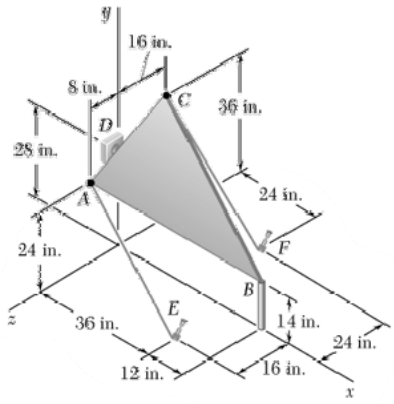
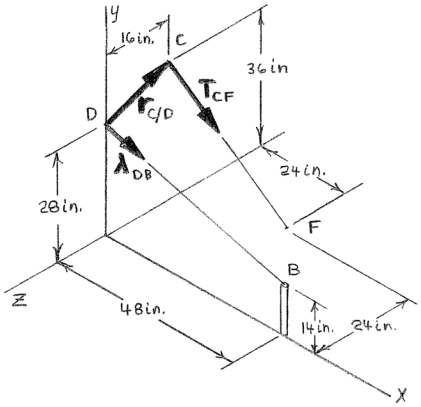
PROBLEM 3.63



In Problem 3.54, determine the perpendicular distance between cable *CF* and the line joining points *D* and *B*.

Problem 3.54: The triangular plate *ABC* is supported by ball-and-socket joints at *B* and *D* and is held in the position shown by cables *AE* and *CF*. If the force exerted by cable *CF* at *C* is 132 lb, determine the moment of that force about the line joining points *D* and *B*.

SOLUTION



Have $$(M_{DB}) = \boldsymbol{\lambda}_{DB} \cdot (\mathbf{r}_{C/D} \times \mathbf{T}_{CF})$$

where $$\boldsymbol{\lambda}_{DB} = \frac{(48 \text{ in.})\mathbf{i} - (14 \text{ in.})\mathbf{j}}{50 \text{ in.}}$$

$$= 0.96\mathbf{i} - 0.28\mathbf{j}$$

$$\mathbf{r}_{C/D} = (8 \text{ in.})\mathbf{j} - (16 \text{ in.})\mathbf{k}$$

$$\mathbf{T}_{CF} = \boldsymbol{\lambda}_{CF} T_{CF}$$

$$= \frac{(24 \text{ in.})\mathbf{i} - (36 \text{ in.})\mathbf{j} - (8 \text{ in.})\mathbf{k}}{44 \text{ in.}}(132 \text{ lb})$$

$$= (72 \text{ lb})\mathbf{i} - (108 \text{ lb})\mathbf{j} - (24 \text{ lb})\mathbf{k}$$

$$\therefore \quad M_{DB} = \begin{vmatrix} 0.96 & -0.28 & 0 \\ 0 & 8 & -16 \\ 72 & -108 & -24 \end{vmatrix} \text{lb}\cdot\text{in}$$

$$= -1520.64 \text{ lb}\cdot\text{in}.$$

Only the perpendicular component of $\mathbf{T}_{CF}$ contributes to the moment of $\mathbf{T}_{CF}$ about line *DB*. The parallel component of $\mathbf{T}_{CF}$ will be used to obtain the perpendicular component.

PROBLEM 3.63 CONTINUED

Have

$$(T_{CF})_{\text{parallel}} = \boldsymbol{\lambda}_{DB} \cdot \mathbf{T}_{CF}$$

$$= (0.96\mathbf{i} - 0.28\mathbf{j}) \cdot \left[(72 \text{ lb})\mathbf{i} - (108 \text{ lb})\mathbf{j} - (24 \text{ lb})\mathbf{k}\right]$$

$$= \left[(0.96)(72) + (-0.28)(-108) + (0)(-24)\right] \text{lb}$$

$$= 99.36 \text{ lb}$$

Since $\mathbf{T}_{CF} = (\mathbf{T}_{CF})_{\text{perp.}} + (\mathbf{T}_{CF})_{\text{parallel}}$

