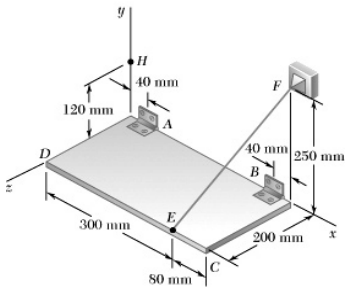
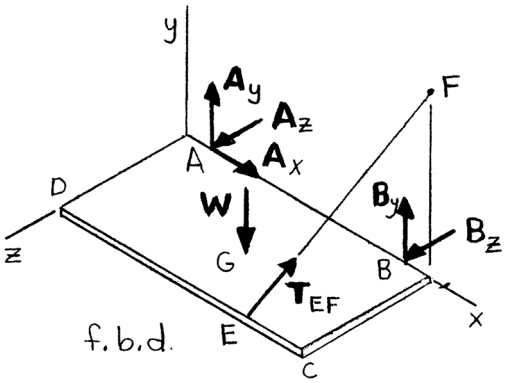
## PROBLEM 4.122




The rectangular plate shown has a mass of 15 kg and is held in the position shown by hinges *A* and *B* and cable *EF*. Assuming that the hinge at *B* does not exert any axial thrust, determine (*a*) the tension in the cable, (*b*) the reactions at *A* and *B*.

## SOLUTION




First note $$W = mg = (15\text{ kg})\left(9.81\text{ m/s}^2\right) = 147.15\text{ N}$$

$$\mathbf{T}_{EF} = \lambda_{EF} T_{EF} = \left[\frac{(0.08\text{ m})\mathbf{i} + (0.25\text{ m})\mathbf{j} - (0.2\text{ m})\mathbf{k}}{\sqrt{(0.08)^2 + (0.25)^2 + (0.2)^2}\text{ m}}\right] T_{EF} = \frac{T_{EF}}{0.33}\left(0.08\mathbf{i} + 0.25\mathbf{j} - 0.2\mathbf{k}\right)$$

From f.b.d. of rectangular plate

$$\Sigma M_x = 0: \quad (147.15\text{ N})(0.1\text{ m}) - (T_{EF})_y (0.2\text{ m}) = 0$$

or $$14.715\text{ N}\cdot\text{m} - \left[\left(\frac{0.25}{0.33}\right)T_{EF}\right](0.2\text{ m}) = 0$$

or $$T_{EF} = 97.119\text{ N}$$

or $T_{EF} = 97.1\text{ N}$ ◀

$$\Sigma F_x = 0: \quad A_x + (T_{EF})_x = 0$$

$$A_x + \left(\frac{0.08}{0.33}\right)(97.119\text{ N}) = 0$$

$$\therefore \quad A_x = -23.544\text{ N}$$

## PROBLEM 4.122 CONTINUED

$$\Sigma M_{B(z\text{-axis})} = 0: \quad -A_y(0.3\text{ m}) - (T_{EF})_y(0.04\text{ m}) + W(0.15\text{ m}) = 0$$

or
$$-A_y(0.3\text{ m}) - \left[\left(\frac{0.25}{0.33}\right)97.119\text{ N}\right](0.04\text{ m}) + 147.15\text{ N}(0.15\text{ m}) = 0$$

$$\therefore \quad A_y = 63.765\text{ N}$$

$$\Sigma M_{B(y\text{-axis})} = 0: \quad A_z(0.3\text{ m}) + (T_{EF})_x(0.2\text{ m}) + (T_{EF})_z(0.04\text{ m}) = 0$$

$$A_z(0.3\text{ m}) + \left[\left(\frac{0.08}{0.33}\right)T_{EF}\right](0.2\text{ m}) - \left[\left(\frac{0.2}{0.33}\right)T_{EF}\right](0.04\text{ m}) = 0$$

$$\therefore \quad A_z = -7.848\text{ N}$$

and $\mathbf{A} = -(23.5\text{ N})\mathbf{i} + (63.8\text{ N})\mathbf{j} - (7.85\text{ N})\mathbf{k}$ ◀

