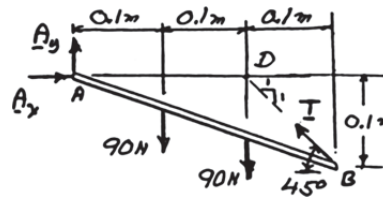


PROBLEM 4.25

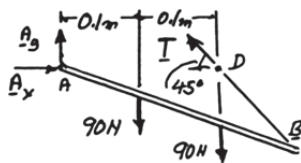
A rod AB hinged at A and attached at B to cable BD supports the loads shown. Knowing that $d = 200$ mm, determine (a) the tension in cable BD , (b) the reaction at A .

SOLUTION

Free-Body Diagram:



(a) Move T along BD until it acts at Point D .



$$+\circlearrowleft \Sigma M_A = 0: (T \sin 45^\circ)(0.2 \text{ m}) + (90 \text{ N})(0.1 \text{ m}) + (90 \text{ N})(0.2 \text{ m}) = 0$$

$$T = 190.919 \text{ N}$$

$$T = 190.9 \text{ N} \quad \blacktriangleleft$$

(b)

$$\pm \rightarrow \Sigma F_x = 0: A_x - (190.919 \text{ N}) \cos 45^\circ = 0$$

$$A_x = +135.0 \text{ N}$$

$$A_x = 135.0 \text{ N} \quad \rightarrow$$

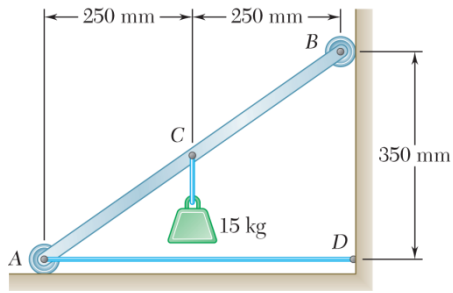
$$+\uparrow \Sigma F_y = 0: A_y - 90 \text{ N} - 90 \text{ N} + (190.919 \text{ N}) \sin 45^\circ = 0$$

$$A_y = +45.0 \text{ N}$$

$$A_y = 45.0 \text{ N} \quad \uparrow$$

$$\mathbf{A} = 142.3 \text{ N} \quad \nearrow 18.43^\circ \quad \blacktriangleleft$$



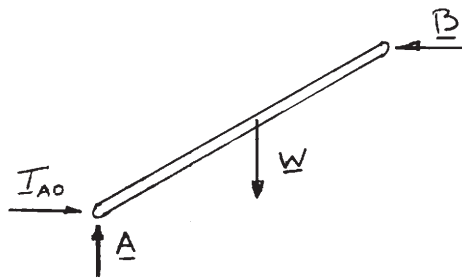


PROBLEM 4.40

A light bar AB supports a 15-kg block at its midpoint C . Rollers at A and B rest against frictionless surfaces, and a horizontal cable AD is attached at A . Determine (a) the tension in cable AD , (b) the reactions at A and B .

SOLUTION

Free-Body Diagram:



