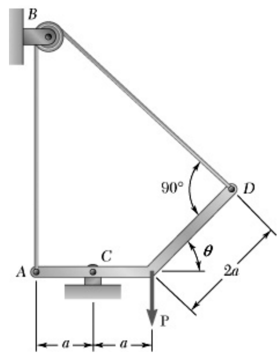
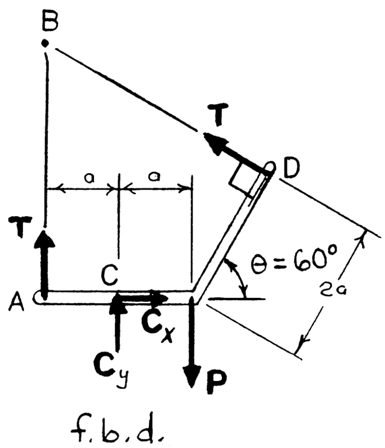
PROBLEM 4.35



Neglecting friction, determine the tension in cable *ABD* and the reaction at *C* when $\theta = 60°$.

SOLUTION



From f.b.d. of bent *ACD*

$$+\circlearrowleft \Sigma M_C = 0: \quad (T\cos 30°)(2a\sin 60°) + (T\sin 30°)(a + 2a\cos 60°)$$

$$-T(a) - P(a) = 0$$

$$\therefore \quad T = \frac{P}{1.5}$$

$$\text{or } T = \frac{2P}{3} \blacktriangleleft$$

$$\xrightarrow{+} \Sigma F_x = 0: \quad C_x - \left(\frac{2P}{3}\right)\cos 30° = 0$$

$$\therefore \quad C_x = \frac{\sqrt{3}}{3}P = 0.57735P$$

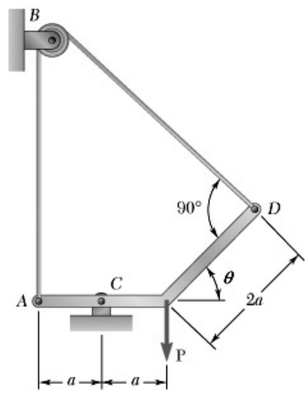
or $\mathbf{C}_x = 0.577P \longrightarrow$

$$+\uparrow \Sigma F_y = 0: \quad C_y + \frac{2}{3}P - P + \left(\frac{2P}{3}\right)\cos 60° = 0$$

$$\therefore \quad C_y = 0$$

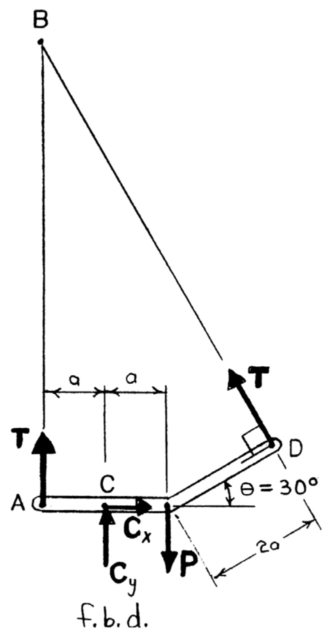
$$\text{or } \mathbf{C} = 0.577P \longrightarrow \blacktriangleleft$$

PROBLEM 4.36



Neglecting friction, determine the tension in cable *ABD* and the reaction at *C* when $\theta = 30^{\circ}$.

SOLUTION



From f.b.d. of bent *ACD*

$$+\circlearrowleft \Sigma M_C = 0: \quad (T\cos 60^{\circ})(2a\sin 30^{\circ}) + T\sin 60^{\circ}(a + 2a\cos 30^{\circ})$$

