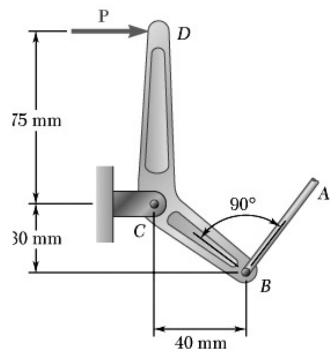
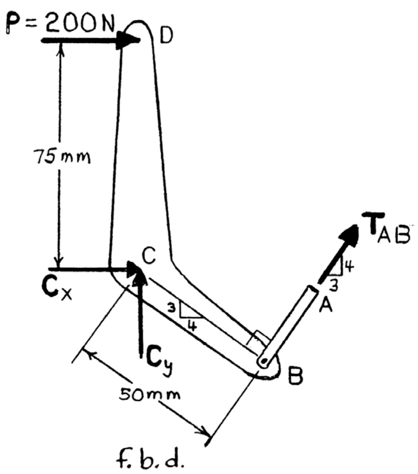
PROBLEM 4.19



The lever *BCD* is hinged at *C* and is attached to a control rod at *B*. If $P = 200$ N, determine (*a*) the tension in rod *AB*, (*b*) the reaction at *C*.

SOLUTION



(*a*) From f.b.d. of lever *BCD*

$$+\circlearrowleft \Sigma M_C = 0: \quad T_{AB}(50 \text{ mm}) - 200 \text{ N}(75 \text{ mm}) = 0$$

$$\therefore T_{AB} = 300 \text{ N} \blacktriangleleft$$

(*b*) From f.b.d. of lever *BCD*

$$\xrightarrow{+} \Sigma F_x = 0: \quad 200 \text{ N} + C_x + 0.6(300 \text{ N}) = 0$$

$$\therefore C_x = -380 \text{ N} \qquad \text{or} \qquad \mathbf{C}_x = 380 \text{ N} \longleftarrow$$

$$+\uparrow \Sigma F_y = 0: \quad C_y + 0.8(300 \text{ N}) = 0$$

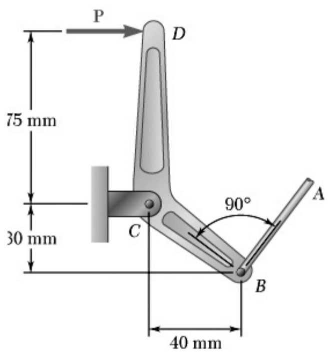
$$\therefore C_y = -240 \text{ N} \qquad \text{or} \qquad \mathbf{C}_y = 240 \text{ N} \downarrow$$

Then $\qquad C = \sqrt{C_x^2 + C_y^2} = \sqrt{(380)^2 + (240)^2} = 449.44 \text{ N}$

and $\qquad \theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \tan^{-1}\left(\frac{-240}{-380}\right) = 32.276°$

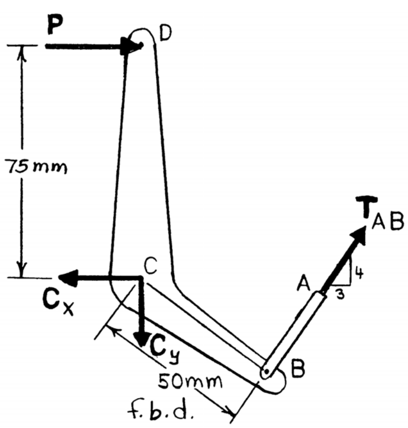
$$\text{or } \mathbf{C} = 449 \text{ N} \measuredangle 32.3° \blacktriangleleft$$

PROBLEM 4.20



The lever *BCD* is hinged at *C* and is attached to a control rod at *B*. Determine the maximum force **P** which can be safely applied at *D* if the maximum allowable value of the reaction at *C* is 500 N.

SOLUTION



From f.b.d. of lever *BCD*

$$+\circlearrowleft \Sigma M_C = 0: \quad T_{AB}(50 \text{ mm}) - P(75 \text{ mm}) = 0$$

$$\therefore T_{AB} = 1.5P \qquad (1)$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad 0.6T_{AB} + P - C_x = 0$$

$$\therefore C_x = P + 0.6T_{AB} \qquad (2)$$

From Equation (1) $\quad C_x = P + 0.6(1.5P) = 1.9P$

$$+\uparrow \Sigma F_y = 0: \quad 0.8T_{AB} - C_y = 0$$

$$\therefore C_y = 0.8T_{AB} \qquad (3)$$

From Equation (1) $\quad C_y = 0.8(1.5P) = 1.2P$

From Equations (2) and (3)