$$\Sigma F_y = 0: \quad A_y - W + (T_{EF})_y + B_y = 0$$

$$63.765\text{ N} - 147.15\text{ N} + \left(\frac{0.25}{0.33}\right)(97.119\text{ N}) + B_y = 0$$

$$\therefore \quad B_y = 9.81\text{ N}$$

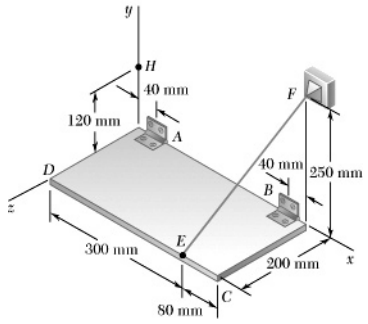
$$\Sigma F_z = 0: \quad A_z - (T_{EF})_z + B_z = 0$$

$$-7.848\text{ N} - \left(\frac{0.2}{0.33}\right)(97.119\text{ N}) + B_z = 0$$

$$\therefore \quad B_z = 66.708\text{ N}$$

and $\mathbf{B} = (9.81\text{ N})\mathbf{j} + (66.7\text{ N})\mathbf{k}$ ◀

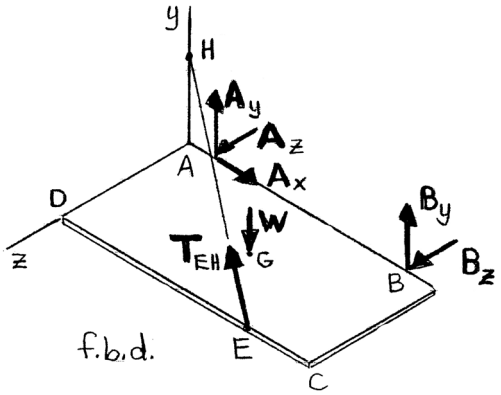
## PROBLEM 4.123




Solve Problem 4.122 assuming that cable *EF* is replaced by a cable attached at points *E* and *H*.

**P4.122** The rectangular plate shown has a mass of 15 kg and is held in the position shown by hinges *A* and *B* and cable *EF*. Assuming that the hinge at *B* does not exert any axial thrust, determine (*a*) the tension in the cable, (*b*) the reactions at *A* and *B*.

**SOLUTION**




First note $$W = mg = (15\text{ kg})\left(9.81\text{ m/s}^2\right) = 147.15\text{ N}$$

$$\mathbf{T}_{EH} = \boldsymbol{\lambda}_{EH} T_{EH} = \left[\frac{-(0.3\text{ m})\mathbf{i} + (0.12\text{ m})\mathbf{j} - (0.2\text{ m})\mathbf{k}}{\sqrt{(0.3)^2 + (0.12)^2 + (0.2)^2}\text{ m}}\right] T_{EH} = \frac{T_{EH}}{0.38}\left[-(0.3)\mathbf{i} + (0.12)\mathbf{j} - (0.2)\mathbf{k}\right]$$

From f.b.d. of rectangular plate

$$\Sigma M_x = 0: \quad (147.15\text{ N})(0.1\text{ m}) - (T_{EH})_y (0.2\text{ m}) = 0$$

or $$(147.15\text{ N})(0.1\text{ m}) - \left[\left(\frac{0.12}{0.38}\right)T_{EH}\right](0.2\text{ m}) = 0$$

or $$T_{EH} = 232.99\text{ N}$$

or $T_{EH} = 233\text{ N}$ ◀

$$\Sigma F_x = 0: \quad A_x + (T_{EH})_x = 0$$

$$A_x - \left(\frac{0.3}{0.38}\right)(232.99\text{ N}) = 0$$

$$\therefore \quad A_x = 183.938\text{ N}$$

## PROBLEM 4.123 CONTINUED

$$\Sigma M_{B(z\text{-axis})} = 0: \quad -A_y(0.3\text{ m}) - (T_{EH})_y(0.04\text{ m}) + W(0.15\text{ m}) = 0$$

or
$$-A_y(0.3\text{ m}) - \left[\frac{0.12}{0.38}(232.99\text{ N})\right](0.04\text{ m}) + (147.15\text{ N})(0.15\text{ m}) = 0$$