$$-P(a) - T(a) = 0$$

$$\therefore \quad T = \frac{P}{1.86603} = 0.53590P$$

or $T = 0.536P$ ◀

$$\xrightarrow{+} \Sigma F_x = 0: \quad C_x - (0.53590P)\cos 60^{\circ} = 0$$

$$\therefore \quad C_x = 0.26795P$$

or $\mathbf{C}_x = 0.268P \longrightarrow$

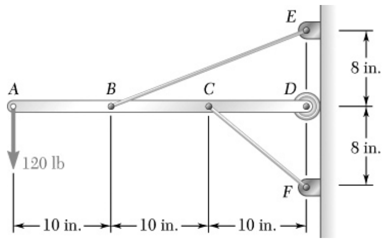
$$+\uparrow \Sigma F_y = 0: \quad C_y + 0.53590P - P + (0.53590P)\sin 60^{\circ} = 0$$

$$\therefore \quad C_y = 0$$

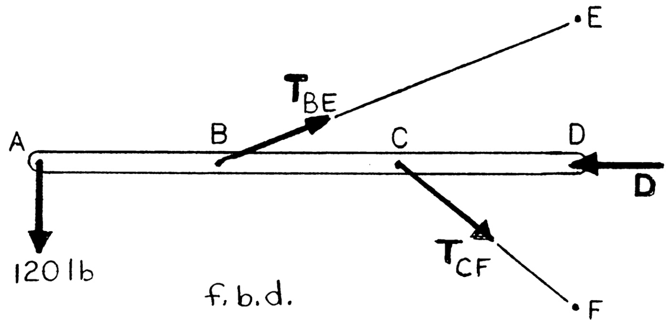
or $\mathbf{C} = 0.268P \longrightarrow$ ◀

PROBLEM 4.37

Determine the tension in each cable and the reaction at D.



SOLUTION



First note

$$\overline{BE} = \sqrt{(20)^2 + (8)^2} \text{ in.} = 21.541 \text{ in.}$$

$$\overline{CF} = \sqrt{(10)^2 + (8)^2} \text{ in.} = 12.8062 \text{ in.}$$

From f.b.d. of member *ABCD*

$$+\circlearrowleft \Sigma M_C = 0: \quad (120 \text{ lb})(20 \text{ in.}) - \left[\left(\frac{8}{21.541}\right)T_{BE}\right](10 \text{ in.}) = 0$$

$$\therefore \quad T_{BE} = 646.24 \text{ lb}$$

or $T_{BE} = 646 \text{ lb}$ ◀

$$+\uparrow \Sigma F_y = 0: \quad -120 \text{ lb} + \left(\frac{8}{21.541}\right)(646.24 \text{ lb}) - \left(\frac{8}{12.8062}\right)T_{CF} = 0$$

$$\therefore \quad T_{CF} = 192.099 \text{ lb}$$

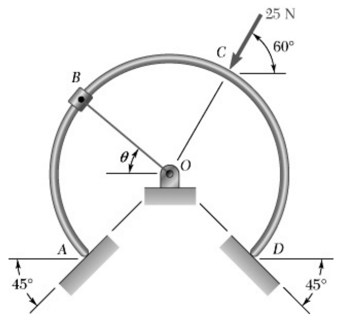
or $T_{CF} = 192.1 \text{ lb}$ ◀

$$\xrightarrow{+} \Sigma F_x = 0: \quad \left(\frac{20}{21.541}\right)(646.24 \text{ lb}) + \left(\frac{10}{12.8062}\right)(192.099 \text{ lb}) - D = 0$$

$$\therefore \quad D = 750.01 \text{ lb}$$

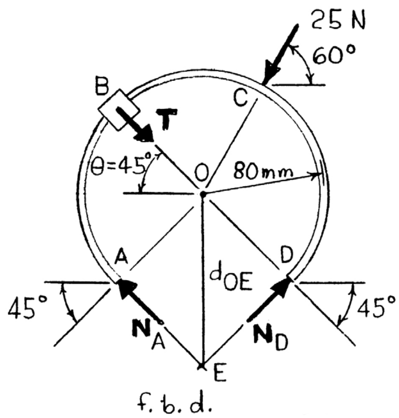
or $\mathbf{D} = 750 \text{ lb} \longleftarrow$ ◀

PROBLEM 4.38



Rod *ABCD* is bent in the shape of a circular arc of radius 80 mm and rests against frictionless surfaces at *A* and *D*. Knowing that the collar at *B* can move freely on the rod and that $\theta = 45^\circ$. determine (*a*) the tension in cord *OB*, (*b*) the reactions at *A* and *D*.