$$C = \sqrt{C_x^2 + C_y^2} = \sqrt{(1.9P)^2 + (1.2P)^2} = 2.2472P$$

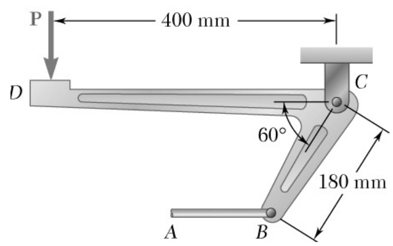
Since $C_{\max} = 500$ N,

$$\therefore 500 \text{ N} = 2.2472P_{\max}$$

or $\quad P_{\max} = 222.49$ lb

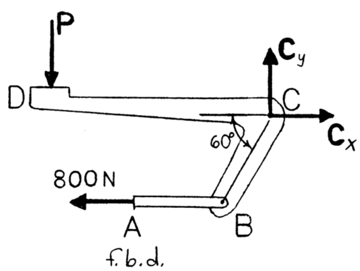
or $\mathbf{P} = 222 \text{ lb} \longrightarrow$ ◀

PROBLEM 4.21



The required tension in cable *AB* is 800 N. Determine (*a*) the vertical force **P** which must be applied to the pedal, (*b*) the corresponding reaction at *C*.

SOLUTION



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

$$+\circlearrowleft \Sigma M_C = 0: \quad P(0.4\text{ m}) - (800\text{ N})\left[(0.18\text{ m})\sin 60°\right] = 0$$

$$\therefore \quad P = 311.77\text{ N}$$

or $\mathbf{P} = 312\text{ N} \downarrow$ ◀

(*b*) From f.b.d. of pedal

$$\xrightarrow{+} \Sigma F_x = 0: \quad C_x - 800\text{ N} = 0$$

$$\therefore \quad C_x = 800\text{ N}$$

or $\mathbf{C}_x = 800\text{ N} \longrightarrow$

$$+\uparrow \Sigma F_y = 0: \quad C_y - 311.77\text{ N} = 0$$

$$\therefore \quad C_y = 311.77\text{ N}$$

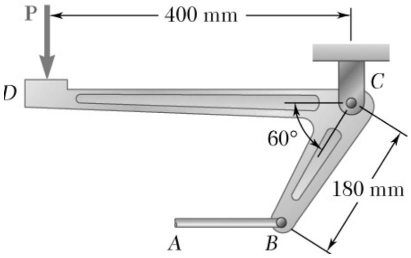
or $\mathbf{C}_y = 311.77\text{ N} \uparrow$

Then $C = \sqrt{C_x^2 + C_y^2} = \sqrt{(800)^2 + (311.77)^2} = 858.60\text{ N}$

and $\theta = \tan^{-1}\left(\dfrac{C_y}{C_x}\right) = \tan^{-1}\left(\dfrac{311.77}{800}\right) = 21.291°$

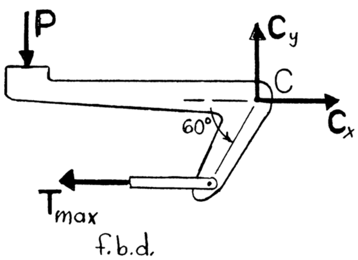
or $\mathbf{C} = 859\text{ N} \measuredangle 21.3°$ ◀

PROBLEM 4.22



Determine the maximum tension which can be developed in cable *AB* if the maximum allowable value of the reaction at *C* is 1000 N.

SOLUTION



Have $$C_{max} = 1000 \text{ N}$$

Now $$C^2 = C_x^2 + C_y^2$$

$$\therefore \quad C_y = \sqrt{(1000)^2 - C_x^2} \tag{1}$$

From f.b.d. of pedal

$$\xrightarrow{+} \Sigma F_x = 0: \quad C_x - T_{max} = 0$$

$$\therefore \quad C_x = T_{max} \tag{2}$$

$$+\circlearrowleft \Sigma M_D = 0: \quad C_y(0.4 \text{ m}) - T_{max}\left[(0.18 \text{ m})\sin 60°\right] = 0$$

$$\therefore \quad C_y = 0.389711T_{max} \tag{3}$$

Equating the expressions for C_y in Equations (1) and (3), with $C_x = T_{max}$ from Equation (2)