$$\therefore \quad (T_{CF})_{\text{perp.}} = \sqrt{(T_{CF})^2 - (T_{CF})^2_{\text{parallel}}}$$

$$= \sqrt{(132)^2 - (99.36)^2}$$

$$= 86.900 \text{ lb}$$

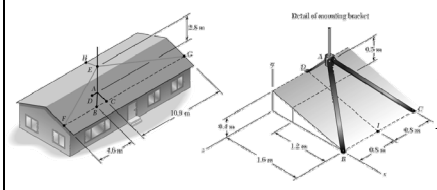
Then $$M_{DB} = (T_{CF})_{\text{perp.}}(d)$$

$$-1520.64 \text{ lb·in.} = (86.900 \text{ lb})d$$

$$d = 17.4988 \text{ in.}$$

or $d = 17.50$ in. ◀

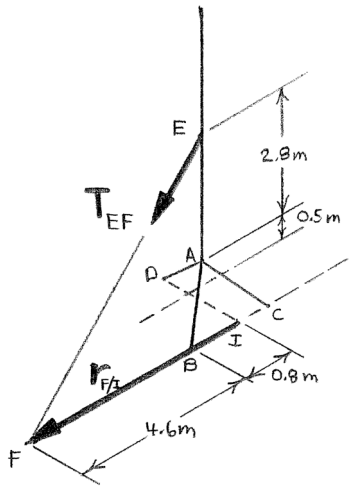
PROBLEM 3.64



In Problem 3.55, determine the perpendicular distance between cable *EF* and the line joining points *D* and *I*.

Problem 3.55: A mast is mounted on the roof of a house using bracket *ABCD* and is guyed by cables *EF*, *EG*, and *EH*. Knowing that the force exerted by cable *EF* at *E* is 66 N, determine the moment of that force about the line joining points *D* and *I*.

SOLUTION



Have $$M_{DI} = \boldsymbol{\lambda}_{DI} \cdot \left(\mathbf{r}_{F/I} \times \mathbf{T}_{EF} \right)$$

where $$\boldsymbol{\lambda}_{DI} = \frac{(1.6\text{ m})\mathbf{i} - (0.4\text{ m})\mathbf{j}}{0.4\sqrt{17}\text{ m}} = \frac{1}{\sqrt{17}}(4\mathbf{i} - \mathbf{j})$$

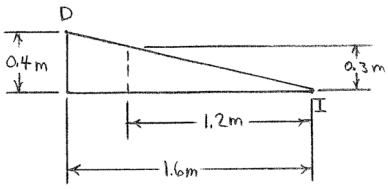
$$\mathbf{r}_{F/I} = (5.4\text{ m})\mathbf{k}$$

$$\mathbf{T}_{EF} = \boldsymbol{\lambda}_{EF} T_{EF} = \frac{(1.2\text{ m})\mathbf{i} - (3.6\text{ m})\mathbf{j} + (5.4\text{ m})\mathbf{k}}{6.6\text{ m}}(66\text{ N})$$

$$= 6\left[(2\text{ N})\mathbf{i} - (6\text{ N})\mathbf{j} + (9\text{ N})\mathbf{k}\right]$$

$$\therefore \quad M_{DI} = \frac{(6\text{ N})(5.4\text{ m})}{\sqrt{17}} \begin{vmatrix} 4 & -1 & 0 \\ 0 & 0 & 1 \\ 2 & -6 & 9 \end{vmatrix} = 172.879\text{ N}\cdot\text{m}$$

Only the perpendicular component of $\mathbf{T}_{EF}$ contributes to the moment of $\mathbf{T}_{EF}$ about line *DI*. The parallel component of $\mathbf{T}_{EF}$ will be used to find the perpendicular component.