SOLUTION



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

$$+\circlearrowleft \Sigma M_E = 0: \quad (25\text{ N})\cos 60^\circ (d_{OE}) - (T\cos 45^\circ)(d_{OE}) = 0$$

$$\therefore \quad T = 17.6777\text{ N}$$

or $T = 17.68\text{ N}$ ◀

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

$$\xrightarrow{+} \Sigma F_x = 0: \quad -(17.6777\text{ N})\cos 45^\circ + (25\text{ N})\cos 60^\circ$$

$$+ N_D \cos 45^\circ - N_A \cos 45^\circ = 0$$

$$\therefore \quad N_A - N_D = 0$$

or $$N_D = N_A \qquad (1)$$

$$+\uparrow \Sigma F_y = 0: \quad N_A \sin 45^\circ + N_D \sin 45^\circ - (17.6777\text{ N})\sin 45^\circ$$

$$-(25\text{ N})\sin 60^\circ = 0$$

$$\therefore \quad N_A + N_D = 48.296\text{ N} \qquad (2)$$

Substituting Equation (1) into Equation (2),

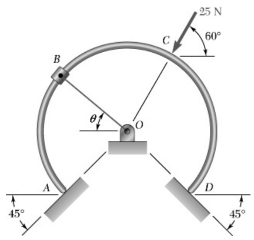
$$2N_A = 48.296\text{ N}$$

$$N_A = 24.148\text{ N}$$

or $\mathbf{N}_A = 24.1\text{ N} \searrow 45.0^\circ$ ◀

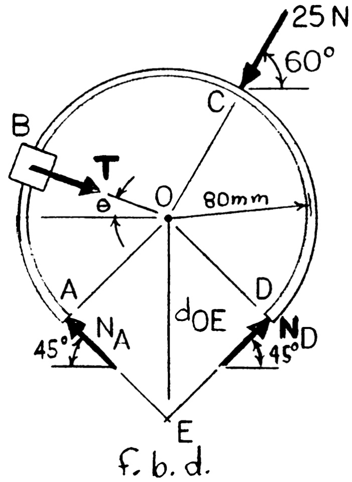
and $\mathbf{N}_D = 24.1\text{ N} \nearrow 45.0^\circ$ ◀

PROBLEM 4.39



Rod *ABCD* is bent in the shape of a circular arc of radius 80 mm and rests against frictionless surfaces at *A* and *D*. Knowing that the collar at *B* can move freely on the rod, determine (*a*) the value of θ for which the tension in cord *OB* is as small as possible, (*b*) the corresponding value of the tension, (*c*) the reactions at *A* and *D*.

SOLUTION



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

$$+\circlearrowleft \Sigma M_E = 0: \quad (25 \text{ N})\cos 60°(d_{OE}) - (T\cos\theta)(d_{OE}) = 0$$

or $$T = \frac{12.5 \text{ N}}{\cos\theta} \qquad (1)$$

$\therefore$ T is minimum when $\cos\theta$ is maximum,

or $\theta = 0°$ ◀

(*b*) From Equation (1)

$$T = \frac{12.5 \text{ N}}{\cos 0} = 12.5 \text{ N}$$

or $T_{\min} = 12.50$ N ◀

(*c*) $\xrightarrow{+} \Sigma F_x = 0: \quad -N_A\cos 45° + N_D\cos 45° + 12.5 \text{ N}$

$$-(25 \text{ N})\cos 60° = 0$$

$$\therefore \quad N_D - N_A = 0$$

or $$N_D = N_A \qquad (2)$$

$$+\uparrow \Sigma F_y = 0: \quad N_A\sin 45° + N_D\sin 45° - (25 \text{ N})\sin 60° = 0$$