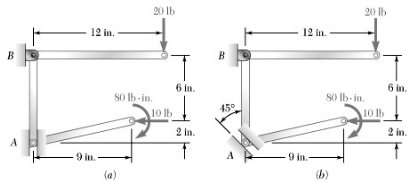
$$\sqrt{(1000)^2 - T_{max}^2} = 0.389711T_{max}$$

$$\therefore \quad T_{max}^2 = 868,150$$

and $$T_{max} = 931.75 \text{ N}$$

or $T_{max} = 932$ N ◀

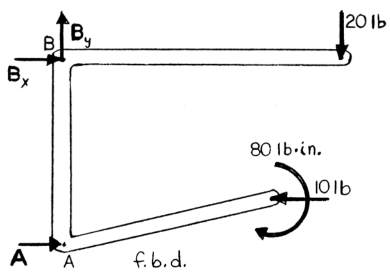
PROBLEM 4.23



A steel rod is bent to form a mounting bracket. For each of the mounting brackets and loadings shown, determine the reactions at *A* and *B*.

SOLUTION

(*a*)



(*a*) From f.b.d. of mounting bracket

$$+\circlearrowleft \Sigma M_E = 0: \quad A(8 \text{ in.}) - 80 \text{ lb}\cdot\text{in.} - (10 \text{ lb})(6 \text{ in.})$$

$$-(20 \text{ lb})(12 \text{ in.}) = 0$$

$$\therefore \quad A = 47.5 \text{ lb}$$

or $\mathbf{A} = 47.5 \text{ lb} \longrightarrow$ ◀

$$\xrightarrow{+} \Sigma F_x = 0: \quad B_x - 10 \text{ lb} + 47.5 \text{ lb} = 0$$

$$\therefore \quad B_x = -37.5 \text{ lb}$$

or $\mathbf{B}_x = 37.5 \text{ lb} \longleftarrow$

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

$$\therefore \quad B_y = 20 \text{ lb}$$

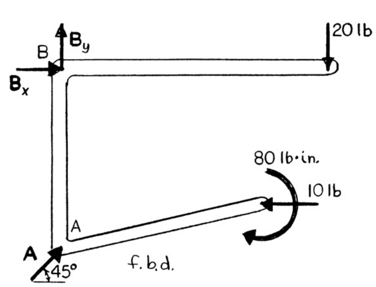
or $\mathbf{B}_y = 20.0 \text{ lb} \uparrow$

Then $B = \sqrt{B_x^2 + B_y^2} = \sqrt{(37.5)^2 + (20.0)^2} = 42.5 \text{ lb}$

and $\theta = \tan^{-1}\left(\dfrac{B_y}{B_x}\right) = \tan^{-1}\left(\dfrac{20}{-37.5}\right) = -28.072°$

or $\mathbf{B} = 42.5 \text{ lb} \searrow 28.1°$ ◀

(*b*)



(*b*) From f.b.d. of mounting bracket

$$+\circlearrowleft \Sigma M_B = 0: \quad (A\cos 45°)(8 \text{ in.}) - 80 \text{ lb}\cdot\text{in.}$$

$$-(10 \text{ lb})(6 \text{ in.}) - (20 \text{ lb})(12 \text{ in.}) = 0$$

$$\therefore \quad A = 67.175 \text{ lb}$$

or $\mathbf{A} = 67.2 \text{ lb} \measuredangle 45°$ ◀

$$\xrightarrow{+} \Sigma F_x = 0: \quad B_x - 10 \text{ lb} + 67.175\cos 45° = 0$$

$$\therefore \quad B_x = -37.500 \text{ lb}$$

or $\mathbf{B}_x = 37.5 \text{ lb} \longleftarrow$

PROBLEM 4.23 CONTINUED

$$+\uparrow \Sigma F_y = 0: \quad B_y - 20 \text{ lb} + 67.175 \sin 45° = 0$$

$$\therefore \quad B_y = -27.500 \text{ lb}$$

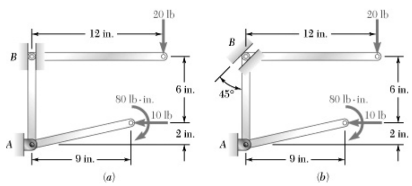
or $$\mathbf{B}_y = 27.5 \text{ lb} \downarrow$$

Then $$B = \sqrt{B_x^2 + B_y^2} = \sqrt{(37.5)^2 + (27.5)^2} = 46.503 \text{ lb}$$

and $$\theta = \tan^{-1}\left(\frac{B_y}{B_x}\right) = \tan^{-1}\left(\frac{-27.5}{-37.5}\right) = 36.254°$$

or $\mathbf{B} = 46.5 \text{ lb} \measuredangle\, 36.3°$ ◀

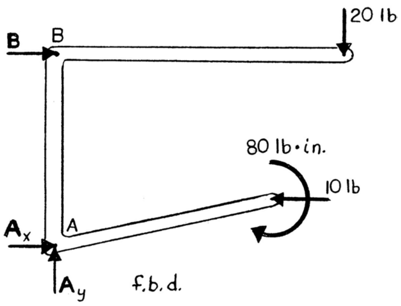
PROBLEM 4.24



A steel rod is bent to form a mounting bracket. For each of the mounting brackets and loadings shown, determine the reactions at A and B.