Have

$$(T_{EF})_{\text{parallel}} = \boldsymbol{\lambda}_{DI} \cdot \mathbf{T}_{EF}$$

$$= \frac{1}{\sqrt{17}}(4\mathbf{i} - \mathbf{j}) \cdot \left[(12\text{ N})\mathbf{i} - (36\text{ N})\mathbf{j} + (54\text{ N})\mathbf{k}\right]$$

$$= \frac{1}{\sqrt{17}}(48 + 36)\text{ N}$$

$$= \frac{84}{\sqrt{17}}\text{ N}$$

PROBLEM 3.64 CONTINUED

Since $\mathbf{T}_{EF} = (\mathbf{T}_{EF})_{\text{perp.}} + (\mathbf{T}_{EF})_{\text{parallel}}$

$$\therefore \quad (T_{EF})_{\text{perp.}} = \sqrt{(T_{EF})^2 - (T_{EF})^2_{\text{parallel}}}$$

$$= \sqrt{(66)^2 - \left(\frac{84}{\sqrt{17}}\right)^2}$$

$$= 62.777 \text{ N}$$

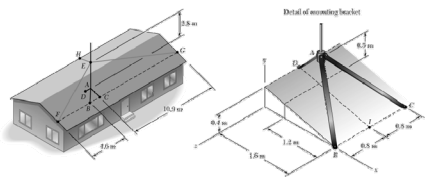
Then $$M_{DI} = (T_{EF})_{\text{perp.}}(d)$$

$$172.879 \text{ N}\cdot\text{m} = (62.777 \text{ N})(d)$$

$$d = 2.7539 \text{ m}$$

or $d = 2.75$ m ◀

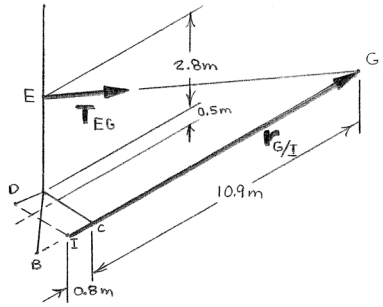
PROBLEM 3.65



In Problem 3.56, determine the perpendicular distance between cable *EG* and the line joining points *D* and *I*.

Problem 3.56: A mast is mounted on the roof of a house using bracket *ABCD* and is guyed by cables *EF*, *EG*, and *EH*. Knowing that the force exerted by cable *EG* at *E* is 61.5 N, determine the moment of that force about the line joining points *D* and *I*.

SOLUTION



Have $$M_{DI} = \boldsymbol{\lambda}_{DI} \cdot \left[\mathbf{r}_{G/I} \times \mathbf{T}_{EG} \right]$$

where $$\boldsymbol{\lambda}_{DI} = \frac{(1.6\text{ m})\mathbf{i} - (0.4\text{ m})\mathbf{j}}{0.4\sqrt{17}\text{ m}} = \frac{1}{\sqrt{17}}(4\mathbf{i} - \mathbf{j})$$

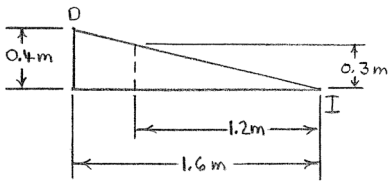
$$\mathbf{r}_{G/I} = -(10.9\text{ m} + 0.8\text{ m})\mathbf{k} = -(11.7\text{ m})\mathbf{k}$$

$$\mathbf{T}_{EG} = \boldsymbol{\lambda}_{EG} T_{EG} = \frac{(1.2\text{ m})\mathbf{i} - (3.6\text{ m})\mathbf{j} - (11.7\text{ m})\mathbf{k}}{12.3\text{ m}}(61.5\text{ N})$$

$$= 5\left[(1.2\text{ N})\mathbf{i} - (3.6\text{ N})\mathbf{j} - (11.7\text{ N})\mathbf{k}\right]$$

$$\therefore\ M_{DI} = \frac{(5\text{ N})(11.7\text{ m})}{\sqrt{17}} \begin{vmatrix} 4 & -1 & 0 \\ 0 & 0 & -1 \\ 1.2 & -3.6 & -11.7 \end{vmatrix}$$

$$= -187.286\text{ N}\cdot\text{m}$$



Only the perpendicular component of $\mathbf{T}_{EG}$ contributes to the moment of $\mathbf{T}_{EG}$ about line *DI*. The parallel component of $\mathbf{T}_{EG}$ will be used to find the perpendicular component.