$$\therefore \quad N_D + N_A = 30.619 \text{ N} \qquad (3)$$

Substituting Equation (2) into Equation (3),

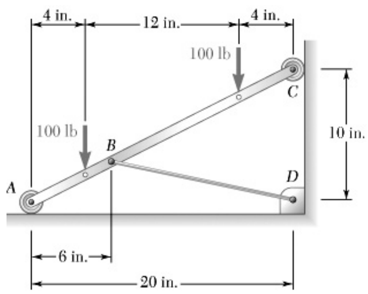
$$2N_A = 30.619$$

$$N_A = 15.3095 \text{ N}$$

or $\mathbf{N}_A = 15.31$ N $\measuredangle$ 45.0° ◀

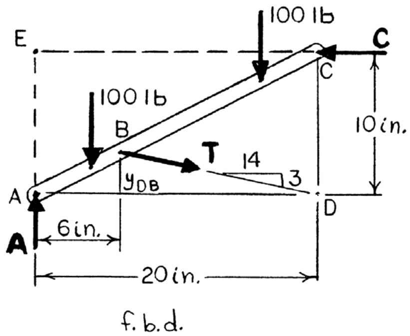
and $\mathbf{N}_D = 15.31$ N $\measuredangle$ 45.0° ◀

PROBLEM 4.40



Bar AC supports two 100-lb loads as shown. Rollers A and C rest against frictionless surfaces and a cable BD is attached at B. Determine (a) the tension in cable BD, (b) the reaction at A, (c) the reaction at C.

SOLUTION



First note that from similar triangles

$$\frac{y_{DB}}{6} = \frac{10}{20} \qquad \therefore \quad y_{DB} = 3 \text{ in.}$$

and

$$\overline{BD} = \sqrt{(3)^2 + (14)^2} \text{ in.} = 14.3178 \text{ in.}$$

$$T_x = \frac{14}{14.3178}T = 0.97780T$$

$$T_y = \frac{3}{14.3178}T = 0.20953T$$

(a) From f.b.d. of bar AC

$$+\circlearrowleft \Sigma M_E = 0: \quad (0.97780T)(7 \text{ in.}) - (0.20953T)(6 \text{ in.})$$

$$-(100 \text{ lb})(16 \text{ in.}) - (100 \text{ lb})(4 \text{ in.}) = 0$$

$$\therefore \quad T = 357.95 \text{ lb}$$

or $T = 358$ lb ◀

(b) From f.b.d. of bar AC

$$+\uparrow \Sigma F_y = 0: \quad A - 100 - 0.20953(357.95) - 100 = 0$$

$$\therefore \quad A = 275.00 \text{ lb}$$

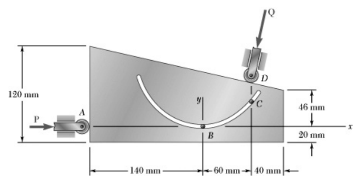
or $\mathbf{A} = 275 \text{ lb} \uparrow$ ◀

(c) From f.b.d of bar AC

$$\xrightarrow{+} \Sigma F_x = 0: \quad 0.97780(357.95) - C = 0$$

$$\therefore \quad C = 350.00 \text{ lb}$$

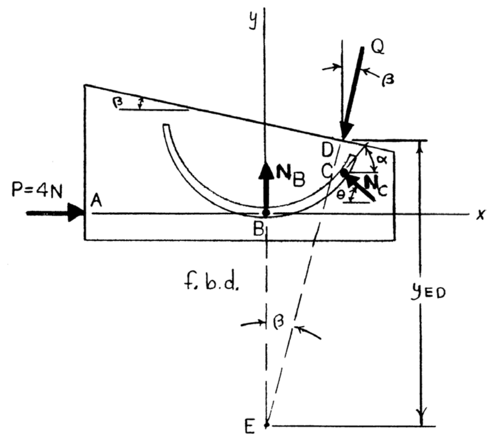
or $\mathbf{C} = 350 \text{ lb} \longleftarrow$ ◀



PROBLEM 4.41

A parabolic slot has been cut in plate AD, and the plate has been placed so that the slot fits two fixed, frictionless pins B and C. The equation of the slot is $y = x^2/100$, where x and y are expressed in mm. Knowing that the input force $P = 4$ N, determine (*a*) the force each pin exerts on the plate, (*b*) the output force **Q**.

