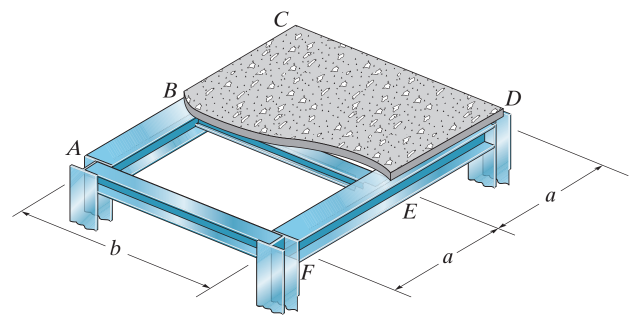
2–1. The steel framework is used to support the reinforced stone concrete slab that is used for an office. The slab is 200 mm thick. Sketch the loading that acts along members BE and FED. Take $a = 2$ m, $b = 5$ m. *Hint:* See Tables 1.2 and 1.4.



SOLUTION

Beam *BE*. Since $\frac{b}{a} = \frac{5\text{ m}}{2\text{ m}} = 2.5$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this beam is rectangular, as shown in Fig. *a,* and the intensity of the uniform distributed load is

200 mm thick reinforced stone concrete slab:

$$(23.6\text{ kN/m}^3)(0.2\text{ m})(2\text{ m}) = 9.44\text{ kN/m}$$

Live load for office: $(2.40\text{ kN/m}^2)(2\text{ m}) = 4.80\text{ kN/m}$

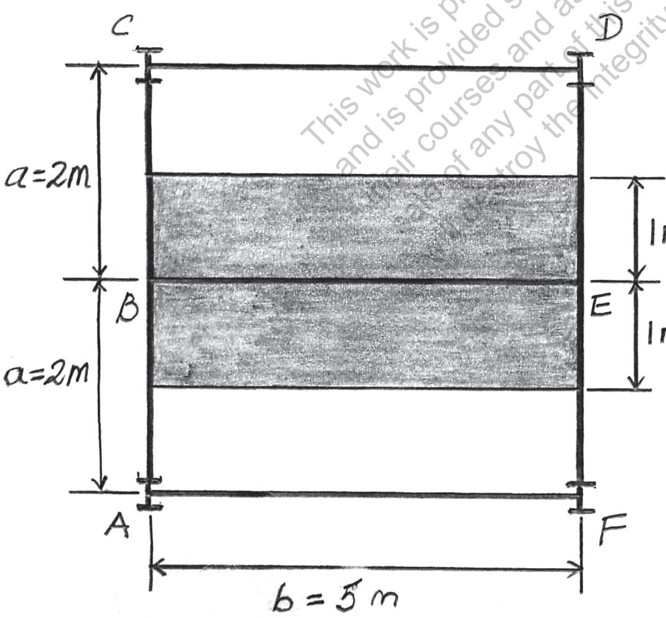
$$14.24\text{ kN/m} \qquad \textbf{Ans.}$$

Due to symmetry the vertical reactions at B and E are

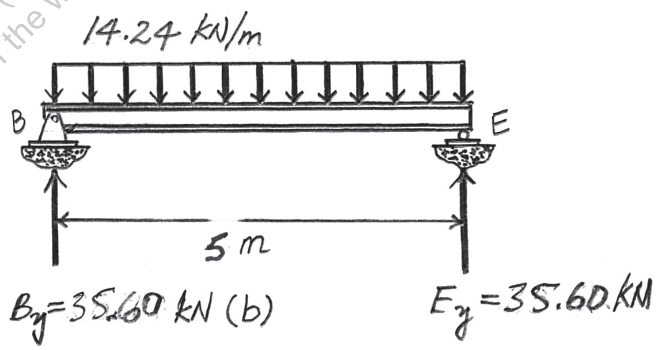
$$B_y = E_y = (14.24\text{ kN/m})(5)/2 = 35.6\text{ kN}$$

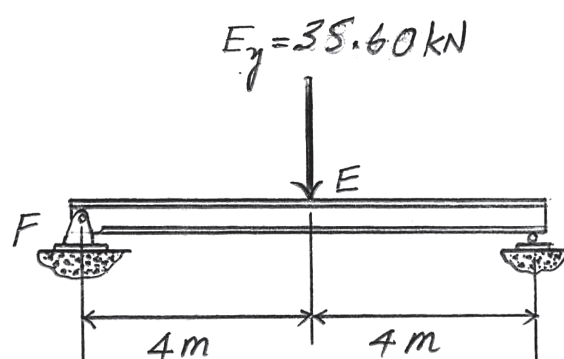
The loading diagram for beam BE is shown in Fig. *b*.

Beam *FED*. The only load this beam supports is the vertical reaction of beam BE at E, which is $E_y = 35.6$ kN. The loading diagram for this beam is shown in Fig. *c*.



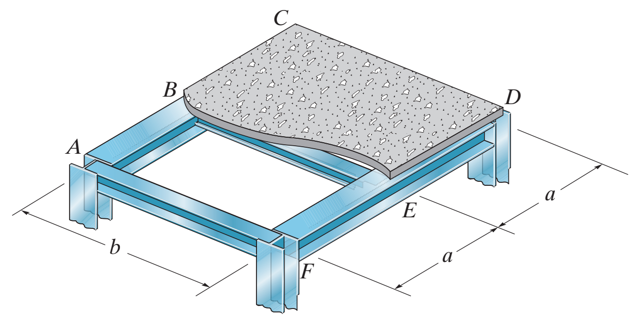
(a)





(C)

2–2. Solve Prob. 2–1 with $a = 3$ m, $b = 4$ m.



SOLUTION

Beam *BE*. Since $\frac{b}{a} = \frac{4}{3} < 2$, the concrete slab will behave as a two-way slab. Thus, the tributary area for this beam is the hexagonal area shown in Fig. *a*, and the maximum intensity of the distributed load is

200 mm thick reinforced stone concrete slab: $(23.6 \text{ kN/m}^3)(0.2 \text{ m})(3 \text{ m}) = 14.16 \text{ kN/m}$

Live load for office: $[(2.40 \text{ kN/m}^2)(3 \text{ m})] = 7.20 \text{ kN/m}$

21.36 kN/m **Ans.**

Due to symmetry, the vertical reactions at B and E are

$$B_y = E_y = \frac{2\left[\frac{1}{2}(21.36 \text{ kN/m})(1.5 \text{ m})\right] + (21.36 \text{ kN/m})(1 \text{ m})}{2}$$

$$= 26.70 \text{ kN}$$

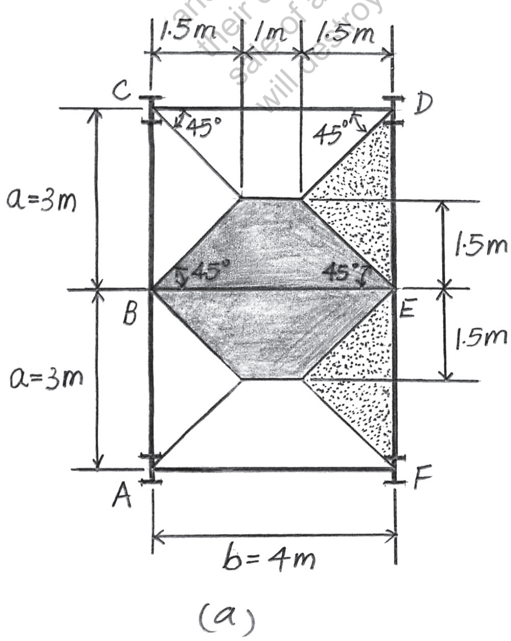
The loading diagram for beam *BE* is shown in Fig. *b*.

Beam *FED*. The loadings that are supported by this beam are the vertical reaction of beam *BE* at *E* which is $E_y = 26.70$ kN and the triangular distributed load of which its tributary area is the triangular area shown in Fig. *a*. Its maximum intensity is

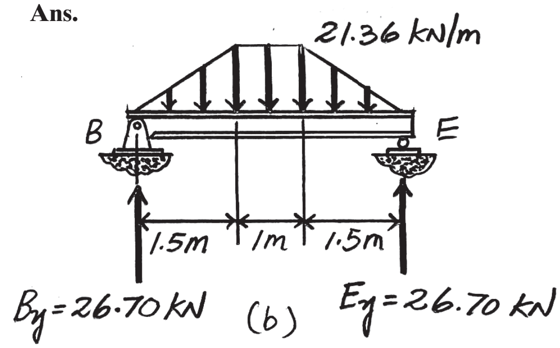
200 mm thick reinforced stone concrete slab: $(23.6 \text{ kN/m}^3)(0.2 \text{ m})(1.5 \text{ m}) = 7.08 \text{ kN/m}$

Live load for office: $(2.40 \text{ kN/m}^2)(1.5 \text{ m}) = \frac{3.60 \text{ kN/m}}{10.68 \text{ kN/m}}$ **Ans.**

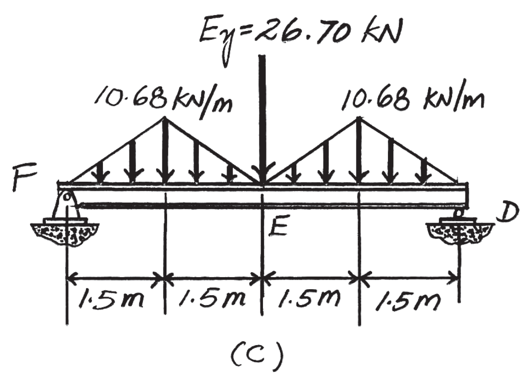
The loading diagram for beam *FED* is shown in Fig. *c*.



(a)

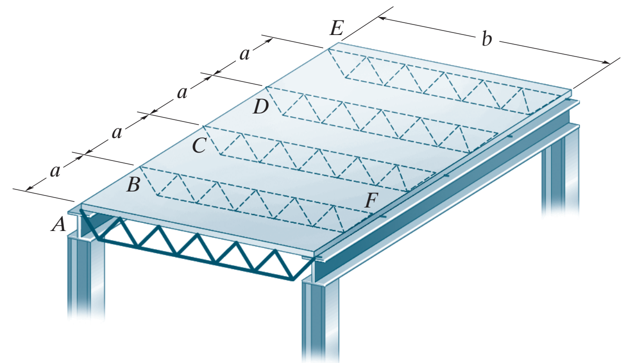


(b)



(c)

2–3. The floor system used in a school classroom consists of a 4-in. reinforced stone concrete slab. Sketch the loading that acts along the joist BF and side girder $ABCDE$. Set $a = 10$ ft, $b = 30$ ft. *Hint:* See Tables 1.2 and 1.4.



SOLUTION

Joist *BF*. Since $\frac{b}{a} = \frac{30\text{ ft}}{10\text{ ft}} = 3$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this joist is the rectangular area shown in Fig. *a,* and the intensity of the uniform distributed load is

4-in.-thick reinforced stone concrete slab: $(0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(10\text{ ft}) = 0.5\text{ k/ft}$

Live load for classroom: $(0.04\text{ k/ft}^2)(10\text{ ft}) \quad = 0.4\text{ k/ft}$

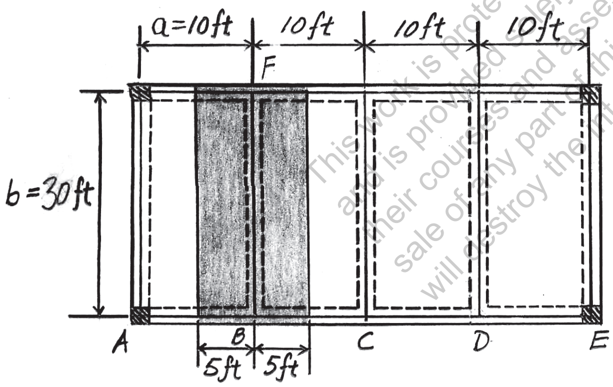
0.9 k/ft **Ans.**

Due to symmetry, the vertical reactions at B and F are

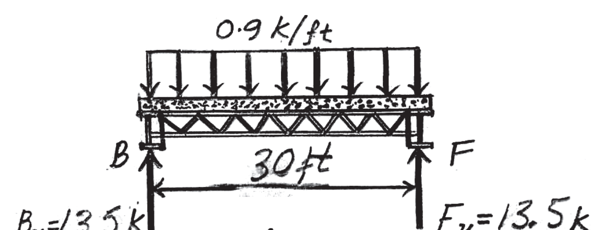
$$B_y = F_y = (0.9\text{ k/ft})(30\text{ ft})/2 = 13.5\text{ k} \qquad \textbf{Ans.}$$

The loading diagram for joist BF is shown in Fig. *b*.

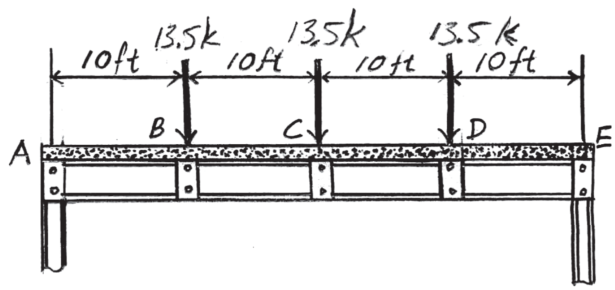
Girder *ABCDE*. The loads that act on this girder are the vertical reactions of the joists at B, C, and D, which are $B_y = C_y = D_y = 13.5$ k. The loading diagram for this girder is shown in Fig. *c*.