$$W = (15 \text{ kg})(9.81 \text{ m/s}^2) = 147.150 \text{ N}$$

$$(a) \quad \pm \rightarrow \Sigma F_x = 0: T_{AD} - 105.107 \text{ N} = 0$$

$$T_{AD} = 105.1 \text{ N} \quad \blacktriangleleft$$

$$(b) \quad + \uparrow \Sigma F_y = 0: A - W = 0$$

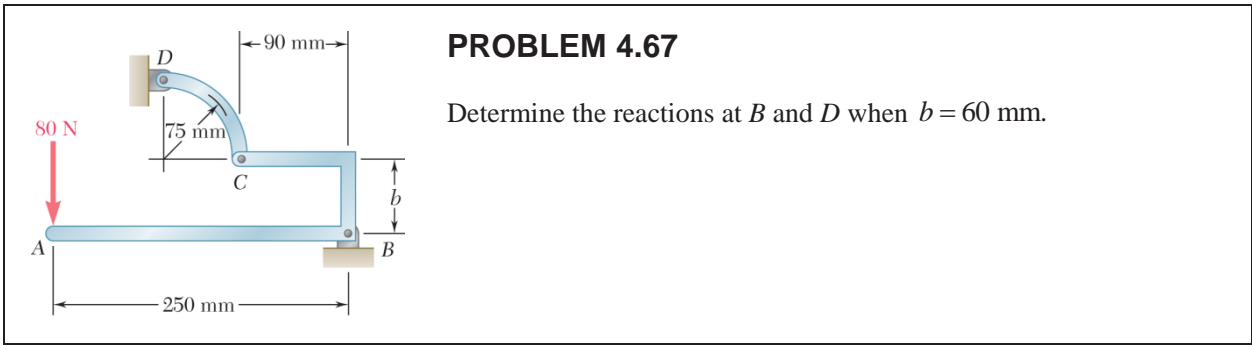
$$A - 147.150 \text{ N} = 0$$

$$A = 147.2 \text{ N} \quad \blacktriangleup$$

$$+ \curvearrowright \Sigma M_A = 0: B(350 \text{ mm}) - (147.150 \text{ N})(250 \text{ mm}) = 0$$

$$B = 105.107 \text{ N}$$

$$B = 105.1 \text{ N} \quad \blacktriangleleft$$



PROBLEM 4.67

Determine the reactions at B and D when $b = 60$ mm.

SOLUTION

Since CD is a two-force member, the line of action of reaction at D must pass through Points C and D .

Free-Body Diagram:
(Three-force body)

Reaction at B must pass through E , where the reaction at D and the 80-N force intersect.

$$\tan \beta = \frac{220 \text{ mm}}{250 \text{ mm}}$$

$$\beta = 41.348^\circ$$

Force triangle

Law of sines:

$$\frac{80 \text{ N}}{\sin 3.652^\circ} = \frac{B}{\sin 45^\circ} = \frac{D}{\sin 131.348^\circ}$$

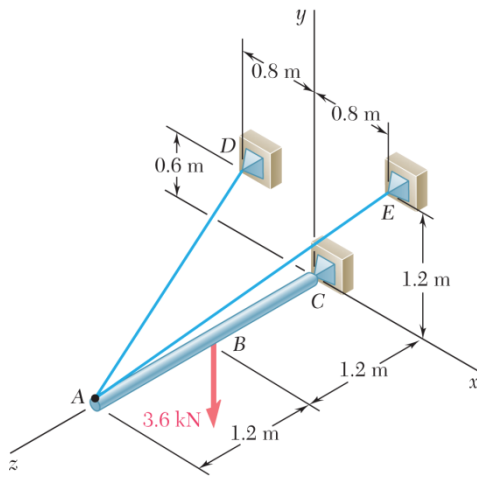
$$B = 888.0 \text{ N}$$

$$D = 942.8 \text{ N}$$

B = 888 N ↘ 41.3° D = 943 N ↘ 45.0° ◀

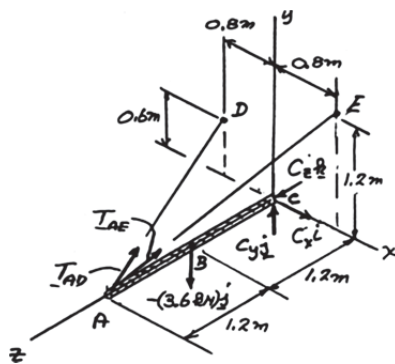
PROBLEM 4.108

A 2.4-m boom is held by a ball-and-socket joint at C and by two cables AD and AE. Determine the tension in each cable and the reaction at C.



SOLUTION

Free-Body Diagram: Five unknowns and six equations of equilibrium, but equilibrium is maintained ($\Sigma M_{AC} = 0$).



$$\mathbf{r}_B = 1.2\mathbf{k}$$

$$\mathbf{r}_A = 2.4\mathbf{k}$$

$$\overline{AD} = -0.8\mathbf{i} + 0.6\mathbf{j} - 2.4\mathbf{k} \quad AD = 2.6 \text{ m}$$

$$\overline{AE} = 0.8\mathbf{i} + 1.2\mathbf{j} - 2.4\mathbf{k} \quad AE = 2.8 \text{ m}$$

$$T_{AD} = \frac{\overline{AD}}{AD} = \frac{T_{AD}}{2.6} (-0.8\mathbf{i} + 0.6\mathbf{j} - 2.4\mathbf{k})$$