SOLUTION



The equation of the slot is $$y = \frac{x^2}{100}$$

Now $$\left(\frac{dy}{dx}\right)_C = \text{slope of the slot at } C$$

$$= \left[\frac{2x}{100}\right]_{x=60\text{ mm}} = 1.200$$

$$\therefore \quad \alpha = \tan^{-1}(1.200) = 50.194°$$

and $$\theta = 90° - \alpha = 90° - 50.194° = 39.806°$$

Coordinates of C are

$$x_C = 60\text{ mm}, \qquad y_C = \frac{(60)^2}{100} = 36\text{ mm}$$

Also, the coordinates of D are $$x_D = 60\text{ mm}$$

$$y_D = 46\text{ mm} + (40\text{ mm})\sin\beta$$

where $$\beta = \tan^{-1}\left(\frac{120 - 66}{240}\right) = 12.6804°$$

$$\therefore \quad y_D = 46\text{ mm} + (40\text{ mm})\tan 12.6804°$$

$$= 55.000\text{ mm}$$

PROBLEM 4.41 CONTINUED

Also,
$$y_{ED} = \frac{60\text{ mm}}{\tan\beta} = \frac{60\text{ mm}}{\tan 12.6804°}$$
$$= 266.67\text{ mm}$$

From f.b.d. of plate *AD*

$$+\circlearrowright \Sigma M_E = 0: \quad \left(N_C\cos\theta\right)\left[y_{ED} - \left(y_D - y_C\right)\right] + \left(N_C\sin\theta\right)\left(x_C\right) - \left(4\text{ N}\right)\left(y_{ED} - y_D\right) = 0$$

$$\left(N_C\cos 39.806°\right)\left[266.67 - \left(55.0 - 36.0\right)\right]\text{mm} + N_C\sin\left(39.806°\right)\left(60\text{ mm}\right) - \left(4\text{ N}\right)\left(266.67 - 55.0\right)\text{mm} = 0$$

$$\therefore\ N_C = 3.7025\text{ N}$$

or
$$\mathbf{N}_C = 3.70\text{ N} \searrow 39.8°$$

$$\overset{+}{\longrightarrow} \Sigma F_x = 0: \quad -4\text{ N} + N_C\cos\theta + Q\sin\beta = 0$$

$$-4\text{ N} + \left(3.7025\text{ N}\right)\cos 39.806° + Q\sin 12.6804° = 0$$

$$\therefore\ Q = 5.2649\text{ N}$$

or
$$\mathbf{Q} = 5.26\text{ N} \swarrow 77.3°$$

$$+\uparrow \Sigma F_y = 0: \quad N_B + N_C\sin\theta - Q\cos\beta = 0$$

$$N_B + \left(3.7025\text{ N}\right)\sin 39.806° - \left(5.2649\text{ N}\right)\cos 12.6804° = 0$$

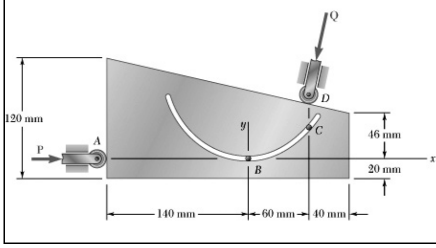
$$\therefore\ N_B = 2.7662\text{ N}$$

or
$$\mathbf{N}_B = 2.77\text{ N}\uparrow$$

(*a*) $\mathbf{N}_B = 2.77\text{ N}\uparrow,\quad \mathbf{N}_C = 3.70\text{ N} \searrow 39.8°$ ◀