(a)

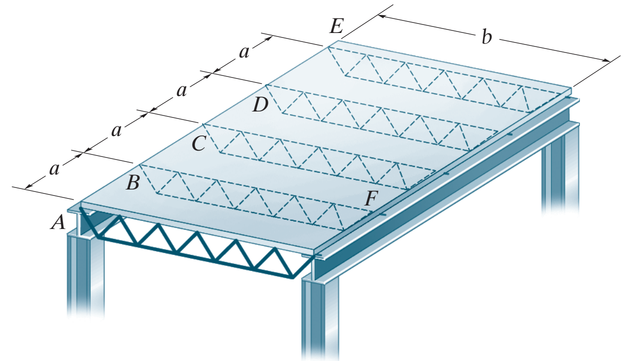


(b)



(c)

***2–4.** Solve Prob. 2–3 with $a = 10$ ft, $b = 15$ ft.



SOLUTION

Joist *BF*. Since $\frac{b}{a} = \frac{15\text{ ft}}{10\text{ ft}} = 1.5 < 2$, the concrete slab will behave as a two-way slab. Thus, the tributary area for the joist is the hexagonal area, as shown in Fig. *a*, and the maximum intensity of the distributed load is

4-in.-thick reinforced stone concrete slab: $(0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(10\text{ ft}) = 0.5\text{ k/ft}$

Live load for classroom: $(0.04\text{ k/ft}^2)(10\text{ ft}) = 0.4\text{ k/ft}$

0.9 k/ft **Ans.**

Due to symmetry, the vertical reactions at B and G are

$$B_y = F_y = \frac{2\left[\frac{1}{2}(0.9\text{ k/ft})(5\text{ ft})\right] + (0.9\text{ k/ft})(5\text{ ft})}{2} = 4.50\text{ k} \quad \textbf{Ans.}$$

The loading diagram for beam BF is shown in Fig. *b*.

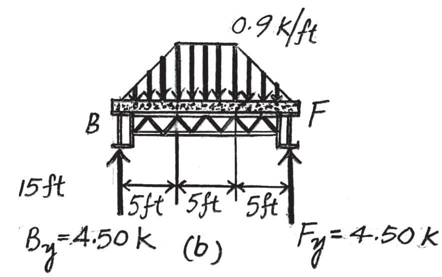
Girder *ABCDE*. The loadings that are supported by this girder are the vertical reactions of the joist at B, C and D, which are $B_y = C_y = D_y = 4.50$ k, and the triangular distributed load shown in Fig. *a*. Its maximum intensity is

4-in.-thick reinforced stone concrete slab:

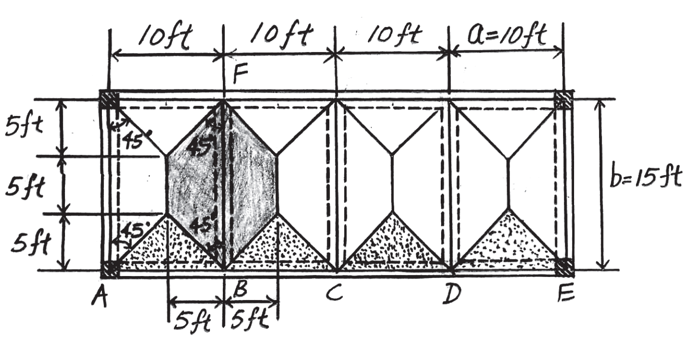
$$(0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(5\text{ ft}) = 0.25\text{ k/ft}$$

Live load for classroom: $(0.04\text{ k/ft}^2)(5\text{ ft}) = \frac{0.20\text{ k/ft}}{0.45\text{ k/ft}}$ **Ans.**

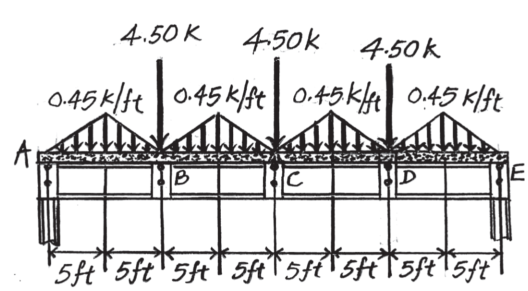
The loading diagram for the girder $ABCDE$ is shown in Fig. *c*.



(b)

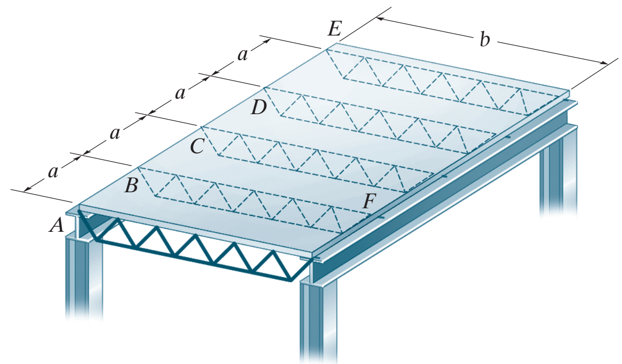


(a)



(c)

2–5. Solve Prob. 2–3 with $a = 7.5$ ft, $b = 20$ ft.



SOLUTION

Beam *BF*. Since $\frac{b}{a} = \frac{20\text{ ft}}{7.5\text{ ft}} = 2.7 > 2$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this beam is a rectangle, as shown in Fig. *a*, and the intensity of the distributed load is

4-in.-thick reinforced stone concrete slab: $(0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(7.5\text{ ft}) = 0.375\text{ k/ft}$

Live load from classroom: $(0.04\text{ k/ft}^2)(7.5\text{ ft}) = 0.300\text{ k/ft}$

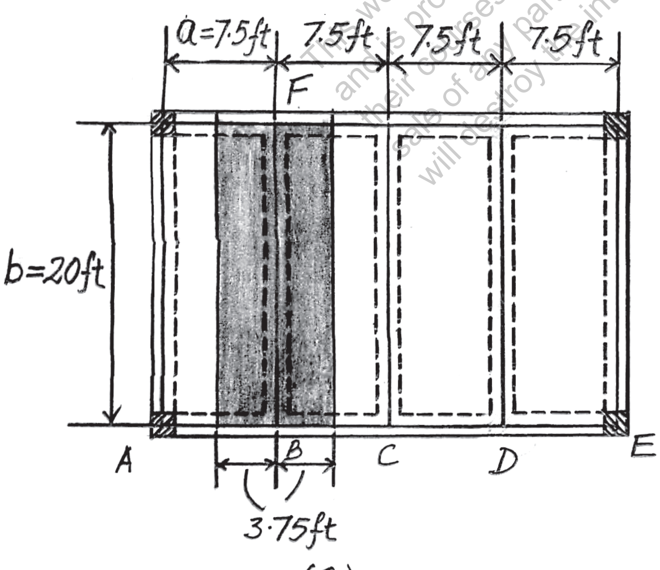
0.675 k/ft **Ans.**

Due to symmetry, the vertical reactions at B and F are

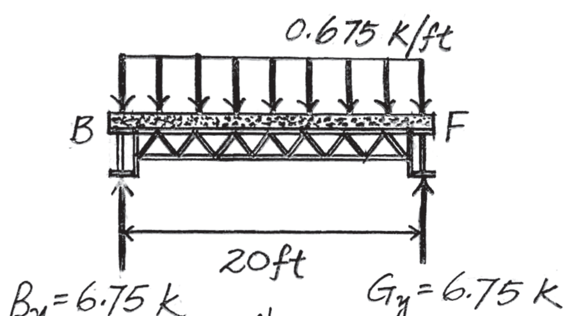
$$B_y = F_y = \frac{(0.675\text{ k/ft})(20\text{ ft})}{2} = 6.75\text{ k}$$ **Ans.**

The loading diagram for beam *BF* is shown in Fig. *b*.

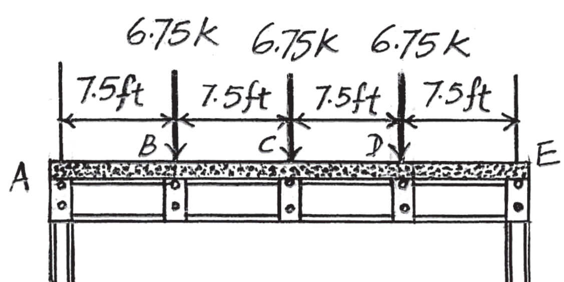
Beam *ABCD*. The loading diagram for this beam is shown in Fig. *c*.



(a)

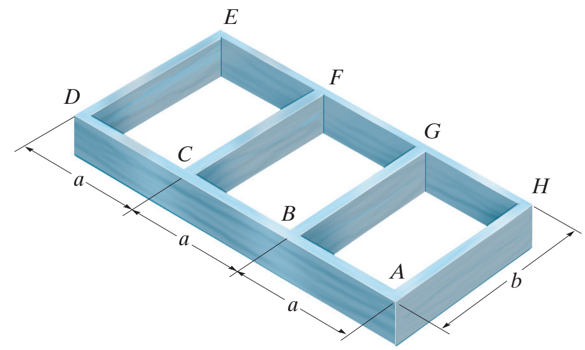


(b)



(c)

2–6. The frame is used to support a 2-in.-thick plywood floor of a residential dwelling. Sketch the loading that acts along members BG and $ABCD$. Set $a = 6$ ft, $b = 18$ ft. *Hint:* See Tables 1.2 and 1.4.



SOLUTION

Beam *BG*. Since $\frac{b}{a} = \frac{18 \text{ ft}}{6 \text{ ft}} = 3 > 2$, the plywood platform will behave as one-way slab. Thus, the tributary area for the beam is rectangular and shown shaded in Fig. *a*. The intensity of the uniform distributed load is

$$\text{2-in.-thick plywood platform: } \left(36 \frac{\text{lb}}{\text{ft}^3}\right)\left(\frac{2}{12} \text{ ft}\right)(6 \text{ ft}) = 36 \text{ lb/ft}$$

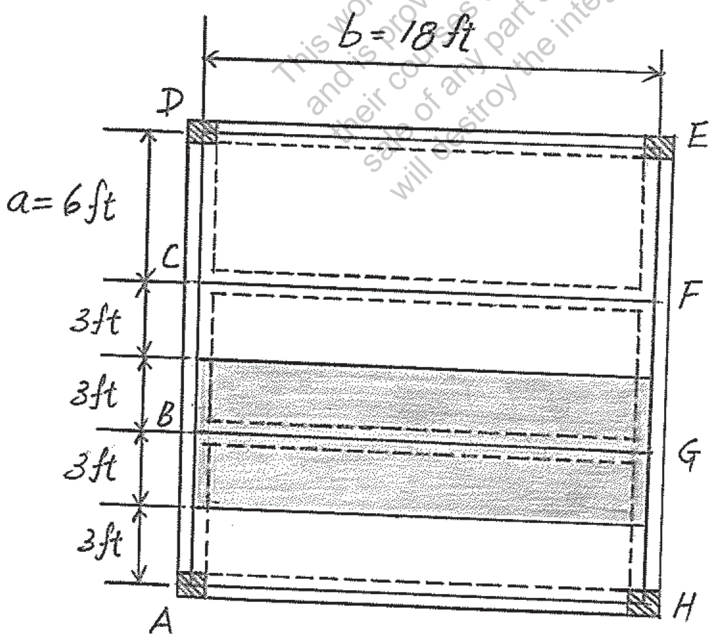
$$\text{Live load for residential dwelling: } \left(40 \frac{\text{lb}}{\text{ft}^2}\right)(6 \text{ ft}) = \frac{240 \text{ lb/ft}}{276 \text{ lb/ft}} \qquad \textbf{Ans.}$$

Due to symmetry, the vertical reaction at B and G are

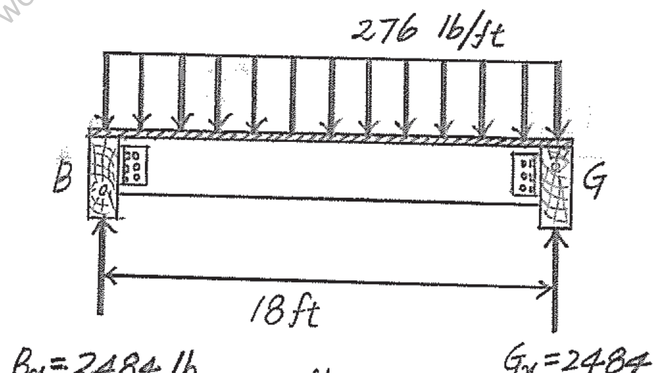
$$B_y = G_y = \frac{(276 \text{ lb/ft})(18 \text{ ft})}{2} = 2484 \text{ lb} \qquad \textbf{Ans.}$$

The loading diagram for beam BG is shown in Fig. *b*.

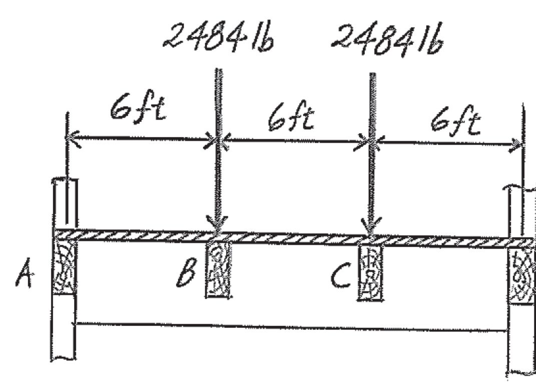
Beam *ABCD*. The loads that act on this beam are the vertical reaction of beams BG and CF at B and C respectively, which are $C_y = B_y = 2484$ lb. The loading diagram of this beam is shown in Fig. *c*.



(a)

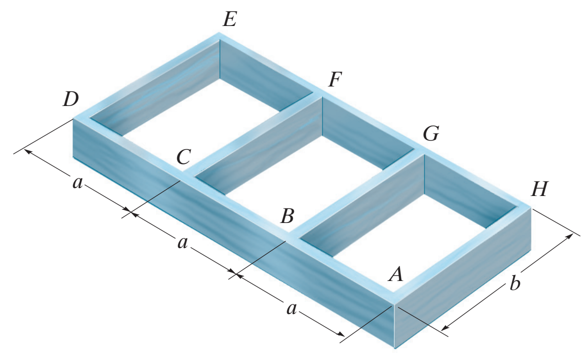


(b)



(c)

2–7. Solve Prob. 2–6, with $a = 10$ ft, $b = 10$ ft.