$$T_{AE} = \frac{\overline{AE}}{AE} = \frac{T_{AE}}{2.8} (0.8\mathbf{i} + 1.2\mathbf{j} - 2.4\mathbf{k})$$

$$\Sigma M_C = 0: \mathbf{r}_A \times \mathbf{T}_{AD} + \mathbf{r}_A \times \mathbf{T}_{AE} + \mathbf{r}_B \times (-3 \text{ kN})\mathbf{j} = 0$$

$$\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 0 & 2.4 \\ -0.8 & 0.6 & -2.4 \end{vmatrix} \frac{T_{AD}}{2.6} + \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 0 & 2.4 \\ 0.8 & 1.2 & -2.4 \end{vmatrix} \frac{T_{AE}}{2.8} + 1.2\mathbf{k} \times (-3.6 \text{ kN})\mathbf{j} = 0$$

Equate coefficients of unit vectors to zero:

$$\mathbf{i}: -0.55385T_{AD} - 1.02857T_{AE} + 4.32 = 0 \quad (1)$$

$$\mathbf{j}: -0.73846T_{AD} + 0.68671T_{AE} = 0$$

$$T_{AD} = 0.92857T_{AE} \quad (2)$$

From Eq. (1): $-0.55385(0.92857)T_{AE} - 1.02857T_{AE} + 4.32 = 0$

$$1.54286T_{AE} = 4.32$$

$$T_{AE} = 2.800 \text{ kN}$$

$$T_{AE} = 2.80 \text{ kN} \quad \blacktriangleleft$$

PROBLEM 4.108 (Continued)

From Eq. (2): $T_{AD} = 0.92857(2.80) = 2.600 \text{ kN}$ $T_{AD} = 2.60 \text{ kN} \blacktriangleleft$

$$\Sigma F_x = 0: C_x - \frac{0.8}{2.6}(2.6 \text{ kN}) + \frac{0.8}{2.8}(2.8 \text{ kN}) = 0 \quad C_x = 0$$

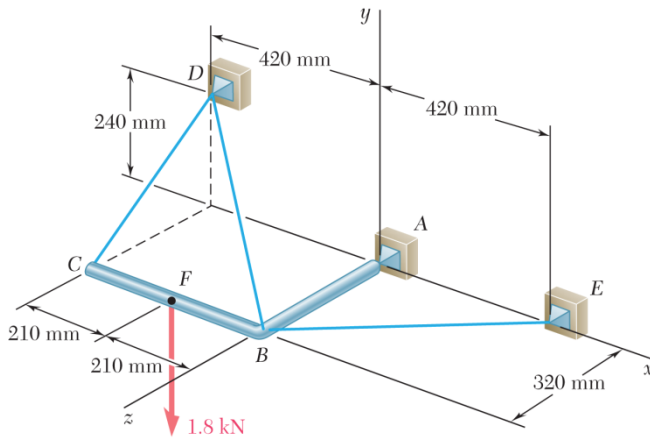
$$\Sigma F_y = 0: C_y + \frac{0.6}{2.6}(2.6 \text{ kN}) + \frac{1.2}{2.8}(2.8 \text{ kN}) - (3.6 \text{ kN}) = 0 \quad C_y = 1.800 \text{ kN}$$

$$\Sigma F_z = 0: C_z - \frac{2.4}{2.6}(2.6 \text{ kN}) - \frac{2.4}{2.8}(2.8 \text{ kN}) = 0 \quad C_z = 4.80 \text{ kN}$$

$$\mathbf{C} = (1.800 \text{ kN})\mathbf{j} + (4.80 \text{ kN})\mathbf{k} \blacktriangleleft$$