$$\therefore \quad A_y = 63.765\text{ N}$$

$$\Sigma M_{B(y\text{-axis})} = 0: \quad A_z(0.3\text{ m}) + (T_{EH})_x(0.2\text{ m}) + (T_{EH})_z(0.04\text{ m}) = 0$$

or
$$A_z(0.3\text{ m}) - \left[\left(\frac{0.3}{0.38}\right)(232.99\text{ N})\right](0.2\text{ m}) - \left[\left(\frac{0.2}{0.38}\right)(232.99)\right](0.04\text{ m}) = 0$$

$$\therefore \quad A_z = 138.976\text{ N}$$

and $\mathbf{A} = (183.9\text{ N})\mathbf{i} + (63.8\text{ N})\mathbf{j} + (139.0\text{ N})\mathbf{k}$ ◀

$$\Sigma F_y = 0: \quad A_y + B_y - W + (T_{EH})_y = 0$$

$$63.765\text{ N} + B_y - 147.15\text{ N} + \left(\frac{0.12}{0.38}\right)(232.99\text{ N}) = 0$$

$$\therefore \quad B_y = 9.8092\text{ N}$$

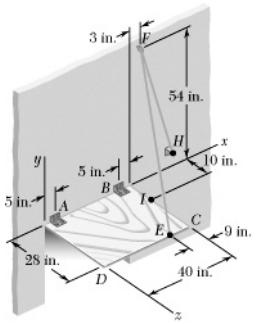
$$\Sigma F_z = 0: \quad A_z + B_z - (T_{EH})_z = 0$$

$$138.976\text{ N} + B_z - \left(\frac{0.2}{0.38}\right)(232.99\text{ N}) = 0$$

$$\therefore \quad B_z = -16.3497\text{ N}$$

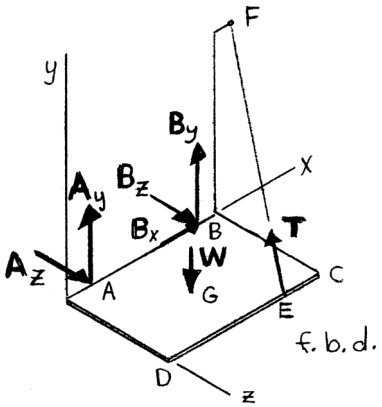
and $\mathbf{B} = (9.81\text{ N})\mathbf{j} - (16.35\text{ N})\mathbf{k}$ ◀

## PROBLEM 4.124




A small door weighing 16 lb is attached by hinges *A* and *B* to a wall and is held in the horizontal position shown by rope *EFH*. The rope passes around a small, frictionless pulley at *F* and is tied to a fixed cleat at *H*. Assuming that the hinge at *A* does not exert any axial thrust, determine (*a*) the tension in the rope, (*b*) the reactions at *A* and *B*.

**SOLUTION**




First note $$\mathbf{T} = \boldsymbol{\lambda}_{EF} T = \frac{(12\text{ in.})\mathbf{i} + (54\text{ in.})\mathbf{j} - (28\text{ in.})\mathbf{k}}{\sqrt{(12)^2 + (54)^2 + (28)^2}\text{ in.}} T$$

$$= \frac{T}{62}(12\mathbf{i} + 54\mathbf{j} - 28\mathbf{k}) = \frac{T}{31}(6\mathbf{i} + 27\mathbf{j} - 14\mathbf{k})$$

$$\mathbf{W} = -(16\text{ lb})\mathbf{j} \quad \text{at } G$$

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

(*a*) $$\Sigma M_x = 0: \quad T_y(28\text{ in.}) - W(14\text{ in.}) = 0$$

$$\left[T\left(\frac{27}{31}\right)\right](28\text{ in.}) - (16\text{ lb})(14\text{ in.}) = 0$$

$$\therefore \quad T = 9.1852\text{ lb}$$

or $T = 9.19$ lb ◀

(*b*) $$\Sigma M_{B(\text{z-axis})} = 0: \quad -A_y(30\text{ in.}) + W(15\text{ in.}) - T_y(4\text{ in.}) = 0$$

$$-A_y(30\text{ in.}) + (16\text{ lb})(15\text{ in.}) - \left[(9.1852\text{ lb})\left(\frac{27}{31}\right)\right](4\text{ in.}) = 0$$