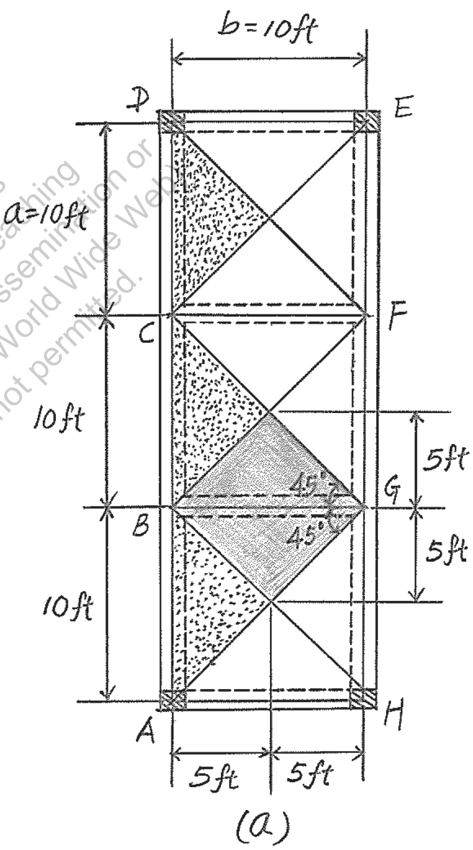


SOLUTION

Beam *BG*. Since $\dfrac{b}{a} = \dfrac{10\text{ ft}}{10\text{ ft}} = 1 < 2$, the plywood platform will behave as a two-way slab. Thus, the tributary area for this beam is the shaded square area shown in Fig. *a*, and the maximum intensity of the triangular distributed load is

$$\text{2-in.-thick plywood platform: } \left(36\,\frac{\text{lb}}{\text{ft}^3}\right)\left(\frac{2}{12}\text{ ft}\right)(10\text{ ft}) = 60\text{ lb/ft}$$

$$\text{Live load for residential dwelling: } \left(40\,\frac{\text{lb}}{\text{ft}^2}\right)(10\text{ ft}) \quad = \frac{400\text{ lb/ft}}{460\text{ lb/ft}} \qquad \textbf{Ans.}$$



Due to symmetry, the vertical reaction at B and G are

$$B_y = G_y = \frac{\frac{1}{2}(460\text{ lb/ft})(10\text{ ft})}{2} = 1150\text{ lb} \qquad \textbf{Ans.}$$

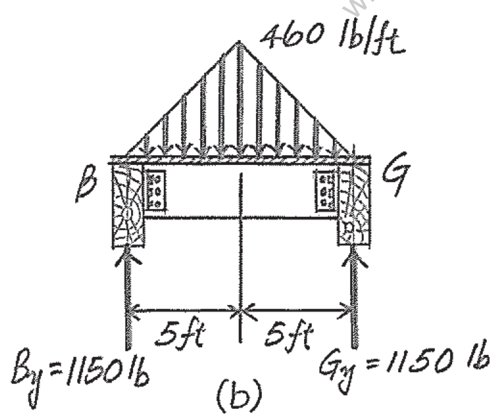
The loading diagram for beam *BG* is shown in Fig. *b*.

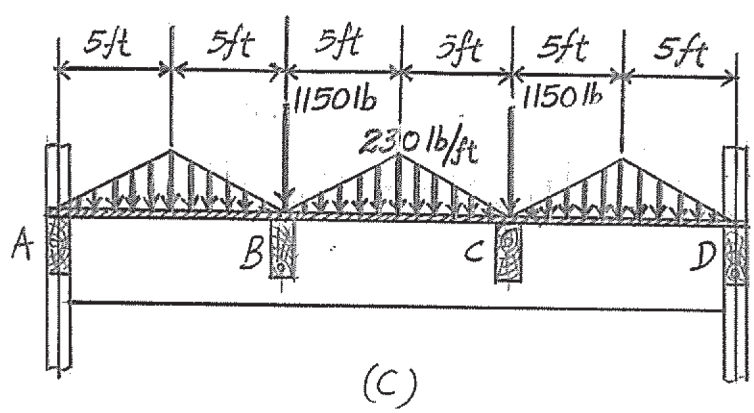
Beam *ABCD*. The loadings that are supported by this beam are the vertical reaction of beams *BG* and *CF* at *B* and *C* respectively, which are $B_y = C_y = 1150$ lb and the triangular distributed load contributed by the dotted triangular area shown in Fig. *a*. Its maximum intensity is

$$\text{2-in.-thick plywood platform: } \left(36\,\frac{\text{lb}}{\text{ft}^3}\right)\left(\frac{2}{12}\text{ ft}\right)(5\text{ ft}) = 30\text{ lb/ft}$$

$$\text{Live load for residential dwelling: } \left(40\,\frac{\text{lb}}{\text{ft}^2}\right)(5\text{ ft}) \quad = \frac{200\text{ lb/ft}}{230\text{ lb/ft}} \qquad \textbf{Ans.}$$

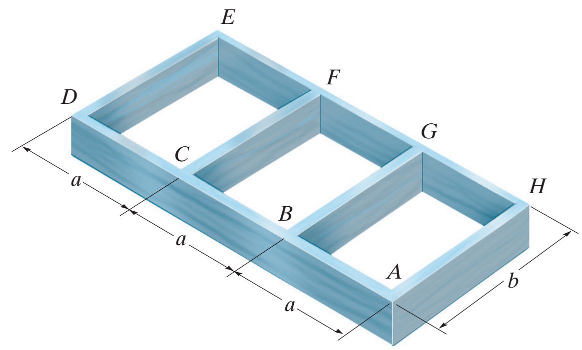
The loading diagram for beam *ABCD* is shown in Fig. *c*.





Beam *ABCD*. 1150 lb at B and C, $w_{max} = 230$ lb/ft

***2–8.** Solve Prob. 2–6, with $a = 10$ ft, $b = 15$ ft.



SOLUTION

Beam *BG*. Since $\frac{b}{a} = \frac{15\text{ ft}}{10\text{ ft}} = 1.5 < 2$, the plywood platform will behave as a two-way slab. Thus, the tributary area for this beam is the shaded octagonal area shown in Fig. *a*, and the maximum intensity of the trapezoidal distributed load is

$$\text{2-in.-thick plywood platform: } \left(36\,\frac{\text{lb}}{\text{ft}^3}\right)\left(\frac{2}{12}\text{ ft}\right)(10\text{ ft}) = 60\text{ lb/ft}$$

$$\text{Live load for residential dwelling: } \left(40\,\frac{\text{lb}}{\text{ft}^2}\right)(10\text{ ft}) \quad = \frac{400\text{ lb/ft}}{460\text{ lb/ft}} \qquad \textbf{Ans.}$$

Due to symmetry, the vertical reactions of B and G are

$$B_y = G_y = \frac{\frac{1}{2}(460\text{ lb/ft})(15\text{ ft} + 5\text{ ft})}{2} = 2300\text{ lb} \qquad \textbf{Ans.}$$

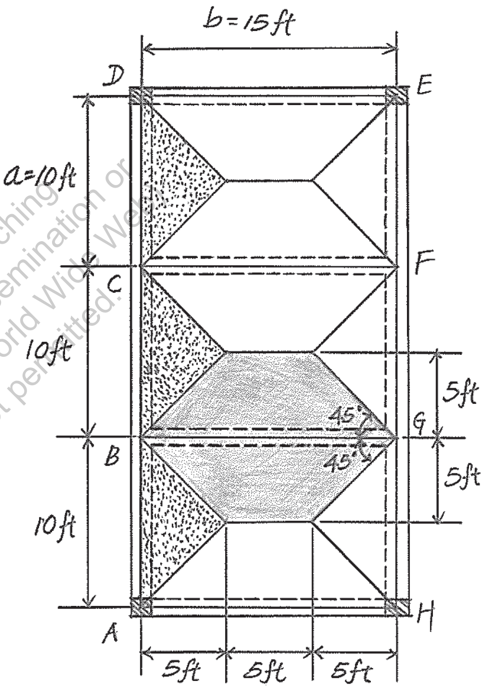
The loading diagram for beam BG is shown in Fig. *b*.

Beam *ABCD*. The loadings that are supported by this beam are the vertical reactions of beam BG and CF at B and C respectively which are $B_y = C_y = 2300$ lb, and the triangular distributed load contributed by the dotted triangular area shown in Fig. *a*. Its maximum intensity is

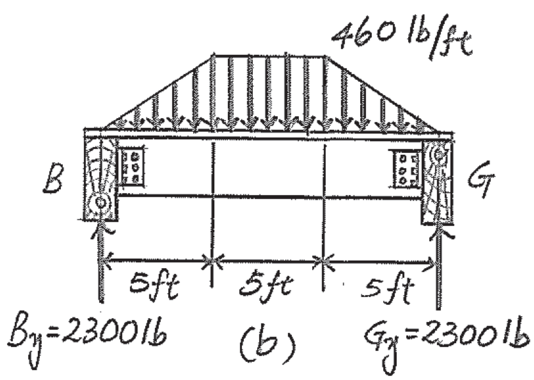
$$\text{2-in.-thick plywood platform: } (36\text{ lb/ft}^3)\left(\frac{2}{12}\text{ ft}\right)(5\text{ ft}) = 30\text{ lb/ft}$$

$$\text{Live load for residential dwelling: } (40\text{ lb/ft}^2)(5\text{ ft}) \quad = \frac{200\text{ lb/ft}}{230\text{ lb/ft}} \qquad \textbf{Ans.}$$

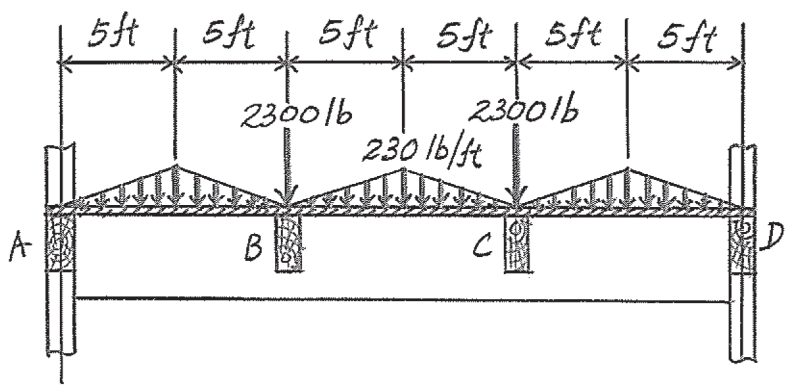
The loading diagram for beam $ABCD$ is shown in Fig. *c*.



(a)

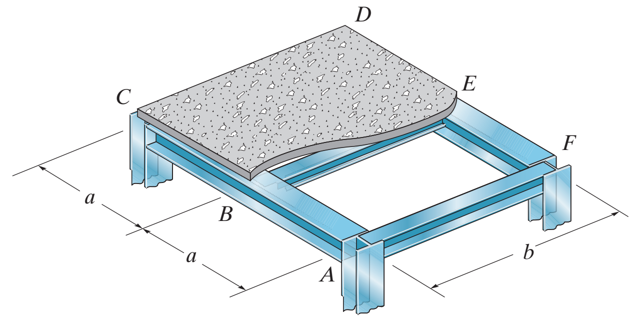


(b)



(C)

2–9. The steel framework is used to support the 4-in. reinforced stone concrete slab that carries a uniform live loading of 400 lb/ft^2. Sketch the loading that acts along members BE and FED. Set $a = 9$ ft, $b = 12$ ft. *Hint:* See Table 1.2.



SOLUTION

Beam *BE*. Since $\frac{b}{a} = \frac{12\text{ ft}}{9\text{ ft}} = \frac{4}{3} < 2$, the concrete slab will behave as a two-way slab. Thus, the tributary area for this beam is the shaded octagonal area shown in Fig. *a,* and the maximum intensity of the trapezoidal distributed load is

4-in.-thick reinforced stone concrete slab: $(0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(9\text{ ft}) = 0.45\text{ k/ft}$

Floor live load: $(0.4\text{ k/ft}^2)(9\text{ ft}) \qquad = \frac{3.60\text{ k/ft}}{4.05\text{ k/ft}}$ **Ans.**

Due to symmetry, the vertical reactions at B and E are

$$B_y = E_y = \frac{\frac{1}{2}(4.05\text{ k/ft})(3\text{ ft} + 12\text{ ft})}{2} = 15.19\text{ k} \qquad \textbf{Ans.}$$

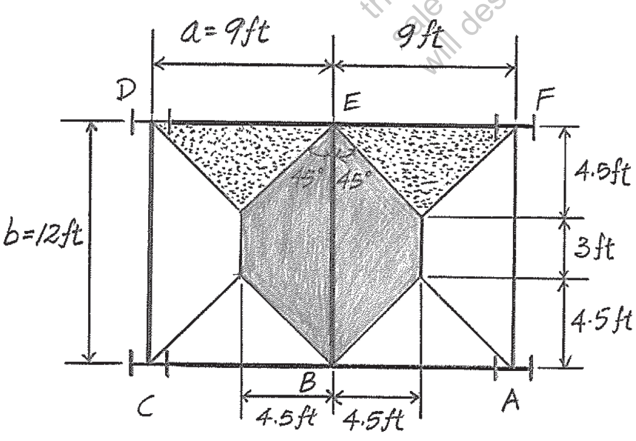
The loading diagram of beam BE is shown in Fig. *a*.

Beam *FED*. The loadings that are supported by this beam are the vertical reactions of beam BE at E, which is $E_y = 15.19$ k and the triangular distributed load contributed by dotted triangular tributary area shown in Fig. *a*. Its maximum intensity is

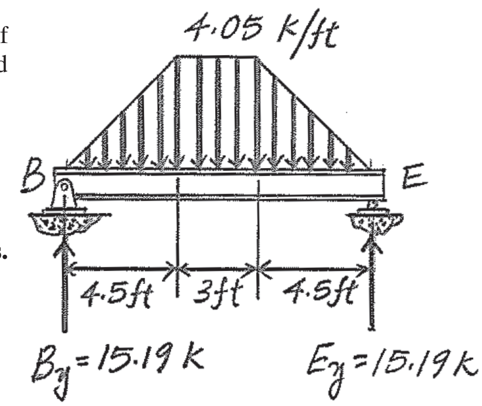
4-in.-thick concrete slab: $(0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(4.5\text{ ft}) = 0.225\text{ k/ft}$

Floor live load: $(0.4\text{ k/ft}^2)(4.5\text{ ft}) \qquad = \frac{1.800\text{ k/ft}}{2.025\text{ k/ft}}$ **Ans.**

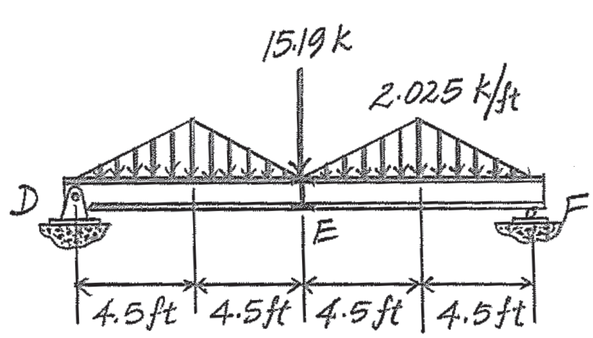
The loading diagram of beam FED is shown in Fig. *c*.



