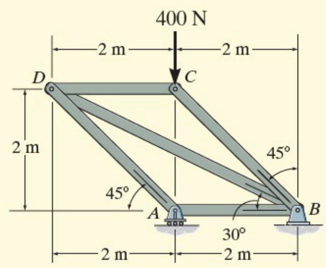
Solution Assignment 1

1.



(a)

SOLUTION

Since joint C has one known and only two unknown forces acting on it, it is possible to start at this joint, then analyze joint D, and finally joint A. This way the support reactions will not have to be determined prior to starting the analysis.

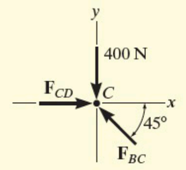
Joint C. By inspection of the force equilibrium, Fig. 5–9b, it can be seen that both members BC and CD must be in compression.

$+\uparrow \Sigma F_y = 0; \qquad F_{BC} \sin 45° - 400 \text{ N} = 0$

$F_{BC} = 565.69 \text{ N} = 566 \text{ N (C)}$ *Ans.*

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad F_{CD} - (565.69 \text{ N}) \cos 45° = 0$

$F_{CD} = 400 \text{ N (C)}$ *Ans.*



(b)

Joint D. Using the result $F_{CD} = 400$ N (C), the force in members BD and AD can be found by analyzing the equilibrium of joint D. We will assume $\mathbf{F}_{AD}$ and $\mathbf{F}_{BD}$ are both tensile forces, Fig. 5–9c. The x', y' coordinate system will be established so that the x' axis is directed along $\mathbf{F}_{BD}$. This way, we will eliminate the need to solve two equations simultaneously. Now $\mathbf{F}_{AD}$ can be obtained *directly* by applying $\Sigma F_{y'} = 0$.

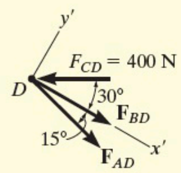
$+\nearrow \Sigma F_{y'} = 0; \qquad -F_{AD} \sin 15° - 400 \sin 30° = 0$

$F_{AD} = -772.74 \text{ N} = 773 \text{ N (C)}$ *Ans.*

The negative sign indicates that $\mathbf{F}_{AD}$ is a compressive force. Using this result,

$+\searrow \Sigma F_{x'} = 0; \quad F_{BD} + (-772.74 \cos 15°) - 400 \cos 30° = 0$

$F_{BD} = 1092.82 \text{ N} = 1.09 \text{ kN (T)}$ *Ans.*

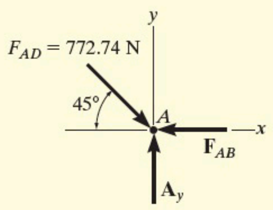


(c)

Joint A. The force in member AB can be found by analyzing the equilibrium of joint A, Fig. 5–9d. We have

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad (772.74 \text{ N}) \cos 45° - F_{AB} = 0$

$F_{AB} = 546.41 \text{ N (C)} = 546 \text{ N (C)}$ *Ans.*



(d)

Fig. 5–9

2.

SOLUTION I

Free-Body Diagrams. By inspection it can be seen that AB is a two-force member. The free-body diagrams are shown in Fig. 5–20*b*.

Equations of Equilibrium. The *three unknowns* can be determined by applying the three equations of equilibrium to member CB.

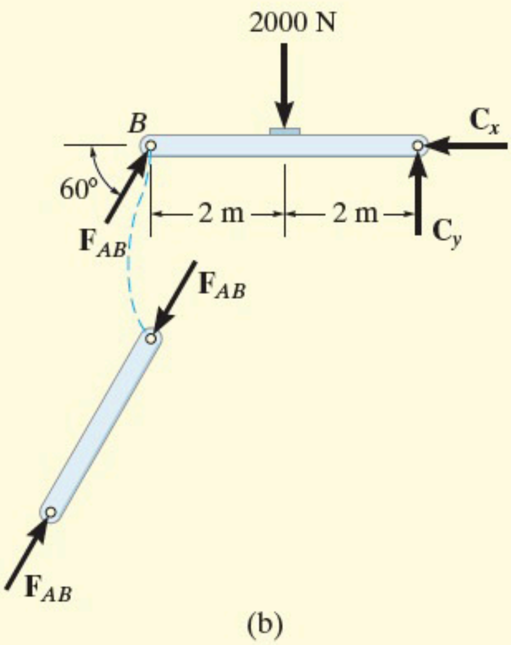
$$\circlearrowleft + \Sigma M_C = 0;\quad 2000\text{ N}(2\text{ m}) - (F_{AB}\sin 60^\circ)(4\text{ m}) = 0 \quad F_{AB} = 1154.7\text{ N}$$

$$\xrightarrow{+} \Sigma F_x = 0;\quad 1154.7\cos 60^\circ\text{ N} - C_x = 0 \qquad C_x = 577\text{ N} \qquad \textit{Ans.}$$

$$+\uparrow \Sigma F_y = 0;\quad 1154.7\sin 60^\circ\text{ N} - 2000\text{ N} + C_y = 0 \quad C_y = 1000\text{ N} \qquad \textit{Ans.}$$

SOLUTION II

Free-Body Diagrams. If one does not recognize that AB is a two-force member, then more work is involved in solving this problem. The free-body diagrams are shown in Fig. 5–20*c*.



(b)

Equations of Equilibrium. The *six unknowns* are determined by applying the three equations of equilibrium to each member.