$$\therefore \quad A_y = 6.9333\text{ lb}$$

## PROBLEM 4.124 CONTINUED

$$\Sigma M_{B(y\text{-axis})} = 0: \quad A_z(30 \text{ in.}) + T_x(28 \text{ in.}) - T_z(4 \text{ in.}) = 0$$

$$A_z(30 \text{ in.}) + \left[(9.1852 \text{ lb})\left(\frac{6}{31}\right)\right](28 \text{ in.}) - \left[(9.1852 \text{ lb})\left(\frac{14}{31}\right)\right](4 \text{ in.}) = 0$$

$$\therefore \quad A_z = -1.10617 \text{ lb}$$

$$\text{or} \quad \mathbf{A} = (6.93 \text{ lb})\mathbf{j} - (1.106 \text{ lb})\mathbf{k} \blacktriangleleft$$

$$\Sigma F_x = 0: \quad B_x + T_x = B_x + (9.1852 \text{ lb})\left(\frac{6}{31}\right) = 0$$

$$\therefore \quad B_x = -1.77778 \text{ lb}$$

$$\Sigma F_y = 0: \quad B_y + T_y - W + A_y = 0$$

$$B_y + (9.1852 \text{ lb})\left(\frac{27}{31}\right) - 16 \text{ lb} + 6.9333 \text{ lb} = 0$$

$$\therefore \quad B_y = 1.06666 \text{ lb}$$

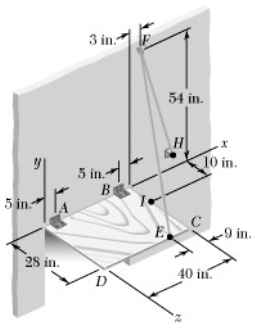
$$\Sigma F_z = 0: \quad A_z - T_z + B_z = 0$$

$$-1.10617 \text{ lb} - (9.1852 \text{ lb})\left(\frac{14}{31}\right) + B_z = 0$$

$$\therefore \quad B_z = 5.2543 \text{ lb}$$

$$\text{or} \quad \mathbf{B} = -(1.778 \text{ lb})\mathbf{i} + (1.067 \text{ lb})\mathbf{j} + (5.25 \text{ lb})\mathbf{k} \blacktriangleleft$$

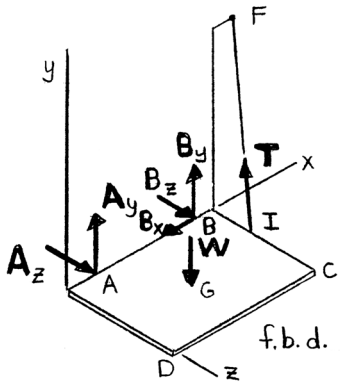
## PROBLEM 4.125




Solve Problem 4.124 assuming that the rope is attached to the door at *I*.

**P4.124** A small door weighing 16 lb is attached by hinges *A* and *B* to a wall and is held in the horizontal position shown by rope *EFH*. The rope passes around a small, frictionless pulley at *F* and is tied to a fixed cleat at *H*. Assuming that the hinge at *A* does not exert any axial thrust, determine (*a*) the tension in the rope, (*b*) the reactions at *A* and *B*.

**SOLUTION**




First note

$$\mathbf{T} = \boldsymbol{\lambda}_{IF} T = \frac{(3\text{ in.})\mathbf{i} + (54\text{ in.})\mathbf{j} - (10\text{ in.})\mathbf{k}}{\sqrt{(3)^2 + (54)^2 + (10)^2}\text{ in.}} T$$

$$= \frac{T}{55}(3\mathbf{i} + 54\mathbf{j} - 10\mathbf{k})$$

$$\mathbf{W} = -(16\text{ lb})\mathbf{j}$$

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

(*a*) $\Sigma M_x = 0$: $W(14\text{ in.}) - T_y(10\text{ in.}) = 0$

$$(16\text{ lb})(14\text{ in.}) - \left(\frac{54}{55}\right)T(10\text{ in.}) = 0$$