(a)



(b)

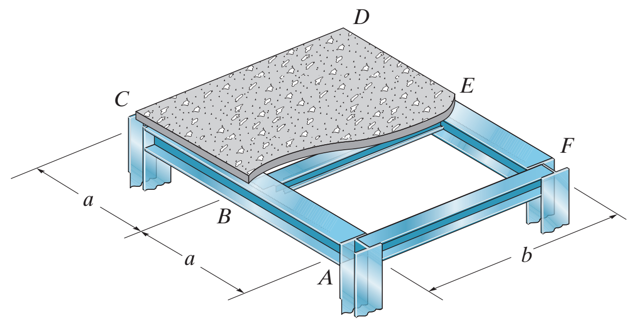


(c)

Beam *BE*. $w_{max} = 4.05$ k/ft

Beam *FED*. 15.2 k at E, $w_{max} = 2.025$ k/ft

2–10. Solve Prob. 2–9, with $a = 6$ ft, $b = 18$ ft.



SOLUTION

Beam *BE*. Since $\dfrac{b}{a} = \dfrac{18\text{ ft}}{6\text{ ft}} = 3 > 2$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this beam is the shaded rectangular area shown in Fig. *a,* and the intensity of the uniform distributed load is

4-in.-thick reinforced stone concrete slab: $(0.15\text{ k/ft}^3)\left(\dfrac{4}{12}\text{ ft}\right)(6\text{ ft}) = 0.30\text{ k/ft}$

Floor live load: $(0.4\text{ k/ft}^2)(6\text{ ft}) \quad = \dfrac{2.40\text{ k/ft}}{2.70\text{ k/ft}}$ **Ans.**

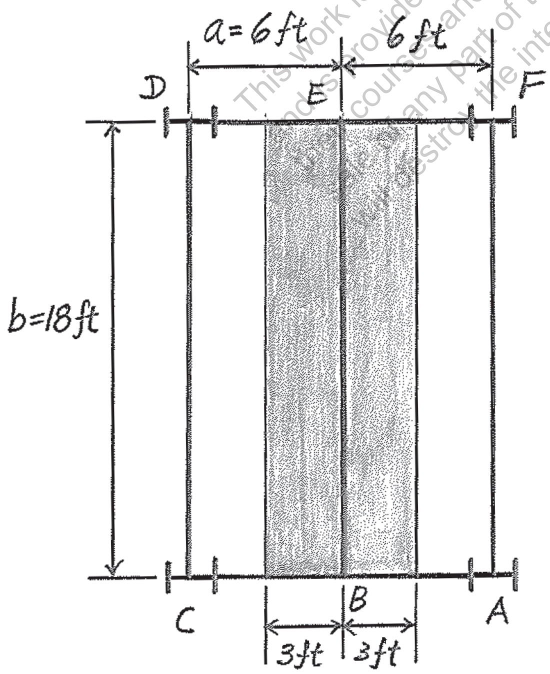
Due to symmetry, the vertical reactions at B and E are

$$B_y = E_y = \frac{(2.70\text{ k/ft})(18\text{ ft})}{2} = 24.3\text{ k}$$

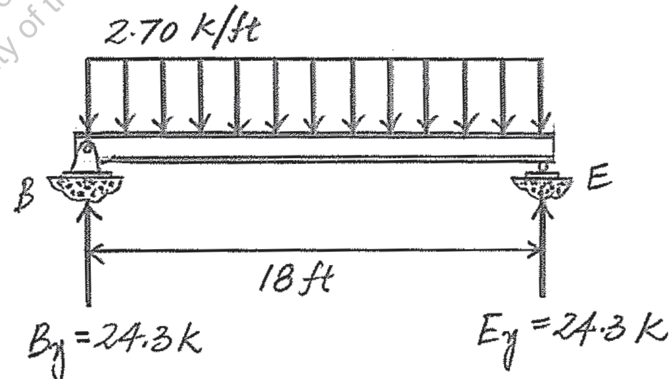
The loading diagram of beam *BE* is shown in Fig. *b*.

Beam *FED*. The only load this beam supports is the vertical reaction of beam *BE* at *E*, which is $E_y = 24.3$ k.

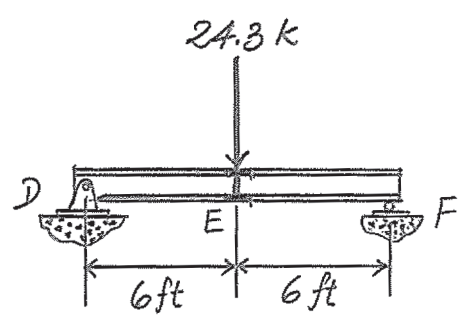
The loading diagram of beam *FED* is shown in Fig. *c*.



(a)

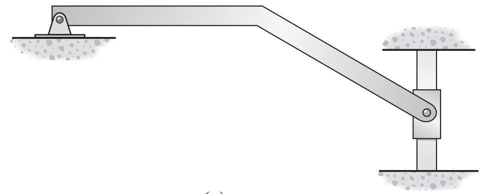


(b)



(c)

2–11. Classify each of the structures as statically determinate or indeterminate. If indeterminate, specify the degree of indeterminacy.



(a)

SOLUTION

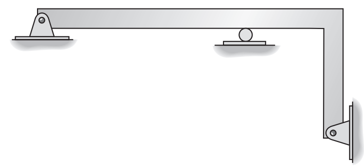
(a) $r = 3$ $\quad 3(1) = 3$
Statically determinate **Ans.**

(b) $r = 5$ $\quad 3(1) < 5$
Statically indeterminate to the second degree **Ans.**

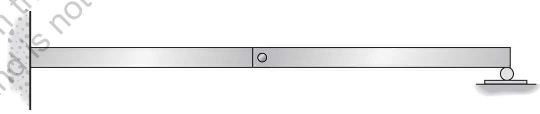
(c) $r = 6$ $\quad 3(2) = 6$
Statically determinate **Ans.**

(d) $r = 10$ $\quad 3(3) < 10$
Statically indeterminate to the first degree **Ans.**

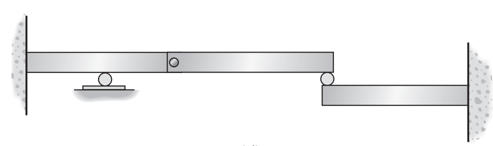
(e) $r = 7$ $\quad 3(2) < 7$
Statically indeterminate to the first degree **Ans.**



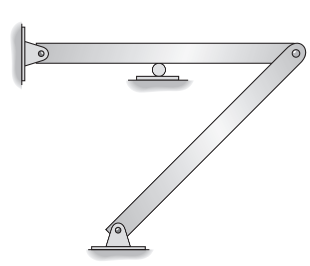
(b)



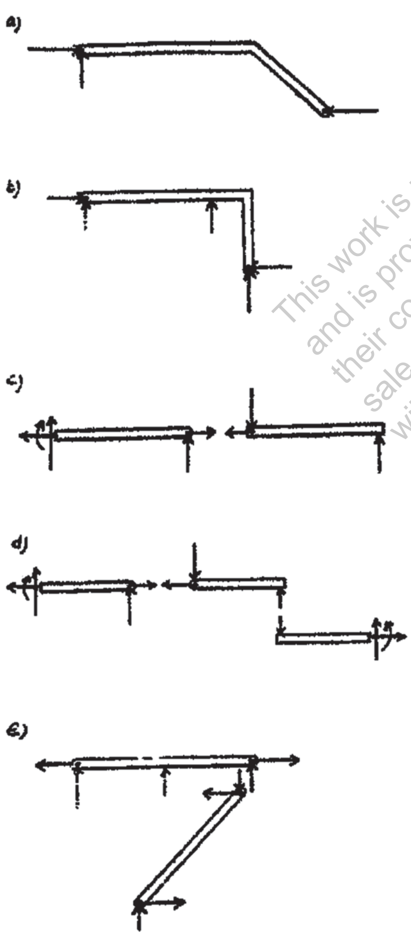
(c)



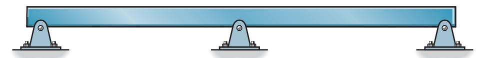
(d)



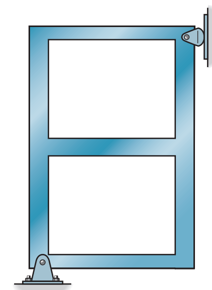
(e)



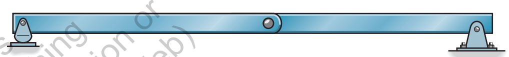
***2–12.** Classify each of the frames as statically determinate or indeterminate. If indeterminate, specify the degree of indeterminacy. All internal joints are fixed connected.



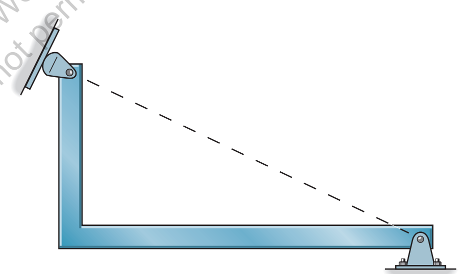
(a)



(b)



(c)



(d)

SOLUTION

$r = 6 \qquad 3n = 3(1) = 3$

$r - 3n = 6 - 3 = 3$

Stable and statically indeterminate to third degree.

$r = 12 \qquad 3n = 3(2) = 6$

$r - 3n = 12 - 6 = 6$

Stable and statically indeterminate to sixth degree.

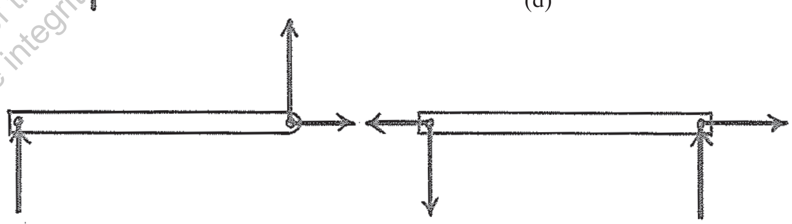
$r = 5 \qquad 3n = 3(2) = 6$

$r < 3n$

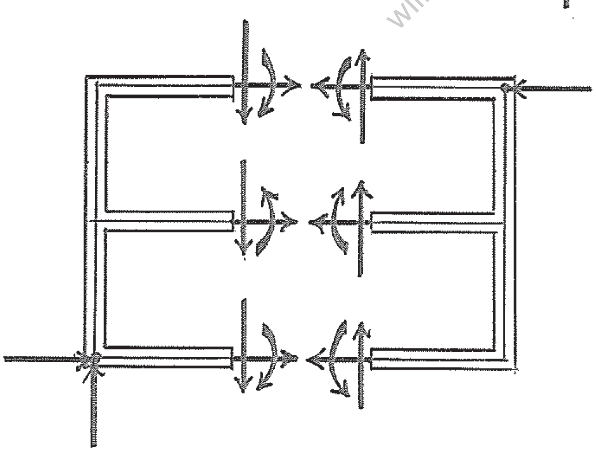
Unstable.

Unstable since the line of action of the reactive force components are concurrent.

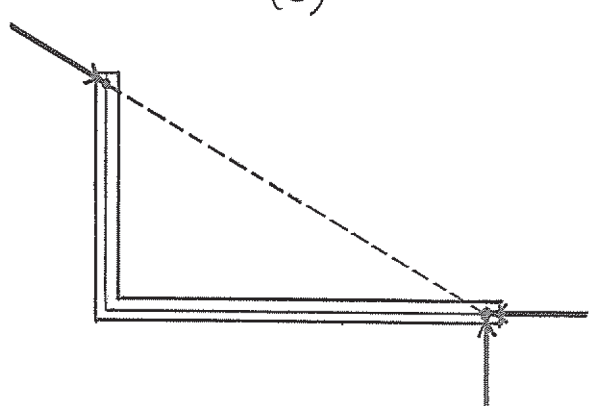
(a)



(c)

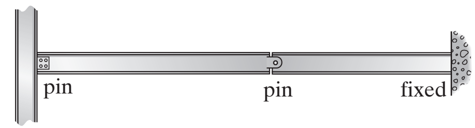


(b)

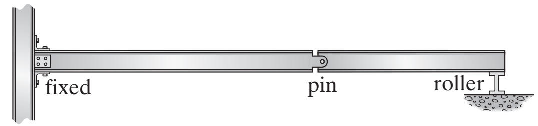


(d)

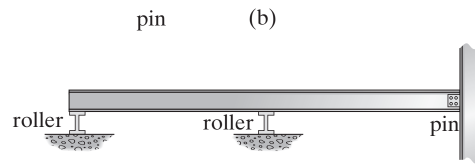
2–13. Classify each of the structures as statically determinate, statically indeterminate, stable, or unstable. If indeterminate, specify the degree of indeterminacy. The supports or connections are to be assumed as stated.



(a)



(b)



(c)

SOLUTION

(a) $r = 7$ $\quad 3n = 3(2) = 6 \quad r - 3n = 7 - 6 = 1$

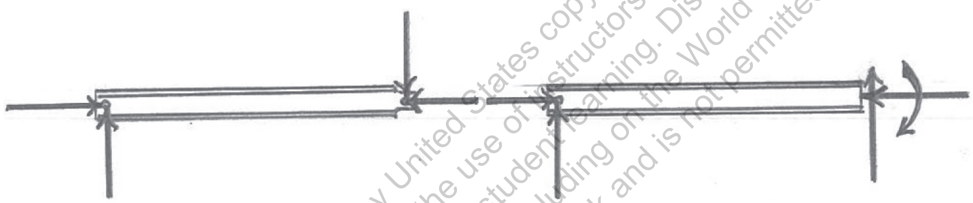
Stable and statically indeterminate to first degree.