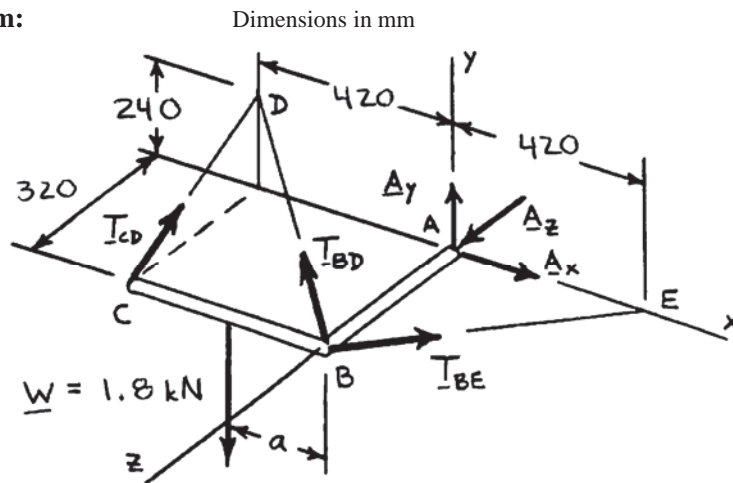
PROBLEM 4.123

The rigid L-shaped member ABC is supported by a ball-and-socket joint at A and by three cables. If a 1.8-kN load is applied at F , determine the tension in each cable.



SOLUTION

Free-Body Diagram:



In this problem:

$$a = 210\text{ mm}$$

We have

$$\overline{CD} = (240\text{ mm})\mathbf{j} - (320\text{ mm})\mathbf{k} \quad CD = 400\text{ mm}$$

$$\overline{BD} = -(420\text{ mm})\mathbf{i} + (240\text{ mm})\mathbf{j} - (320\text{ mm})\mathbf{k} \quad BD = 580\text{ mm}$$

$$\overline{BE} = (420\text{ mm})\mathbf{i} - (320\text{ mm})\mathbf{k} \quad BE = 528.02\text{ mm}$$

Thus,

$$T_{CD} = T_{CD} \frac{\overline{CD}}{CD} = T_{CD}(0.6\mathbf{j} - 0.8\mathbf{k})$$

$$T_{BD} = T_{BD} \frac{\overline{BD}}{BD} = T_{BD}(-0.72414\mathbf{i} + 0.41379\mathbf{j} - 0.55172\mathbf{k})$$

$$T_{BE} = T_{BE} \frac{\overline{BE}}{BE} = T_{BE}(0.79542\mathbf{i} - 0.60604\mathbf{k})$$

$$\Sigma \mathbf{M}_A = 0: (\mathbf{r}_C \times \mathbf{T}_{CD}) + (\mathbf{r}_B \times \mathbf{T}_{BD}) + (\mathbf{r}_B \times \mathbf{T}_{BE}) + (\mathbf{r}_W \times \mathbf{W}) = 0$$

PROBLEM 4.123 (Continued)

Noting that

$$\mathbf{r}_C = -(420 \text{ mm})\mathbf{i} + (320 \text{ mm})\mathbf{k}$$

$$\mathbf{r}_B = (320 \text{ mm})\mathbf{k}$$

$$\mathbf{r}_W = -a\mathbf{i} + (320 \text{ mm})\mathbf{k}$$

and using determinants, we write

$$\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -420 & 0 & 320 \\ 0 & 0.6 & -0.8 \end{vmatrix} T_{CD} + \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 0 & 320 \\ -0.72414 & 0.41379 & -0.55172 \end{vmatrix} T_{BD} \\ + \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 0 & 320 \\ 0.79542 & 0 & -0.60604 \end{vmatrix} T_{BE} + \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -a & 0 & 320 \\ 0 & -1.8 & 0 \end{vmatrix} = 0$$

Equating to zero the coefficients of the unit vectors,

$$\mathbf{i}: \quad -192T_{CD} - 132.413T_{BD} + 576 = 0 \quad (1)$$

$$\mathbf{j}: \quad -336T_{CD} - 231.72T_{BD} + 254.53T_{BE} = 0 \quad (2)$$

$$\mathbf{k}: \quad -252T_{CD} + 1.8a = 0 \quad (3)$$

Recalling that $a = 210 \text{ mm}$, Eq. (3) yields

$$T_{CD} = \frac{1.8(210)}{252} = 1.500 \text{ kN} \quad T_{CD} = 1.500 \text{ kN} \quad \blacktriangleleft$$

From Eq. (1): $-192(1.5) - 132.413T_{BD} + 576 = 0$

$$T_{BD} = 2.1751 \text{ kN} \quad T_{BD} = 2.18 \text{ kN} \quad \blacktriangleleft$$

From Eq. (2): $-336(1.5) - 231.72(2.1751) + 254.53T_{BE} = 0$

$$T_{BE} = 3.9603 \text{ kN} \quad T_{BE} = 3.96 \text{ kN} \quad \blacktriangleleft$$