SOLUTION

(*a*)



(*a*) From f.b.d. of mounting bracket

$$+\circlearrowleft \Sigma M_A = 0: \quad -B(8 \text{ in.}) - (20 \text{ lb})(12 \text{ in.})$$

$$+(10 \text{ lb})(2 \text{ in.}) - 80 \text{ lb}\cdot\text{in.} = 0$$

$$\therefore \quad B = -37.5 \text{ lb}$$

or $\mathbf{B} = 37.5 \text{ lb} \longleftarrow$ ◀

$$\xrightarrow{+} \Sigma F_x = 0: \quad -37.5 \text{ lb} - 10 \text{ lb} + A_x = 0$$

$$\therefore \quad A_x = 47.5 \text{ lb}$$

or $\mathbf{A}_x = 47.5 \text{ lb} \longrightarrow$

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

$$\therefore \quad A_y = 20 \text{ lb}$$

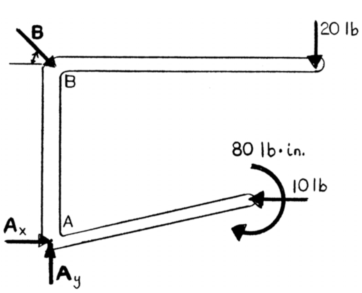
or $\mathbf{A}_y = 20.0 \text{ lb} \uparrow$

Then $A = \sqrt{A_x^2 + A_y^2} = \sqrt{(47.5)^2 + (20)^2} = 51.539 \text{ lb}$

and $\theta = \tan^{-1}\left(\dfrac{A_y}{A_x}\right) = \tan^{-1}\left(\dfrac{20}{47.5}\right) = 22.834°$

or $\mathbf{A} = 51.5 \text{ lb} \measuredangle 22.8°$ ◀

(*b*)



(*b*) From f.b.d. of mounting bracket

$$+\circlearrowleft \Sigma M_A = 0: \quad -(B\cos 45°)(8 \text{ in.}) - (20 \text{ lb})(2 \text{ in.})$$

$$-80 \text{ lb}\cdot\text{in.} + (10 \text{ lb})(2 \text{ in.}) = 0$$

$$\therefore \quad B = -53.033 \text{ lb}$$

or $\mathbf{B} = 53.0 \text{ lb} \searrow 45°$ ◀

$$\xrightarrow{+} \Sigma F_x = 0: \quad A_x + (-53.033 \text{ lb})\cos 45° - 10 = 0$$

$$\therefore \quad A_x = 47.500 \text{ lb}$$

or $\mathbf{A}_x = 47.5 \text{ lb} \longrightarrow$

PROBLEM 4.24 CONTINUED

$$+\uparrow \Sigma F_y = 0: \quad A_y - (53.033 \text{ lb})\sin 45° - 20 = 0$$

$$\therefore \quad A_y = -17.500 \text{ lb}$$

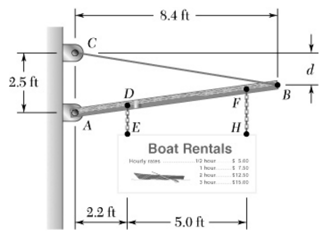
or $$\mathbf{A}_y = 17.50 \text{ lb} \downarrow$$

Then $$A = \sqrt{A_x^2 + A_y^2} = \sqrt{(47.5)^2 + (17.5)^2} = 50.621 \text{ lb}$$

and $$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right) = \tan^{-1}\left(\frac{-17.5}{47.5}\right) = -20.225°$$

or $\mathbf{A} = 50.6 \text{ lb} \searrow 20.2° \blacktriangleleft$

PROBLEM 4.25

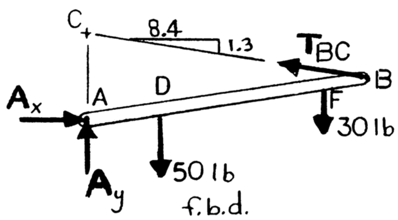


A sign is hung by two chains from mast *AB*. The mast is hinged at *A* and is supported by cable *BC*. Knowing that the tensions in chains *DE* and *FH* are 50 lb and 30 lb, respectively, and that $d = 1.3$ ft, determine (*a*) the tension in cable *BC*, (*b*) the reaction at *A*.