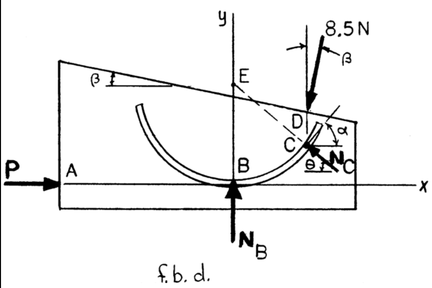
(*b*) $\mathbf{Q} = 5.26\text{ N} \nearrow 77.3°\left(\text{output}\right)$ ◀

PROBLEM 4.42



A parabolic slot has been cut in plate *AD*, and the plate has been placed so that the slot fits two fixed, frictionless pins *B* and *C*. The equation of the slot is $y = x^2/100$, where *x* and *y* are expressed in mm. Knowing that the maximum allowable force exerted on the roller at *D* is 8.5 N, determine (*a*) the corresponding magnitude of the input force **P**, (*b*) the force each pin exerts on the plate.

SOLUTION



The equation of the slot is, $$y = \frac{x^2}{100}$$

Now $$\left(\frac{dy}{dx}\right)_C = \text{slope of slot at } C$$

$$= \left[\frac{2x}{100}\right]_{x=60\text{ mm}} = 1.200$$

$$\therefore \quad \alpha = \tan^{-1}(1.200) = 50.194°$$

and $$\theta = 90° - \alpha = 90° - 50.194° = 39.806°$$

Coordinates of *C* are

$$x_C = 60\text{ mm}, \ \ y_C = \frac{(60)^2}{100} = 36\text{ mm}$$

Also, the coordinates of *D* are

$$x_D = 60\text{ mm}$$

$$y_D = 46\text{ mm} + (40\text{ mm})\sin\beta$$

where $$\beta = \tan^{-1}\left(\frac{120 - 66}{240}\right) = 12.6804°$$

$$\therefore \quad y_D = 46\text{ mm} + (40\text{ mm})\tan 12.6804° = 55.000\text{ mm}$$

Note: $$x_E = 0$$

$$y_E = y_C + (60\text{ mm})\tan\theta$$

$$= 36\text{ mm} + (60\text{ mm})\tan 39.806°$$

$$= 86.001\text{ mm}$$

(*a*) From f.b.d. of plate *AD*

$$+\circlearrowleft \Sigma M_E = 0: \quad P(y_E) - [(8.5\text{ N})\sin\beta](y_E - y_D)$$

$$-[(8.5\text{ N})\cos\beta](60\text{ mm}) = 0$$

PROBLEM 4.42 CONITNIUED

$$P(86.001\text{ mm}) - [(8.5\text{ N})\sin 12.6804°](31.001\text{ mm})$$

$$-[(8.5\text{ N})\cos 12.6804°](60\text{ mm}) = 0$$

$$\therefore \quad P = 6.4581\text{ N}$$

$$\text{or } P = 6.46\text{ N} \blacktriangleleft$$

(*b*) $\xrightarrow{+} \Sigma F_x = 0: \quad P - (8.5\text{ N})\sin\beta - N_C\cos\theta = 0$

$$6.458\text{ N} - (8.5\text{ N})(\sin 12.6804°) - N_C(\cos 39.806°) = 0$$

$$\therefore \quad N_C = 5.9778\text{ N}$$

$$\text{or } \mathbf{N}_C = 5.98\text{ N} \searrow 39.8° \blacktriangleleft$$

$$+\uparrow \Sigma F_y = 0: \quad N_B + N_C\sin\theta - (8.5\text{ N})\cos\beta = 0$$

$$N_B + (5.9778\text{ N})\sin 39.806° - (8.5\text{ N})\cos 12.6804° = 0$$

$$\therefore \quad N_B = 4.4657\text{ N}$$

$$\text{or } \mathbf{N}_B = 4.47\text{ N} \uparrow \blacktriangleleft$$