exceed $2.5\ \text{N}\cdot\text{m}$.

SOLUTION



$$W_B = m_B g = 1\ \text{kg}\left(9.81\ \text{m/s}^2\right) = 9.81\ \text{N}$$

$$W_C = m_C g = 0.5\ \text{kg}\left(9.81\ \text{m/s}^2\right) = 4.905\ \text{N}$$

Maximum M_A value is $2.5\ \text{N}\cdot\text{m}$

$F_{\min}$: From f.b.d. of beam $ABCD$ with $\mathbf{M}_A = 2.5\ \text{N}\cdot\text{m}$

$$+\circlearrowleft \Sigma M_A = 0: \quad 2.5\ \text{N}\cdot\text{m} - W_B(0.2\ \text{m}) - W_C(0.3\ \text{m}) + F_{\min}(0.4\ \text{m}) = 0$$

$$2.5\ \text{N}\cdot\text{m} - (9.81\ \text{N})(0.2\ \text{m}) - (4.905\ \text{N})(0.3\ \text{m}) + F_{\min}(0.4\ \text{m}) = 0$$

$$\therefore \quad F_{\min} = 2.3338\ \text{N}$$

or $$F_{\min} = 2.33\ \text{N}$$

$F_{\max}$: From f.b.d. of beam $ABCD$ with $\mathbf{M}_A = 2.5\ \text{N}\cdot\text{m}$

$$+\circlearrowleft \Sigma M_A = 0: \quad -2.5\ \text{N}\cdot\text{m} - W_B(0.2\ \text{m}) - W_C(0.3\ \text{m}) + F_{\max}(0.4\ \text{m}) = 0$$

$$-2.5\ \text{N}\cdot\text{m} - (9.81\ \text{N})(0.2\ \text{m}) - (4.905\ \text{N})(0.3\ \text{m}) + F_{\max}(0.4\ \text{m}) = 0$$

$$\therefore \quad F_{\max} = 14.8338\ \text{N}$$

or $$F_{\max} = 14.83\ \text{N}$$

or $2.33\ \text{N} \le F_E \le 14.83\ \text{N}$ ◀