SOLUTION

First note $$\overline{BC} = \sqrt{(8.4)^2 + (1.3)^2} = 8.5 \text{ ft}$$

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



$$+\circlearrowleft \Sigma M_A = 0: \quad \left[\left(\frac{8.4}{8.5}\right)T_{BC}\right](2.5 \text{ ft}) - (30 \text{ lb})(7.2 \text{ ft})$$

$$-50 \text{ lb}(2.2 \text{ ft}) = 0$$

$$\therefore \quad T_{BC} = 131.952 \text{ lb}$$

$$\text{or } T_{BC} = 132.0 \text{ lb} \blacktriangleleft$$

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

$$\xrightarrow{+} \Sigma F_x = 0: \quad A_x - \left(\frac{8.4}{8.5}\right)(131.952 \text{ lb}) = 0$$

$$\therefore \quad A_x = 130.400 \text{ lb}$$

or $$\mathbf{A}_x = 130.4 \text{ lb} \longrightarrow$$

$$+\uparrow \Sigma F_y = 0: \quad A_y + \left(\frac{1.3}{8.5}\right)(131.952 \text{ lb}) - 30 \text{ lb} - 50 \text{ lb} = 0$$

$$\therefore \quad A_y = 59.819 \text{ lb}$$

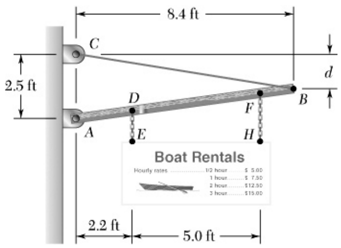
or $$\mathbf{A}_y = 59.819 \text{ lb} \uparrow$$

Then $$A = \sqrt{A_x^2 + A_y^2} = \sqrt{(130.4)^2 + (59.819)^2} = 143.466 \text{ lb}$$

and $$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right) = \tan^{-1}\left(\frac{59.819}{130.4}\right) = 24.643°$$

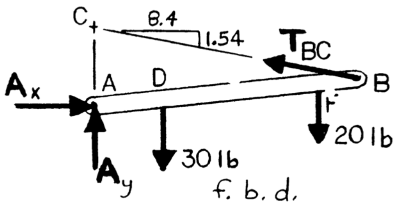
$$\text{or } \mathbf{A} = 143.5 \text{ lb} \measuredangle 24.6° \blacktriangleleft$$

PROBLEM 4.26



A sign is hung by two chains from mast AB. The mast is hinged at A and is supported by cable BC. Knowing that the tensions in chains DE and FH are 30 lb and 20 lb, respectively, and that $d = 1.54$ ft, determine (a) the tension in cable BC, (b) the reaction at A.

SOLUTION



First note $\overline{BC} = \sqrt{(8.4)^2 + (1.54)^2} = 8.54$ ft

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

$$+\circlearrowleft \Sigma M_A = 0: \quad \left[\left(\frac{8.4}{8.54}\right)T_{BC}\right](2.5 \text{ ft}) - 20 \text{ lb}(7.2 \text{ ft})$$

$$- 30 \text{ lb}(2.2 \text{ ft}) = 0$$

$$\therefore \quad T_{BC} = 85.401 \text{ lb}$$

or $T_{BC} = 85.4$ lb ◀

(b) From f.b.d. of mast AB

$$\xrightarrow{+} \Sigma F_x = 0: \quad A_x - \left(\frac{8.4}{8.54}\right)(85.401 \text{ lb}) = 0$$

$$\therefore \quad A_x = 84.001 \text{ lb}$$

or $\mathbf{A}_x = 84.001 \text{ lb} \longrightarrow$

$$+\uparrow \Sigma F_y = 0: \quad A_y + \left(\frac{1.54}{8.54}\right)(85.401 \text{ lb}) - 20 \text{ lb} - 30 \text{ lb} = 0$$

$$\therefore \quad A_y = 34.600 \text{ lb}$$

or $\mathbf{A}_y = 34.600 \text{ lb} \uparrow$

Then $A = \sqrt{A_x^2 + A_y^2} = \sqrt{(84.001)^2 + (34.600)^2} = 90.848$ lb

and $\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right) = \tan^{-1}\left(\frac{34.6}{84.001}\right) = 22.387°$

or $\mathbf{A} = 90.8$ lb $\measuredangle$ 22.4° ◀