Member AB

$$\circlearrowleft + \Sigma M_A = 0; \quad B_x(3 \sin 60^\circ \text{ m}) - B_y(3 \cos 60^\circ \text{ m}) = 0 \qquad (1)$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - B_x = 0 \qquad (2)$$

$$+\uparrow \Sigma F_y = 0; \quad A_y - B_y = 0 \qquad (3)$$

Member BC

$$\circlearrowleft + \Sigma M_C = 0; \quad 2000 \text{ N}(2 \text{ m}) - B_y(4 \text{ m}) = 0 \qquad (4)$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad B_x - C_x = 0 \qquad (5)$$

$$+\uparrow \Sigma F_y = 0; \quad B_y - 2000 \text{ N} + C_y = 0 \qquad (6)$$

The results for C_x and C_y can be determined by solving these equations in the following sequence: 4, 1, 5, then 6. The results are

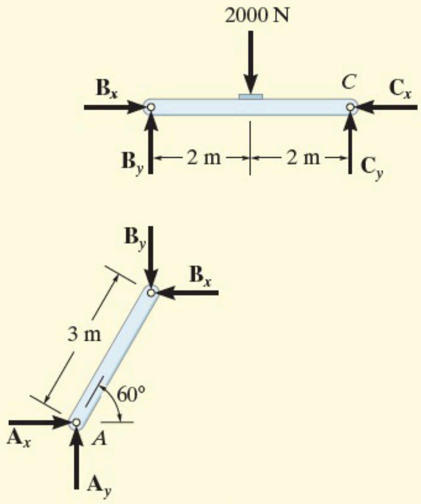
$$B_y = 1000 \text{ N}$$

$$B_x = 577 \text{ N}$$

$$C_x = 577 \text{ N} \qquad \textit{Ans.}$$

$$C_y = 1000 \text{ N} \qquad \textit{Ans.}$$

By comparison, Solution I is simpler since the requirement that F_{AB} in Fig. 5–20*b* be equal, opposite, and collinear at the ends of member *AB* automatically satisfies Eqs. 1, 2, and 3 above and therefore eliminates the need to write these equations. *As a result, save yourself some time and effort by always identifying the two-force members before starting the analysis!*



(c)

Fig. 5–20

3.

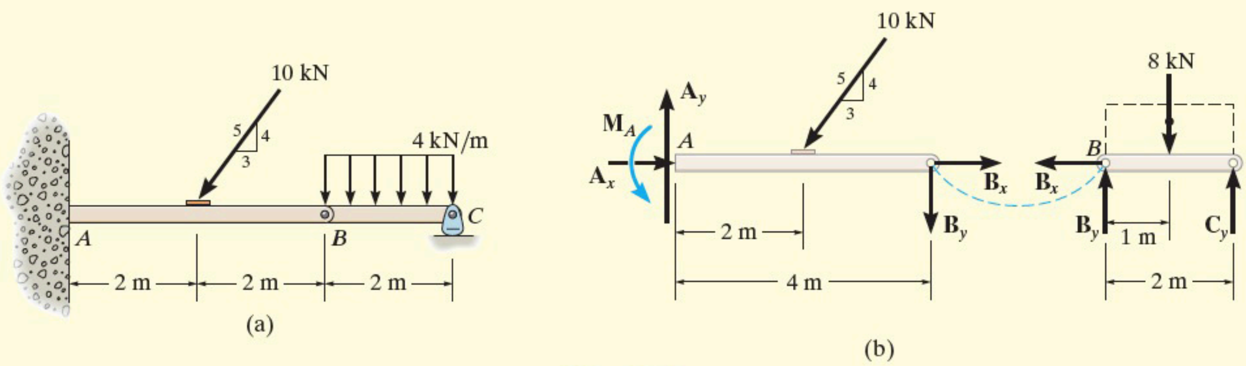


Fig. 5–21

SOLUTION

Free-Body Diagrams. By inspection, if we consider a free-body diagram of the *entire beam ABC*, there will be three unknown reactions at *A* and one at *C*. These four unknowns cannot all be obtained from the three available equations of equilibrium, and so for the solution it will become necessary to dismember the beam into its two segments, as shown in Fig. 5–21*b*.

Equations of Equilibrium. The six unknowns are determined as follows:

Segment BC

$$\overset{+}{\leftarrow} \Sigma F_x = 0; \qquad B_x = 0$$

$$\circlearrowleft + \Sigma M_B = 0; \qquad -8\text{ kN}(1\text{ m}) + C_y(2\text{ m}) = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad B_y - 8\text{ kN} + C_y = 0$$

Segment AB

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad A_x - (10\text{ kN})\left(\tfrac{3}{5}\right) + B_x = 0$$

$$\circlearrowleft + \Sigma M_A = 0; \qquad M_A - (10\text{ kN})\left(\tfrac{4}{5}\right)(2\text{ m}) - B_y(4\text{ m}) = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad A_y - (10\text{ kN})\left(\tfrac{4}{5}\right) - B_y = 0$$

Solving each of these equations successively, using previously calculated results, we obtain

$A_x = 6\text{ kN}$ $\quad A_y = 12\text{ kN}$ $\quad M_A = 32\text{ kN}\cdot\text{m}$ *Ans.*

$B_x = 0$ $\quad B_y = 4\text{ kN}$

$C_y = 4\text{ kN}$ *Ans.*