Have

$$T_{EG(\text{parallel})} = \boldsymbol{\lambda}_{DI} \cdot \mathbf{T}_{EG}$$

$$= \frac{1}{\sqrt{17}}(4\mathbf{i} - \mathbf{j}) \cdot 5\left[(1.2\text{ N})\mathbf{i} - (3.6\text{ N})\mathbf{j} - (11.7\text{ N})\mathbf{k}\right]$$

$$= \frac{5}{\sqrt{17}}(4.8 + 3.6)\text{N}$$

$$= \frac{42}{\sqrt{17}}\text{ N}$$

PROBLEM 3.65 CONTINUED

Since $\mathbf{T}_{EF} = (\mathbf{T}_{EG})_{\text{perp.}} + (\mathbf{T}_{EG})_{\text{parallel}}$

$$\therefore \quad (T_{EG})_{\text{perp.}} = \sqrt{(T_{EG})^2 - (T_{EG})^2_{\text{parallel}}}$$

$$= \sqrt{(61.5)^2 - \left(\frac{42}{\sqrt{17}}\right)^2}$$

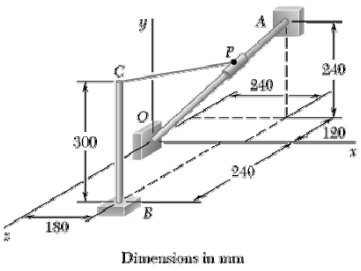
$$= 60.651 \text{ N}$$

Then $$M_{DI} = (T_{EG})_{\text{perp.}}(d)$$

$$187.286 \text{ N}\cdot\text{m} = (60.651 \text{ N})(d)$$

$$d = 3.0880 \text{ m}$$

or $d = 3.09$ m ◀



Dimensions in mm

PROBLEM 3.66

In Problem 3.41, determine the perpendicular distance between post *BC* and the line connecting points *O* and *A*.

Problem 3.41: Slider *P* can move along rod *OA*. An elastic cord *PC* is attached to the slider and to the vertical member *BC*. Knowing that the distance from *O* to *P* is 0.12 m and the tension in the cord is 30 N, determine (*a*) the angle between the elastic cord and the rod *OA*, (*b*) the projection on *OA* of the force exerted by cord *PC* at point *P*.

SOLUTION

Assume post *BC* is represented by a force of magnitude F_{BC}

where $$\mathbf{F}_{BC} = F_{BC}\mathbf{j}$$

Have $$M_{OA} = \boldsymbol{\lambda}_{OA} \cdot \left(\mathbf{r}_{B/O} \times \mathbf{F}_{BC}\right)$$

where $$\boldsymbol{\lambda}_{OA} = \frac{(0.24\text{ m})\mathbf{i} + (0.24\text{ m})\mathbf{j} - (0.12\text{ m})\mathbf{k}}{0.36\text{ m}} = \frac{2}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} - \frac{1}{3}\mathbf{k}$$

$$\mathbf{r}_{B/O} = (0.18\text{ m})\mathbf{i} + (0.24\text{ m})\mathbf{k}$$

$$\therefore \quad M_{OA} = \frac{1}{3}F_{BC}\begin{vmatrix} 2 & 2 & -1 \\ 0.18 & 0 & 0.24 \\ 0 & 1 & 0 \end{vmatrix} = \frac{F_{BC}}{3}(-0.48 - 0.18) = -0.22F_{BC}$$

Only the perpendicular component of $\mathbf{F}_{BC}$ contributes to the moment of $\mathbf{F}_{BC}$ about line *OA*. The parallel component will be found first so that the perpendicular component of $\mathbf{F}_{BC}$ can be determined.