(b) $r = 6$ $\quad 3n = 3(2) = 6 \quad r = 3n$

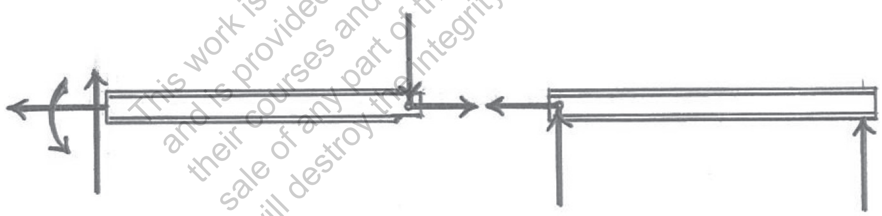
Stable and statically determinate

(c) $r = 4$ $\quad 3n = 3(1) = 3 \quad r - 3n = 4 - 3 = 1$

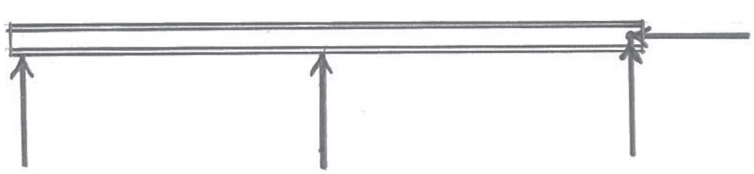
Stable and statically indeterminate to first degree



(a)

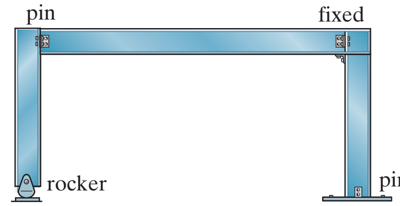


(b)

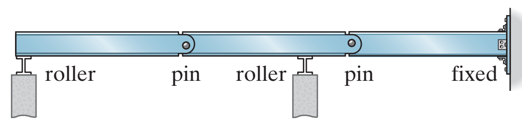


(c)

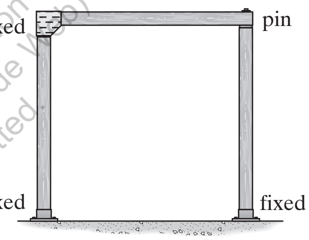
2–14. Classify each of the structures as statically determinate, statically indeterminate, stable, or unstable. If indeterminate, specify the degree of indeterminacy. The supports or connections are to be assumed as stated.



(a)



(b)



(c)

SOLUTION

(a) $r = 5 \qquad 3n = 3(2) = 6$

$r < 3n$

Unstable

(b) $r = 9 \qquad 3n = 3(3) = 9$

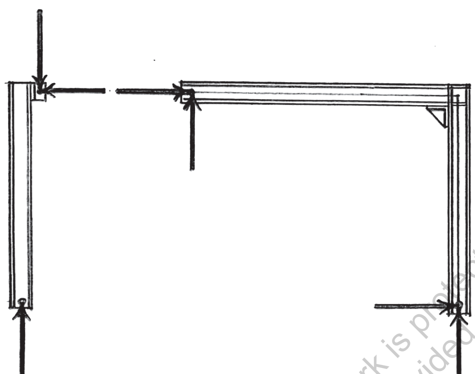
$r = 3n$

Stable and statically determinate

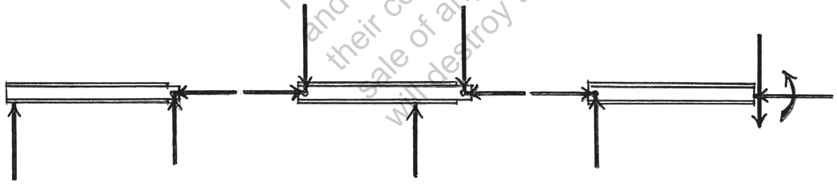
(c) $r = 8 \qquad 3n = 3(2) = 6$

$r - 3n = 8 - 6 = 2$

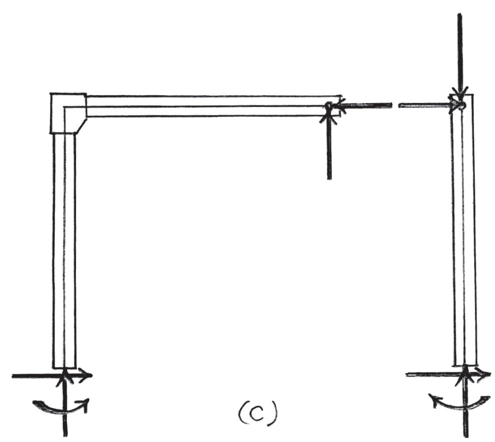
Stable and statically indeterminate to the second degree



(a)

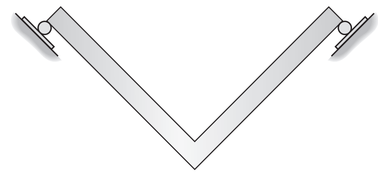


(b)



(c)

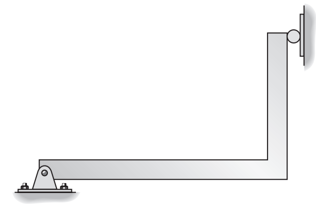
2–15. Classify each of the structures as statically determinate, statically indeterminate, stable, or unstable.



(a)

SOLUTION

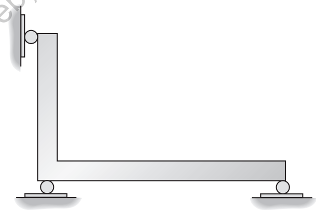
(a) Unstable
(support reactions concurrent) **Ans.**



(b)

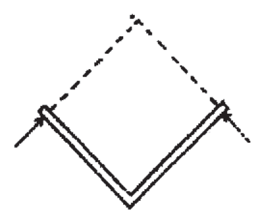
(b) $r = 3 \qquad 3n = 3(1) = 3$
Statically determinate **Ans.**

(c) $r = 3 \qquad 3n = 3(1) = 3$
Statically determinate **Ans.**



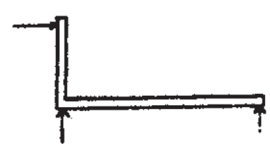
(c)

a)

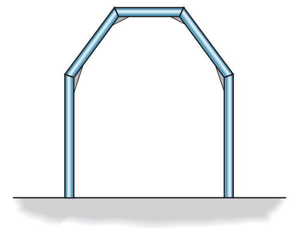


b)

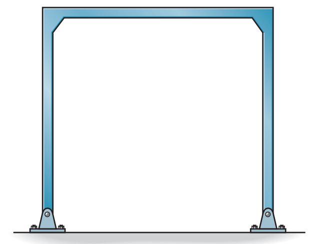
c)



***2–16.** Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.

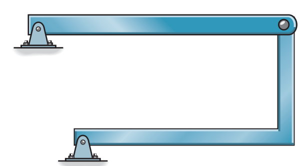


(a)



(b)

(c)



(d)

SOLUTION

(a) $r = 6 \qquad 3n = 3(1) = 3$

$r - 3n = 6 - 3 = 3$

Stable and statically indeterminate to the third degree

(b) $r = 4 \qquad 3n = 3(1) = 3$

$r - 3n = 4 - 3 = 1$

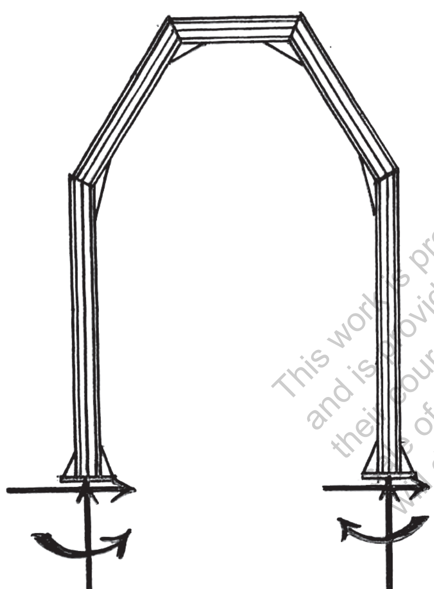
Stable and statically indeterminate to the first degree

(c) $r = 3 \qquad 3n = 3(1) = 3 \qquad r = 3n$

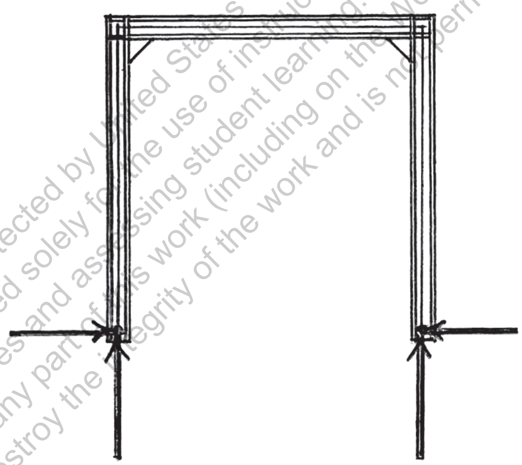
Stable and statically determinate

(d) $r = 6 \qquad 3n = 3(2) = 6 \qquad r = 3n$

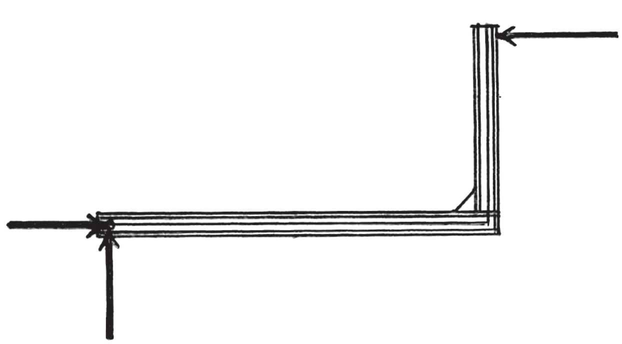
Stable and statically determinate



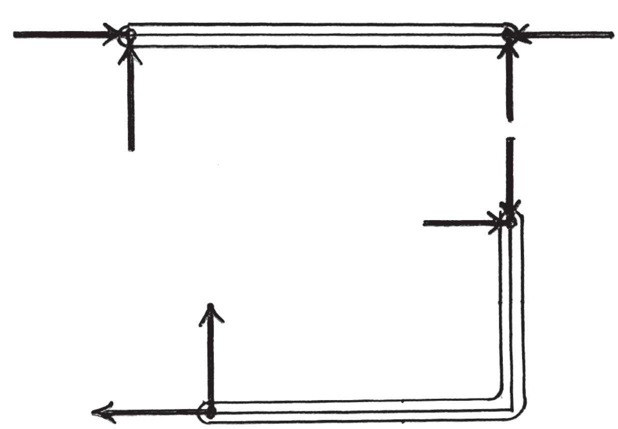
(a)



(b)

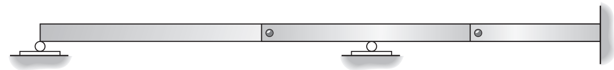


(c)

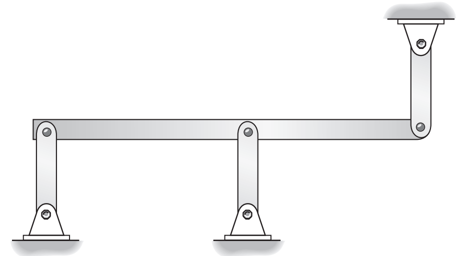


(d)

2–17. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.

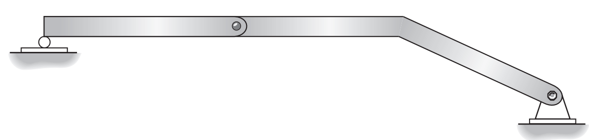


(a)



(b)

(c)



(d)

SOLUTION

a)

$r = 9, \quad n = 3$

$r = 3n$

$9 = 3(3)$

Statically determinate **Ans.**

b)

$r = 12, \quad n = 4$

$r = 3n$

$12 = 3(4)$

Statically determinate **Ans.**

c)

$r = 3, \quad n = 1$

$r = 3n$

$3 = 3(1)$

Stable and statically determinate **Ans.**

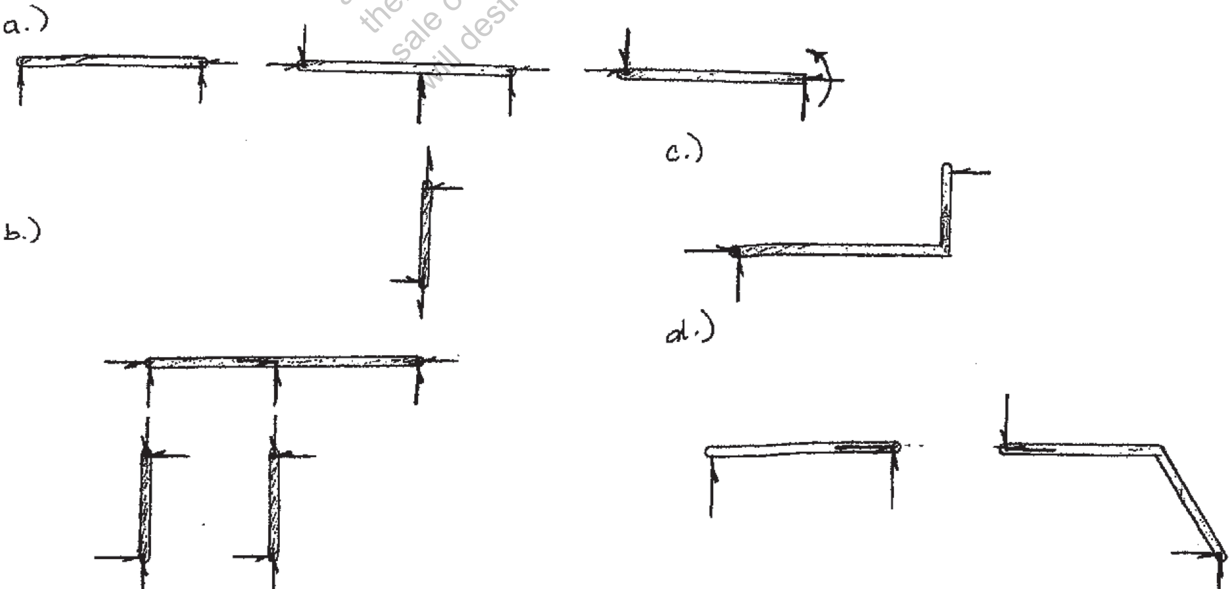
d)

$r = 5, \quad n = 2$

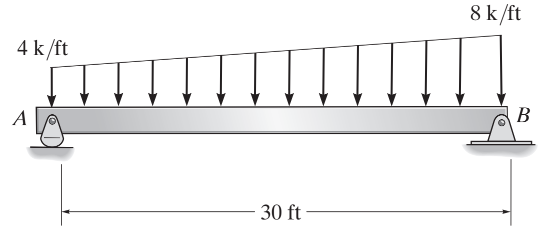
$r < 3n$

$5 < 3(2)$

Unstable **Ans.**



***2–18.** Determine the reactions on the beam.



SOLUTION

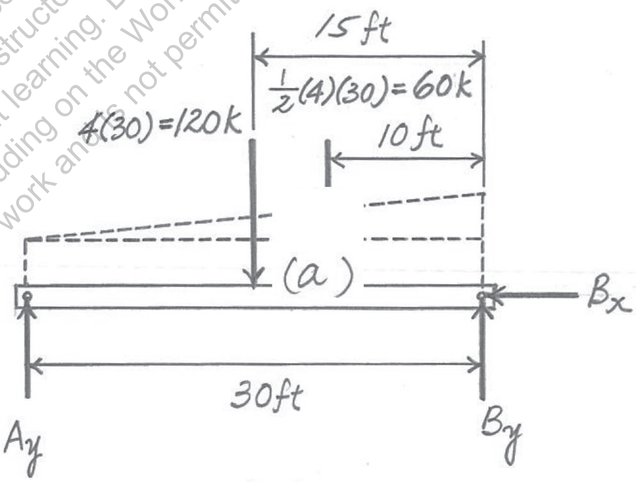
Equations of Equilibrium. Referring to the *FBD* of the beam in Fig. *a*, $\mathbf{A}_y$ and $\mathbf{B}_y$ can be determined directly by writing the moment equations of equilibrium about B and A respectively.