$$\therefore \quad T = 22.815\text{ lb}$$

or $T = 22.8$ lb ◀

(*b*) $\Sigma M_{B(z\text{-axis})} = 0$: $-A_y(30\text{ in.}) + W(15\text{ in.}) + T_y(5\text{ in.}) = 0$

$$-A_y(30\text{ in.}) + (16\text{ lb})(15\text{ in.}) + (22.815\text{ lb})\left(\frac{54}{55}\right)(5\text{ in.}) = 0$$

$$\therefore A_y = 11.7334\text{ lb}$$

## PROBLEM 4.125 CONTINUED

$$\Sigma M_{B(y\text{-axis})} = 0: \quad A_z(30 \text{ in.}) + T_x(10 \text{ in.}) + T_z(5 \text{ in.}) = 0$$

$$A_z(30 \text{ in.}) + \left[(22.815 \text{ lb})\left(\frac{3}{55}\right)\right](10 \text{ in.}) + \left[(22.815 \text{ lb})\left(\frac{10}{55}\right)\right](5 \text{ in.}) = 0$$

$$\therefore \; A_z = -1.10618 \text{ lb}$$

$$\text{or } \mathbf{A} = (11.73 \text{ lb})\mathbf{j} - (1.106 \text{ lb})\mathbf{k} \blacktriangleleft$$

$$\Sigma F_x = 0: \quad B_x + T_x = 0$$

$$B_x + \left(\frac{3}{55}\right)(22.815 \text{ lb}) = 0$$

$$\therefore \; B_x = -1.24444 \text{ lb}$$

$$\Sigma F_y = 0: \quad A_y - W + T_y + B_y = 0$$

$$11.7334 \text{ lb} - 16 \text{ lb} + (22.815 \text{ lb})\left(\frac{54}{55}\right) + B_y = 0$$

$$\therefore \; B_y = -18.1336 \text{ lb}$$

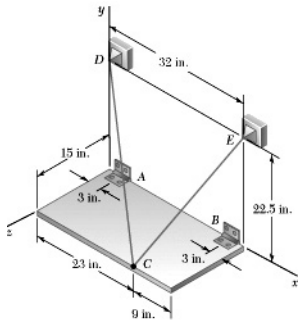
$$\Sigma F_z = 0: \quad A_z - T_z + B_z = 0$$

$$-1.10618 \text{ lb} - (22.815 \text{ lb})\left(\frac{10}{55}\right) + B_z = 0$$

$$\therefore \; B_z = 5.2544 \text{ lb}$$

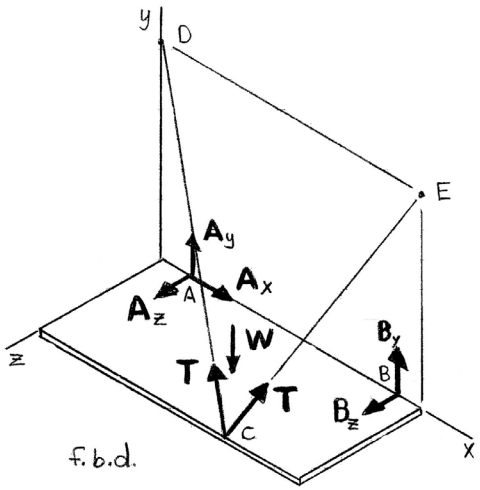
$$\text{or } \mathbf{B} = -(1.244 \text{ lb})\mathbf{i} - (18.13 \text{ lb})\mathbf{j} + (5.25 \text{ lb})\mathbf{k} \blacktriangleleft$$

## PROBLEM 4.126




A 285-lb uniform rectangular plate is supported in the position shown by hinges *A* and *B* and by cable *DCE*, which passes over a frictionless hook at *C*. Assuming that the tension is the same in both parts of the cable, determine (*a*) the tension in the cable, (*b*) the reactions at *A* and *B*. Assume that the hinge at *B* does not exert any axial thrust.