$$F_{BC(\text{parallel})} = \boldsymbol{\lambda}_{OA} \cdot \mathbf{F}_{BC} = \left(\frac{2}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} - \frac{1}{3}\mathbf{k}\right) \cdot F_{BC}\mathbf{j}$$

$$= \frac{2}{3}F_{BC}$$

Since $$\mathbf{F}_{BC} = (\mathbf{F}_{BC})_{\text{parallel}} + (\mathbf{F}_{BC})_{\text{perp.}}$$

$$(F_{BC})_{\text{perp.}} = \sqrt{(F_{BC})^2 - (F_{BC})^2_{\text{parallel}}} = \sqrt{(F_{BC})^2 - \left(\frac{2F_{BC}}{3}\right)^2}$$

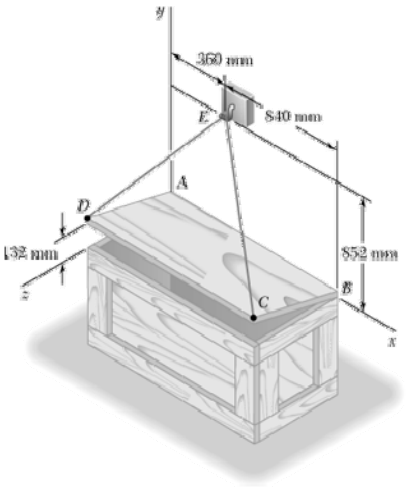
$$= 0.74536F_{BC}$$

Then $$|M_{OA}| = (F_{BC})_{\text{perp.}}(d)$$

$$0.22F_{BC} = (0.74536F_{BC})d$$

$$d = 0.29516\text{ m}$$

or $d = 295$ mm ◀

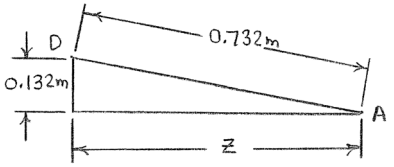


PROBLEM 3.67

In Problem 3.45, determine the perpendicular distance between cord *DE* and the *y* axis.

Problem 3.45: The 0.732×1.2-m lid *ABCD* of a storage bin is hinged along side *AB* and is held open by looping cord *DEC* over a frictionless hook at *E*. If the tension in the cord is 54 N, determine the moment about each of the coordinate axes of the force exerted by the cord at *D*.

SOLUTION



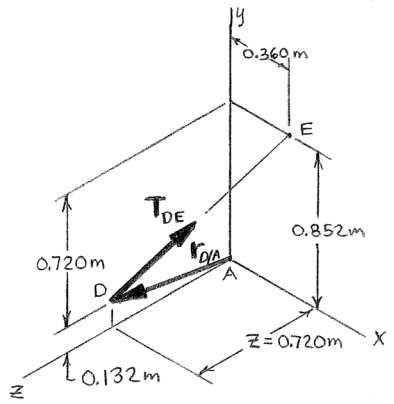
First note

$$z = \sqrt{(0.732)^2 - (0.132)^2}\ \text{m}$$

$$= 0.720\ \text{m}$$

Have $$M_y = \mathbf{j} \cdot \left(\mathbf{r}_{D/A} \times \mathbf{T}_{DE}\right)$$

where $$\mathbf{r}_{D/A} = \left(0.132\mathbf{j} + 0.720\mathbf{k}\right)\ \text{m}$$



$$\mathbf{T}_{DE} = \boldsymbol{\lambda}_{DE} T_{DE}$$

$$= \frac{(0.360\ \text{m})\mathbf{i} + (0.732\ \text{m})\mathbf{j} - (0.720\ \text{m})\mathbf{k}}{1.08\ \text{m}}(54\ \text{N})$$

$$= (18\ \text{N})\mathbf{i} + (36\ \text{N})\mathbf{j} - (36\ \text{N})\mathbf{k}$$

$$\therefore\ M_y = \begin{vmatrix} 0 & 1 & 0 \\ 0 & 0.132 & 0.720 \\ 18 & 36 & -36 \end{vmatrix} = 12.96\ \text{N} \cdot \text{m}$$