$\zeta+\Sigma M_B = 0; \qquad 60(10) + 120(15) - A_y(30) = 0 \qquad A_y = 80.0\text{ k}$ **Ans.**

$\zeta+\Sigma M_A = 0; \qquad B_y(30) - 120(15) - 60(20) = 0 \qquad B_y = 100\text{ k}$ **Ans.**

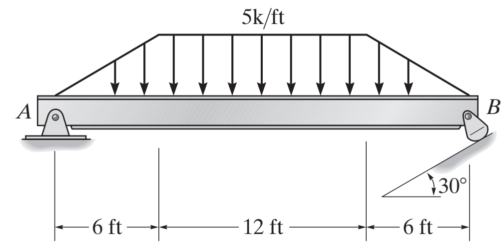
Write the force equation of equilibrium along x axis,

$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad B_x = 0$ **Ans.**



(a)

2–19. Determine the reactions at the supports.



SOLUTION

$\circlearrowleft + \Sigma M_A = 0; \quad -15\text{ k}(4\text{ ft}) - 60\text{ k}(12\text{ ft}) - 15\text{ k}(20\text{ ft}) + F_B\cos 30°(24\text{ ft}) = 0$

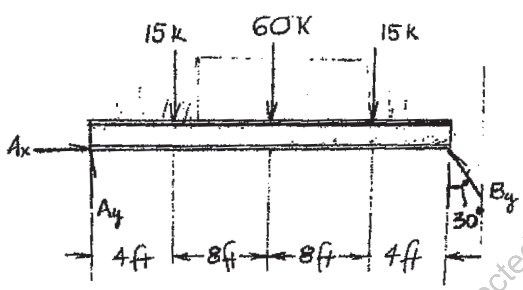
$F_B = 51.962\text{ k} = 52.0\text{ k}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 51.962\text{ k}(\sin 30°) = 0$

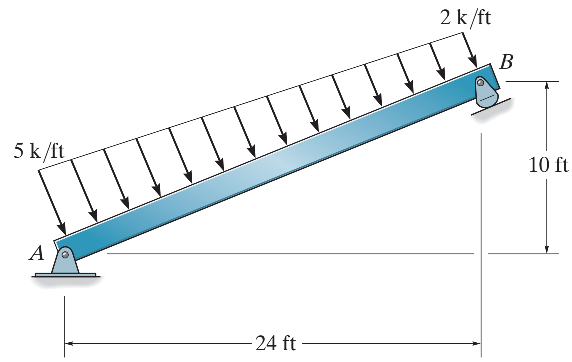
$A_x = 25.981\text{ k} = 26.0\text{ k}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad A_y + 51.962\text{ k}(\cos 30°) - 15\text{ k} - 60\text{ k} - 15\text{ k} = 0$

$A_y = 45\text{ k}$ **Ans.**



***2–20.** Determine the reactions on the beam.



SOLUTION

$\circlearrowleft + \Sigma M_A = 0; \qquad F_B(26) - 52(13) - 39\left(\frac{1}{3}\right)(26) = 0$

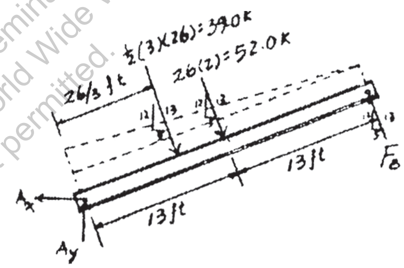
$F_B = 39.0 \text{ k}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad A_y - \frac{12}{13}(39) - \left(\frac{12}{13}\right)52 + \left(\frac{12}{13}\right)(39.0) = 0$

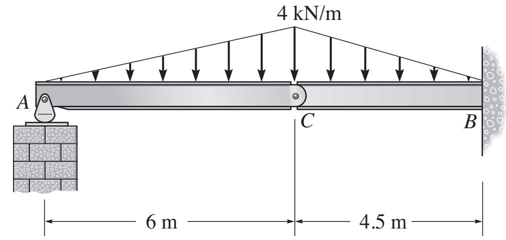
$A_y = 48.0 \text{ k}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad -A_x + \left(\frac{5}{13}\right)39 + \left(\frac{5}{13}\right)52 - \left(\frac{5}{13}\right)39.0 = 0$

$A_x = 20.0 \text{ k}$ **Ans.**



2–21. Determine the reactions at the supports A and B of the compound beam. There is a pin at C.



SOLUTION

Member *AC:*

$\circlearrowleft + \Sigma M_C = 0; \quad -A_y(6) + 12(2) = 0$

$A_y = 4.00 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \; C_y + 4.00 - 12 = 0$

$C_y = 8.00 \text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0; \; C_x = 0$

Member *CB:*

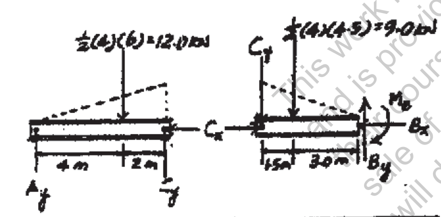
$\circlearrowleft + \Sigma M_B = 0; -M_B + 8.00(4.5) + 9(3) = 0$

$M_B = 63.0 \text{ kN} \cdot \text{m}$ **Ans.**

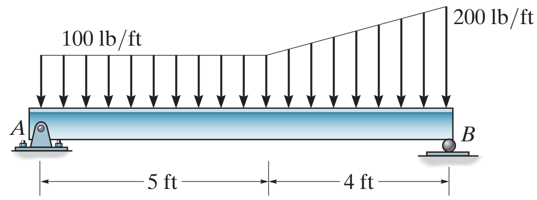
$+\uparrow \Sigma F_y = 0; \; B_y - 8 - 9 = 0$

$B_y = 17.0 \text{ kN}$ **Ans.**

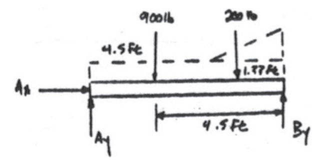
$\xrightarrow{+} \Sigma F_x = 0; \; B_x = 0$ **Ans.**



2–22. Determine the reactions at the supports.



SOLUTION



$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 0$ **Ans.**

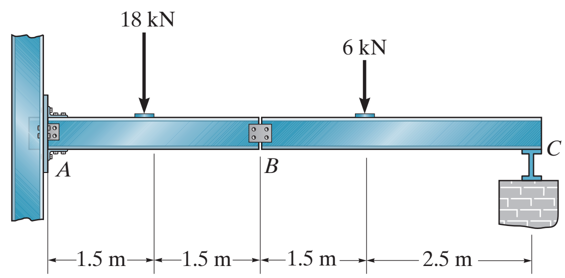
$\circlearrowleft + \Sigma M_B = 0; \quad 900\,(4.5) + 200\,(1.333) - A_y(9) = 0$

$A_y = 480 \text{ lb}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad 480 - 1100 + B_y = 0$

$B_y = 620 \text{ lb}$ **Ans.**

2–23. Determine the reactions at the supports A and C of the compound beam. Assume A is fixed, B is a pin, and C is a roller.



SOLUTION

Equations of Equilibrium. First consider the *FBD* of segment *BC* in Fig. *a*. $\boldsymbol{N_C}$ and $\boldsymbol{B_y}$ can be determined directly by writing the moment equations of equilibrium about B and C respectively.

$\circlearrowleft + \Sigma M_B = 0; \qquad N_C(4) - 6(1.5) = 0 \qquad N_C = 2.25 \text{ kN}$ **Ans.**

$\circlearrowleft + \Sigma M_C = 0; \qquad 6(2.5) - B_y(4) = 0 \qquad B_y = 3.75 \text{ kN}$ **Ans.**

Write the force equation of equilibrium along x axis,

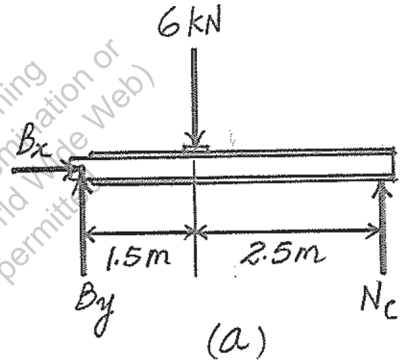
$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad B_x = 0$

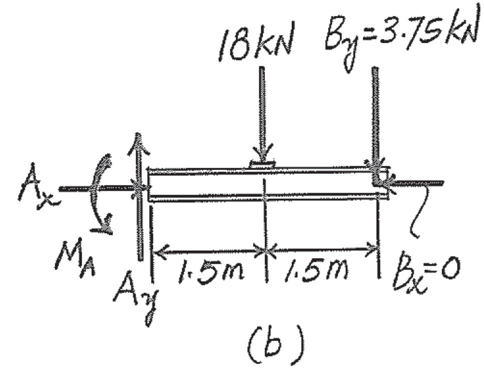
Then consider the *FBD* of segment *AB*, Fig. *b*,

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad A_x = 0$ **Ans.**

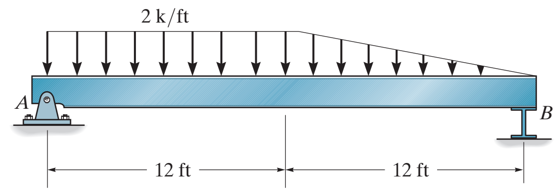
$+\uparrow \Sigma F_y = 0; \qquad A_y - 18 - 3.75 = 0 \qquad A_y = 21.75 \text{ kN}$ **Ans.**

$\circlearrowleft + \Sigma M_A = 0; \qquad M_A - 18(1.5) - 3.75(3) = 0 \qquad M_A = 38.25 \text{ kN} \cdot \text{m}$ **Ans.**





***2–24.** Determine the reactions on the beam. The support at B can be assumed to be a roller.



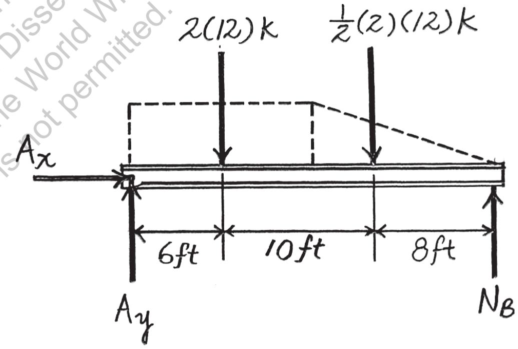
SOLUTION

Equations of Equilibrium:

$\circlearrowleft + \Sigma M_A = 0;$ $\quad N_B(24) - 2(12)(6) - \frac{1}{2}(2)(12)(16) = 0 \quad N_B = 14.0 \text{ k}$ **Ans.**

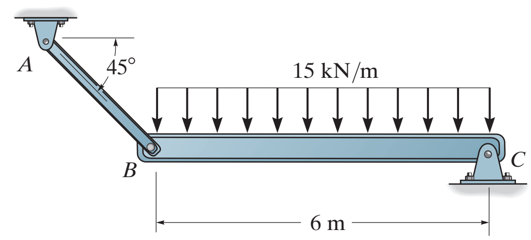
$\circlearrowleft + \Sigma M_B = 0;$ $\quad \frac{1}{2}(2)(12)(8) + 2(12)(18) - A_y(24) = 0 \quad A_y = 22.0 \text{ k}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad A_x = 0$ **Ans.**



(a)

2–25. Determine the horizontal and vertical components of reaction at the pins A and C.



SOLUTION

Equations of Equilibrium. Here, member AB is a two force member, which is reflected in the FBD of beam BC, Fig. a. $\boldsymbol{F}_{AB}$ and $\boldsymbol{C}_y$ can be determined directly by writing the moment equation of equilibrium about C and B respectively.