**SOLUTION**




First note

$$\boldsymbol{\lambda}_{CD} = \frac{-(23\text{ in.})\mathbf{i} + (22.5\text{ in.})\mathbf{j} - (15\text{ in.})\mathbf{k}}{35.5\text{ in.}}$$

$$= \frac{1}{35.5}(-23\mathbf{i} + 22.5\mathbf{j} - 15\mathbf{k})$$

$$\boldsymbol{\lambda}_{CE} = \frac{(9\text{ in.})\mathbf{i} + (22.5\text{ in.})\mathbf{j} - (15\text{ in.})\mathbf{k}}{28.5\text{ in.}}$$

$$= \frac{1}{28.5}(9\mathbf{i} + 22.5\mathbf{j} - 15\mathbf{k})$$

$$\mathbf{W} = -(285\text{ lb})\mathbf{j}$$

From f.b.d. of plate

(*a*) $$\Sigma M_x = 0: \quad (285\text{ lb})(7.5\text{ in.}) - \left[\left(\frac{22.5}{35.5}\right)T\right](15\text{ in.}) - \left[\left(\frac{22.5}{28.5}\right)T\right](15\text{ in.}) = 0$$

$$\therefore \quad T = 100.121\text{ lb}$$

or $T = 100.1$ lb ◀

## PROBLEM 4.126 CONTINUED

(*b*) $\Sigma F_x = 0$: $A_x - T\left(\frac{23}{35.5}\right) + T\left(\frac{9}{28.5}\right) = 0$

$$A_x - (100.121 \text{ lb})\left(\frac{23}{35.5}\right) + (100.121 \text{ lb})\left(\frac{9}{28.5}\right) = 0$$

$$\therefore \quad A_x = 33.250 \text{ lb}$$

$$\Sigma M_{B(z\text{-axis})} = 0: \quad -A_y(26 \text{ in.}) + W(13 \text{ in.}) - \left[T\left(\frac{22.5}{35.5}\right)\right](6 \text{ in.}) - \left[T\left(\frac{22.5}{28.5}\right)\right](6 \text{ in.}) = 0$$

or $$-A_y(26 \text{ in.}) + (285 \text{ lb})(13 \text{ in.}) - \left[(100.121 \text{ lb})\left(\frac{22.5}{35.5}\right)\right](6 \text{ in.})$$

$$-\left[(100.121 \text{ lb})\left(\frac{22.5}{28.5}\right)\right](6 \text{ in.}) = 0$$

$$\therefore \quad A_y = 109.615 \text{ lb}$$

$$\Sigma M_{B(y\text{-axis})} = 0: \quad A_z(26 \text{ in.}) - \left[T\left(\frac{15}{35.5}\right)\right](6 \text{ in.}) - \left[T\left(\frac{23}{35.5}\right)\right](15 \text{ in.})$$

$$-\left[T\left(\frac{15}{28.5}\right)\right](6 \text{ in.}) + \left[T\left(\frac{9}{28.5}\right)\right](15 \text{ in.}) = 0$$

or $$A_z(26 \text{ in.}) + \left[\frac{-1}{35.5}(90 + 345) - \frac{1}{28.5}(90 - 135)\right](100.121 \text{ lb}) = 0$$

$$\therefore \quad A_z = 41.106 \text{ lb}$$

or $\mathbf{A} = (33.3 \text{ lb})\mathbf{i} + (109.6 \text{ lb})\mathbf{j} + (41.1 \text{ lb})\mathbf{k}$ ◀

$$\Sigma F_y = 0: \quad B_y - W + T\left(\frac{22.5}{35.5}\right) + T\left(\frac{22.5}{28.5}\right) + A_y = 0$$

$$B_y - 285 \text{ lb} + (100.121 \text{ lb})\left(\frac{22.5}{35.5} + \frac{22.5}{28.5}\right) + 109.615 \text{ lb} = 0$$

$$\therefore \quad B_y = 32.885 \text{ lb}$$

$$\Sigma F_z = 0: \quad B_z + A_z - T\left(\frac{15}{35.5}\right) - T\left(\frac{15}{28.5}\right) = 0$$

$$B_z + 41.106 \text{ lb} - (100.121 \text{ lb})\left(\frac{15}{35.5} + \frac{15}{28.5}\right) = 0$$

$$\therefore \quad B_z = 53.894 \text{ lb}$$

or $\mathbf{B} = (32.9 \text{ lb})\mathbf{j} + (53.9 \text{ lb})\mathbf{k}$ ◀