Only the perpendicular component of $\mathbf{T}_{DE}$ contributes to the moment of $\mathbf{T}_{DE}$ about the *y*-axis. The parallel component will be found first so that the perpendicular component of $\mathbf{T}_{DE}$ can be determined.

$$T_{DE(\text{parallel})} = \mathbf{j} \cdot \mathbf{T}_{DE} = 36\ \text{N}$$

PROBLEM 3.67 CONTINUED

Since $$\left(\mathbf{T}_{DE}\right) = \left(\mathbf{T}_{DE}\right)_{\text{parallel}} + \left(\mathbf{T}_{DE}\right)_{\text{perp.}}$$

$$\left(T_{DE}\right)_{\text{perp.}} = \sqrt{\left(T_{DE}\right)^2 - \left(T_{DE}\right)^2_{\text{parallel}}}$$

$$= \sqrt{\left(54\right)^2 - \left(36\right)^2} = 40.249 \text{ N}$$

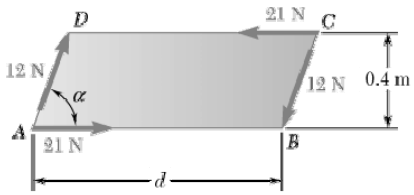
Then $$M_y = \left(T_{DE}\right)_{\text{perp.}} \left(d\right)$$

$$12.96 \text{ N}\cdot\text{m} = \left(40.249 \text{ N}\right)\left(d\right)$$

$$d = 0.32199 \text{ m}$$

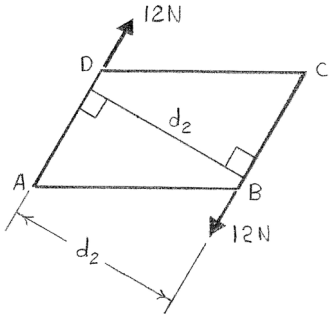
or $d = 322$ mm ◀

PROBLEM 3.68



A plate in the shape of a parallelogram is acted upon by two couples. Determine (*a*) the moment of the couple formed by the two 21-N forces, (*b*) the perpendicular distance between the 12-N forces if the resultant of the two couples is zero, (*c*) the value of α if the resultant couple is $1.8\ \text{N}\cdot\text{m}$ clockwise and *d* is 1.05 m.

SOLUTION



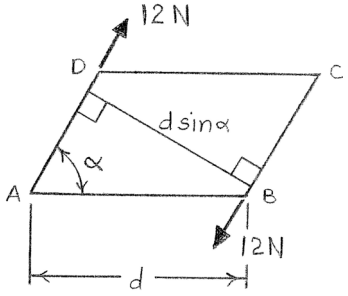
(*a*) Have $M_1 = d_1 F_1$

where $d_1 = 0.4\ \text{m}$

$F_1 = 21\ \text{N}$

$\therefore\ M_1 = (0.4\ \text{m})(21\ \text{N}) = 8.4\ \text{N}\cdot\text{m}$

or $\mathbf{M}_1 = 8.40\ \text{N}\cdot\text{m}\ \circlearrowright$ ◀



(*b*) Have $\mathbf{M}_1 + \mathbf{M}_2 = 0$

or $8.40\ \text{N}\cdot\text{m} - d_2(12\ \text{N}) = 0$

$\therefore\ d_2 = 0.700\ \text{m}$ ◀

(*c*) Have $\mathbf{M}_{\text{total}} = \mathbf{M}_1 + \mathbf{M}_2$

or $1.8\ \text{N}\cdot\text{m} = 8.40\ \text{N}\cdot\text{m} - (1.05\ \text{m})(\sin\alpha)(12\ \text{N})$

$\therefore\ \sin\alpha = 0.52381$

and $\alpha = 31.588°$

or $\alpha = 31.6°$ ◀