$\circlearrowleft +\Sigma M_C = 0;\quad 90(3) - F_{AB}\sin 45°\,(6) = 0 \qquad F_{AB} = 63.64\text{ kN}$

$\circlearrowleft +\Sigma M_B = 0;\quad C_y(6) - 90(3) = 0 \qquad C_y = 45.0\text{ kN}$ **Ans.**

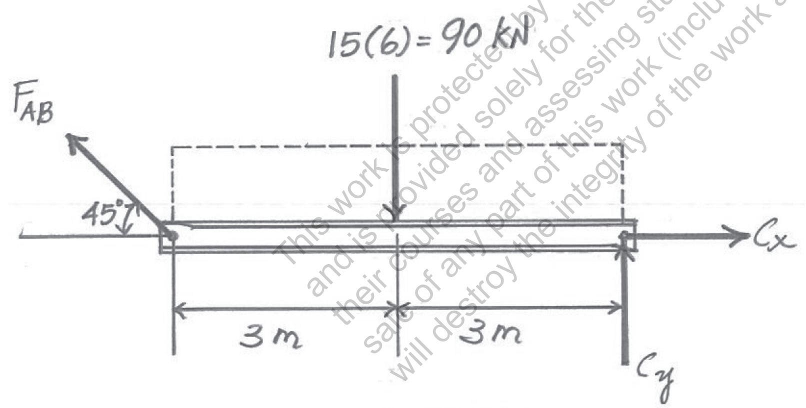
Then write the force equation of equilibrium along x axis,

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad C_x - 63.64\cos 45° = 0 \qquad C_x = 45.0\text{ kN}$ **Ans.**

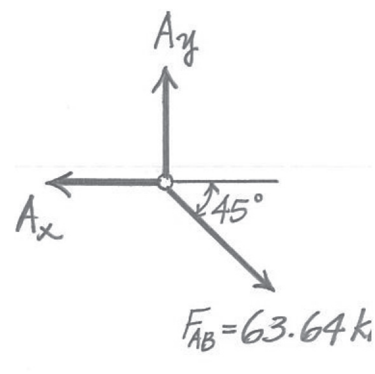
Now consider the FBD of pin A, Fig. b,

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad 63.64\cos 45° - A_x = 0 \qquad A_x = 45.0\text{ kN}$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad A_y - 63.64\sin 45° = 0 \qquad A_y = 45.0\text{ kN}$ **Ans.**

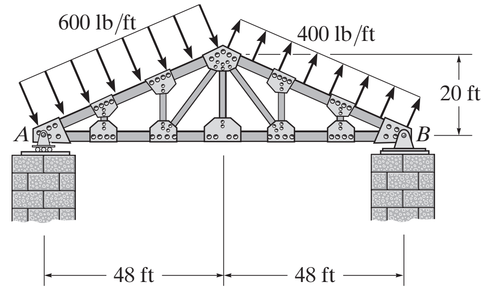


(a)

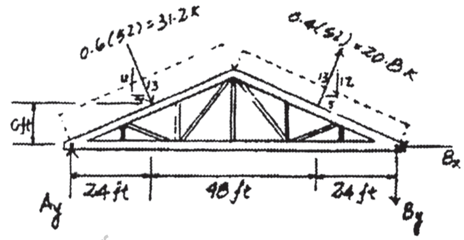


(b)

2–26. Determine the reactions at the truss supports A and B. The distributed loading is caused by wind.



SOLUTION



$$\circlearrowleft + \Sigma M_A = 0; \quad B_y(96) + \left(\frac{12}{13}\right)20.8(72) - \left(\frac{5}{13}\right)20.8(10) - \left(\frac{12}{13}\right)31.2(24) - \left(\frac{5}{13}\right)31.2(10) = 0$$

$B_y = 5.117 \text{ k} = 5.12 \text{ k}$ **Ans.**

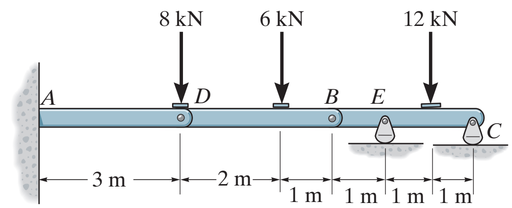
$$+\uparrow \Sigma F_y = 0; \quad A_y - 5.117 + \left(\frac{12}{13}\right)20.8 - \left(\frac{12}{13}\right)31.2 = 0$$

$A_y = 14.7 \text{ k}$ **Ans.**

$$\xrightarrow{+} \Sigma F_x = 0; \quad -B_x + \left(\frac{5}{13}\right)31.2 + \left(\frac{5}{13}\right)20.8 = 0$$

$B_x = 20.0 \text{ k}$ **Ans.**

2–27. The compound beam is fixed at A and supported by a rocker at E and C. There are hinges (pins) at D and B. Determine the reactions at the supports.



SOLUTION

Equation of Equilibrium. First consider the *FBD* of segment *BD*, Fig. *b*.

$\circlearrowleft +\Sigma M_D = 0; \quad B_y(3) - 6(2) = 0 \quad B_y = 4.00 \text{ kN}$

$\circlearrowleft +\Sigma M_B = 0; \quad 6(1) - D_y(3) = 0 \quad D_y = 2.00 \text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0; \quad D_x - B_x = 0 \quad (1)$

Next consider the *FBD* of segment *BEC*, Fig. *c*.

$\circlearrowleft +\Sigma M_C = 0; \quad 12(1) + 400(3) - N_E(2) = 0 \quad N_E = 12.0 \text{ kN}$ **Ans.**

$\circlearrowleft +\Sigma M_E = 0; \quad N_C(2) + 4.00(1) - 12(1) = 0 \quad N_C = 4.00 \text{ kN}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0; \quad B_x = 0$

Then, from Eq. (1),

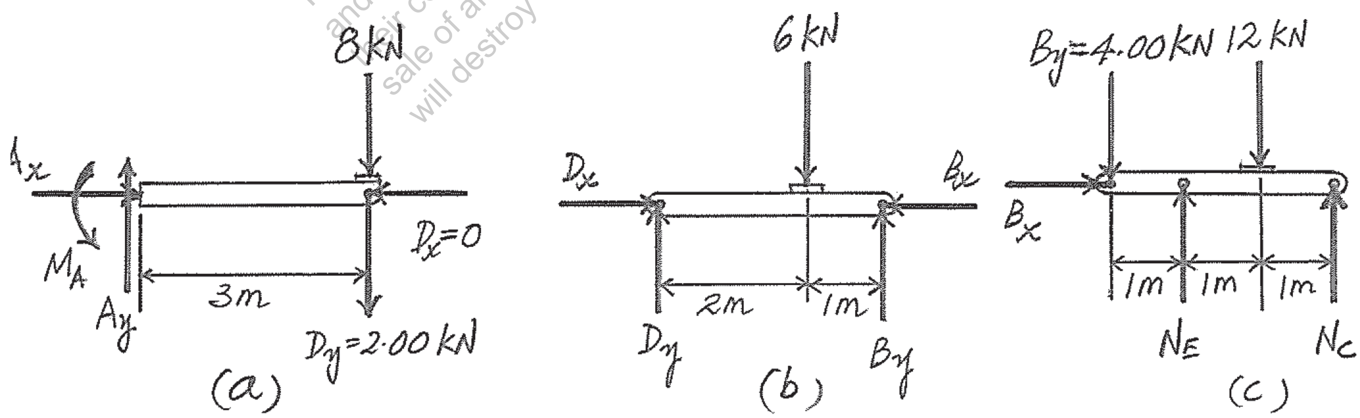
$$D_x = 0$$

Finally consider the *FBD* of segment *AD*, Fig. *a*.

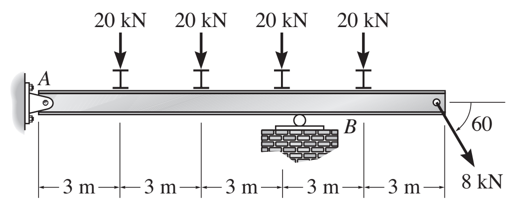
$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad A_y - 8 - 2.00 = 0 \quad A_y = 10.0 \text{ kN}$ **Ans.**

$\circlearrowleft +\Sigma M_A = 0; \quad M_A - 8(3) - 2.00(3) = 0 \quad M_A = 30.0 \text{ kN} \cdot \text{m}$ **Ans.**



***2–28.** Determine the reactions on the beam. The support at B can be assumed as a roller.



SOLUTION

$\circlearrowleft+\Sigma M_A = 0;\quad -20\text{ kN}(3\text{ m}) - 20\text{ kN}(6\text{ m}) - 20\text{ kN}(9\text{ m}) - 20\text{ kN}(12\text{ m}) - 8\text{ kN}(\sin 60^\circ)(15\text{ m}) + B_y(9\text{ m}) = 0$

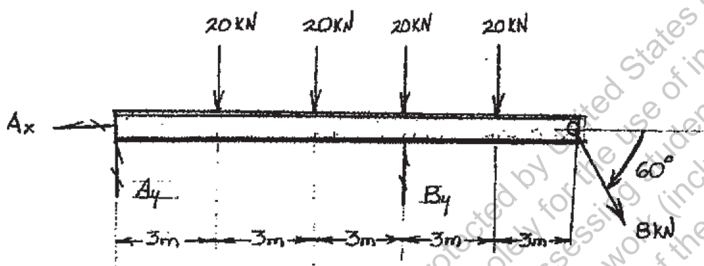
$B_y = 78.2\text{ kN}$ **Ans.**

$\xrightarrow{+}\Sigma F_x = 0;\quad -A_x + 8\text{ kN}(\cos 60^\circ) = 0$

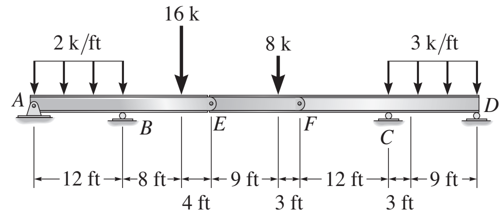
$A_x = 4\text{ kN}$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad -20\text{ kN} - 20\text{ kN} - 20\text{ kN} - 20\text{ kN} - 8\text{ kN}(\sin 60^\circ) + 78.2\text{ kN} + A_y = 0$

$A_y = 8.71\text{ kN}$ **Ans.**



2–29. Determine the reactions at the supports A, B, C, and D.



SOLUTION

Member EF:

$\circlearrowleft + \Sigma M_F = 0;\quad 8\text{ k}(3\text{ ft}) - E_y(12\text{ ft}) = 0$

$E_y = 2\text{ k}$

$+\uparrow \Sigma F_y = 0;\quad 2\text{ k} - 8\text{ k} + F_y = 0$

$F_y = 6\text{ k}$

Member ABE:

$\circlearrowleft + \Sigma M_A = 0;\quad -24\text{ k}(6\text{ ft}) + B_y(12\text{ ft}) - 2\text{ k}(24\text{ ft}) = 0$

$B_y = 16\text{ k}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\quad A_y - 24\text{ k} + 16\text{ k} - 2\text{ k} = 0$

$A_y = 10\text{ k}$ **Ans.**

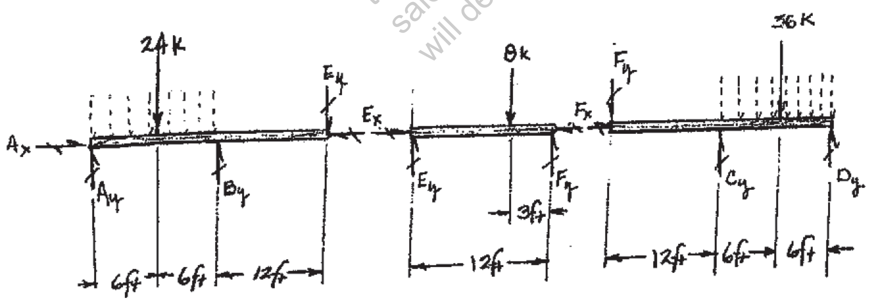
Member FCD:

$\circlearrowleft + \Sigma M_D = 0;\quad 36\text{ k}(6\text{ ft}) - C_y(12\text{ ft}) + (24\text{ ft})(6\text{ k}) = 0$

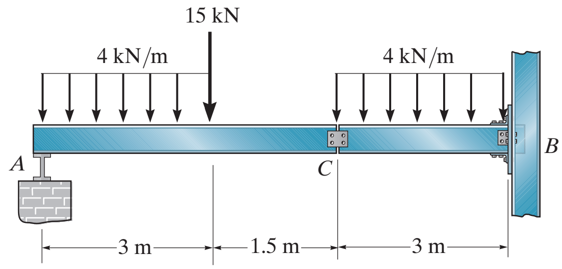
$C_y = 30\text{ k}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\quad -6\text{ k} + 30\text{ k} - 36\text{ k} + D_y = 0$

$D_y = 12\text{ k}$ **Ans.**



2–30. Determine the reactions at the supports *A* and *B* of the compound beam. Assume *A* is a roller, *C* is a pin, and *B* is fixed.



SOLUTION

Equations of Equilibrium. First consider the *FBD* of segment *AC* in Fig. *a*. $\mathbf{N}_A$ and $\mathbf{C}_y$ can be determined directly by writing the moment equations of equilibrium about *C* and *A* respectively.

$\circlearrowleft +\Sigma M_C = 0;\quad 15(1.5) + 12(3) - N_A(4.5) = 0 \qquad N_A = 13.0\text{ kN}$ **Ans.**

$\circlearrowleft +\Sigma M_A = 0;\quad C_y(4.5) - 12(1.5) - 15(3) = 0 \qquad C_y = 14.0\text{ kN}$

Then write the force equation of equilibrium along *x* axis,

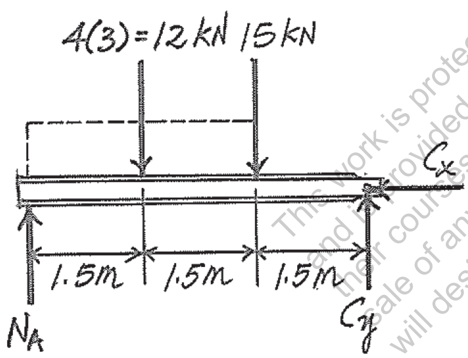
$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad C_x = 0$

Now consider the *FBD* of segment *CB*, Fig. *b*,

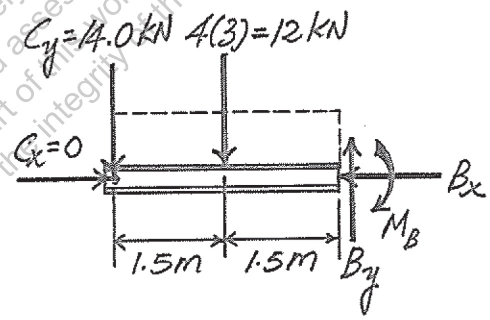
$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad B_x = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0;\quad B_y - 14.0 - 12 = 0 \qquad B_y = 26.0\text{ kN}$ **Ans.**

$\circlearrowleft +\Sigma M_B = 0;\quad 14.0(3) + 12(1.5) - M_B = 0 \qquad M_B = 60.0\text{ kN}\cdot\text{m}$ **Ans.**

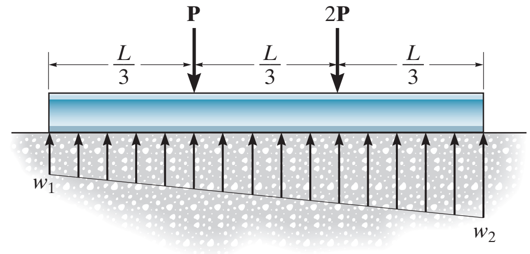


(a)

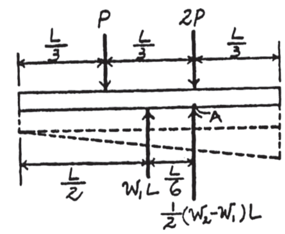


(b)

2–31. The beam is subjected to the two concentrated loads as shown. Assuming that the foundation exerts a linearly varying load distribution on its bottom, determine the load intensities w_1 and w_2 for equilibrium (a) in terms of the parameters shown; (b) set $P = 500$ lb, $L = 12$ ft.



SOLUTION



Equations of Equilibrium: The load intensity w_1 can be determined directly by summing moments about point A.

$$\zeta+\Sigma M_A = 0; \qquad P\left(\frac{L}{3}\right) - w_1 L\left(\frac{L}{6}\right) = 0$$

$$w_1 = \frac{2P}{L} \qquad \textbf{Ans.}$$

$$+\uparrow\Sigma F_y = 0; \qquad \frac{1}{2}\left(w_2 - \frac{2P}{L}\right)L + \frac{2P}{L}(L) - 3P = 0$$

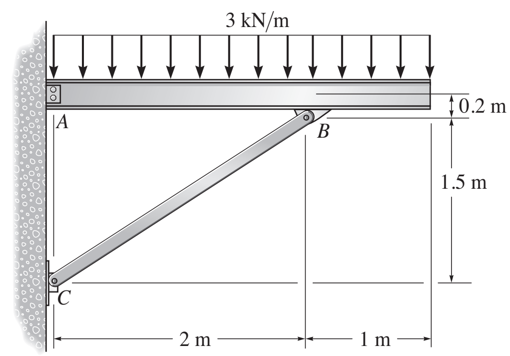
$$w_2 = \left(\frac{4P}{L}\right) \qquad \textbf{Ans.}$$

If $P = 500$ lb and $L = 12$ ft,

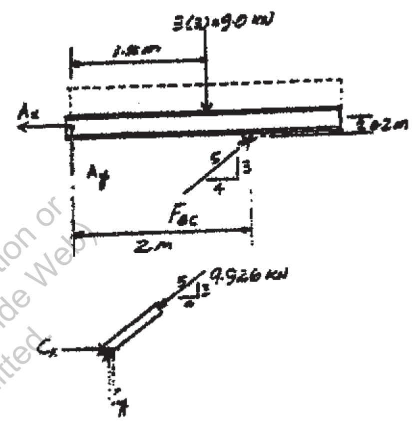
$$w_1 = \frac{2(500)}{12} = 83.3 \text{ lb/ft} \qquad \textbf{Ans.}$$

$$w_2 = \frac{4(500)}{12} = 167 \text{ lb/ft} \qquad \textbf{Ans.}$$

***2–32.** Determine the horizontal and vertical components of reaction at the supports A and C. Assume the members are pin connected at A, B, and C.



SOLUTION



$$\zeta + \Sigma M_A = 0; \left(\frac{3}{5}\right) F_{CB}(2) + \left(\frac{4}{5}\right) F_{CB}(0.2) - 9(1.5) = 0$$

$$F_{CB} = 9.926 \text{ kN}$$

$$\xrightarrow{+} \Sigma F_x = 0; \ -A_x + \left(\frac{4}{5}\right) 9.926 = 0$$

$$A_B = 7.94 \text{ kN}$$ **Ans.**

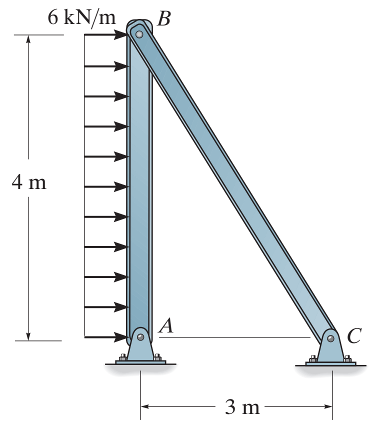
$$+\uparrow \Sigma F_y = 0; \ A_y + \frac{3}{5}(9.926) - 9 = 0$$

$$A_y = 3.04 \text{ kN}$$ **Ans.**

$$C_x = \frac{4}{5}(9.926) = 7.94 \text{ kN}$$ **Ans.**

$$C_y = \frac{3}{5}(9.926) = 5.96 \text{ kN}$$ **Ans.**

2–33. Determine the horizontal and vertical components of reaction at the supports A and C.



SOLUTION

Equations of Equilibrium. Member BC is a two force member, which is reflected in the *FBD* diagram of member AB, Fig. *a*. $\mathbf{F}_{BC}$ and $\mathbf{A}_x$ can be determined directly by writing the moment equations of equilibrium about A and B respectively.

$\circlearrowleft + \Sigma M_A = 0;\quad F_{BC}\left(\frac{3}{5}\right)(4) - 24(2) = 0\qquad F_{BC} = 20.0\text{ kN}$

$\circlearrowleft + \Sigma M_B = 0;\quad 24(2) - A_x(4) = 0\qquad A_x = 12.0\text{ kN}$ **Ans.**

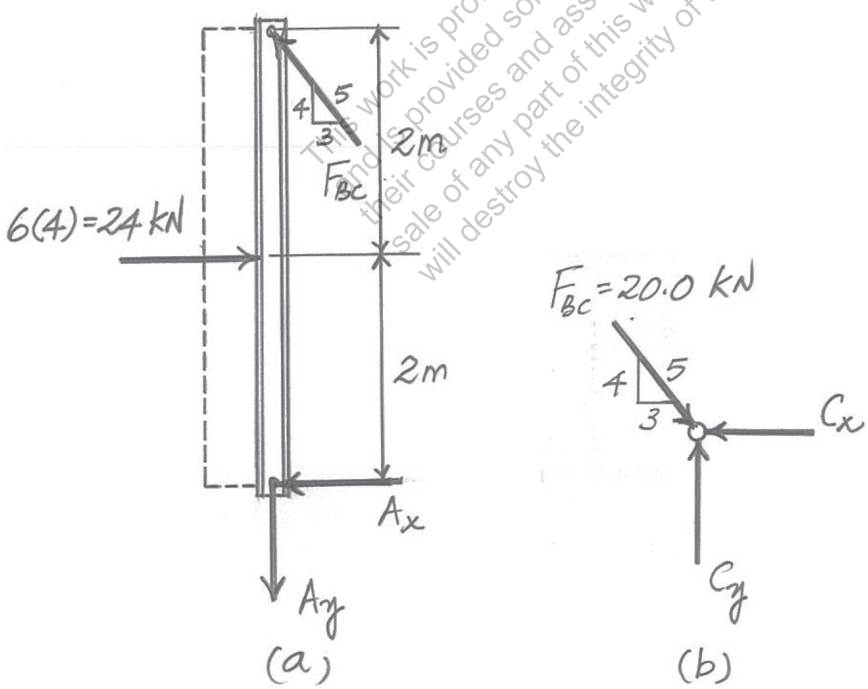
Write the force equation of equilibrium along y axis using the result of F_{BC},

$+\uparrow \Sigma F_y = 0;\quad 20.0\left(\frac{4}{5}\right) - A_y = 0\qquad A_y = 16.0\text{ kN}$ **Ans.**

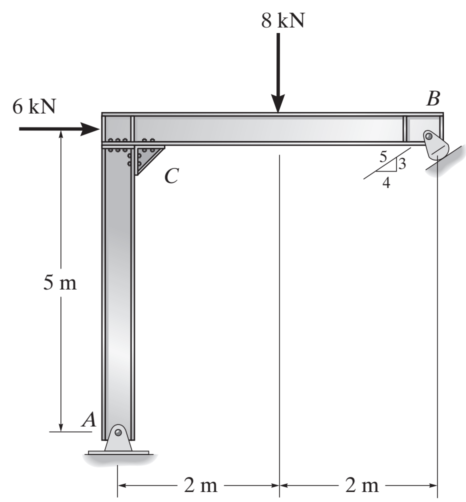
Then consider the *FBD* of pin at C, Fig. *b*,

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad 20.0\left(\frac{3}{5}\right) - C_x = 0\qquad C_x = 12.0\text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\quad C_y - 20.0\left(\frac{4}{5}\right) = 0\qquad C_y = 16.0\text{ kN}$ **Ans.**



2–34. Determine the components of reaction at the supports. Joint C is a rigid connection.



SOLUTION

Equations of Equilibrium. From the *FBD* of the frame in Fig. *a*, we notice that $\mathbf{N}_B$ can be determined directly by writing the moment equation of equilibrium about A.

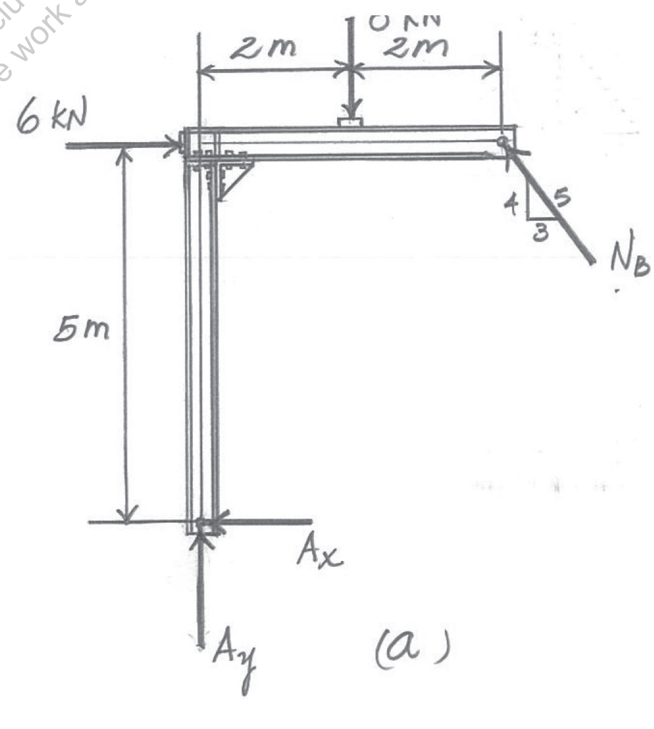
$$\zeta + \Sigma M_A = 0; \qquad N_B\left(\frac{3}{5}\right)(5) + N_B\left(\frac{4}{5}\right)(4) - 8(2) - 6(5) = 0$$

$$N_B = 7.419 \text{ kN} = 7.42 \text{ kN} \qquad \textbf{Ans.}$$

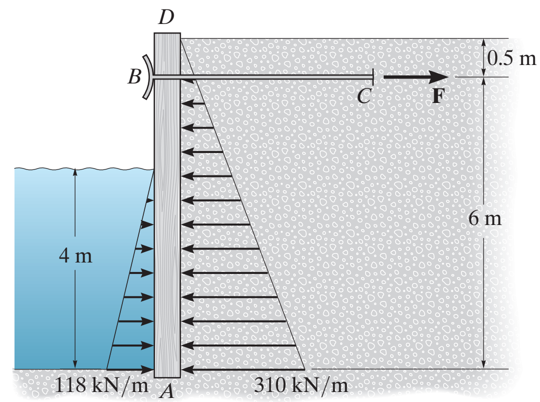
Then write the force equation of equilibrium along x and y axis using this result,

$$\xrightarrow{+} \Sigma F_x = 0; \qquad 6 - 7.419\left(\frac{3}{5}\right) - A_x = 0 \qquad A_x = 1.548 \text{ kN} = 1.55 \text{ kN} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad A_y + 7.419\left(\frac{4}{5}\right) - 8 = 0 \qquad A_y = 2.064 \text{ kN} = 2.06 \text{ kN} \qquad \textbf{Ans.}$$



2–35. The bulkhead AD is subjected to both water and soil-backfill pressures. Assuming AD is "pinned" to the ground at A, determine the horizontal and vertical reactions there and also the required tension in the ground anchor BC necessary for equilibrium. The bulkhead has a mass of 800 kg.



SOLUTION

Equations of Equilibrium: The force in ground anchor BC can be obtained directly by summing moments about point A.

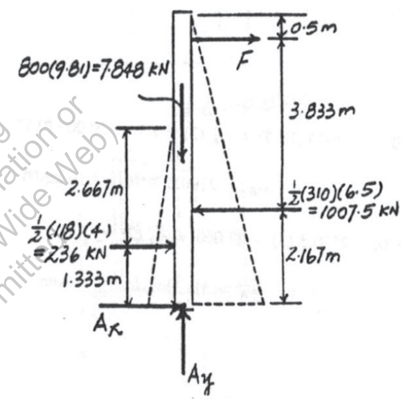
$\circlearrowleft + \Sigma M_A = 0;$ $\quad 1007.5(2.167) - 236(1.333) - F(6) = 0$

$F = 311.375 \text{ kN} = 311 \text{ kN}$ **Ans.**

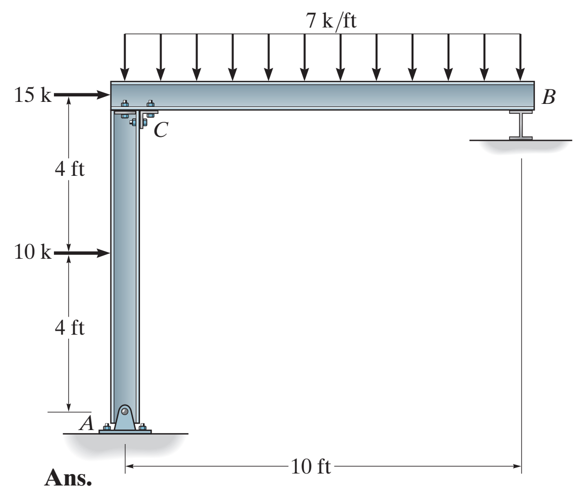
$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad A_x + 311.375 + 236 - 1007.5 = 0$

$A_x = 460 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 7.848 = 0 \quad A_y = 7.85 \text{ kN}$ **Ans.**



***2–36.** Determine the reactions at the supports A and B. Assume the support at B is a roller. C is a fixed-connected joint.



SOLUTION

$+\Sigma M_A = 0; \qquad B_y(10) - 70(5) - 10(4) - 15(8) = 0$

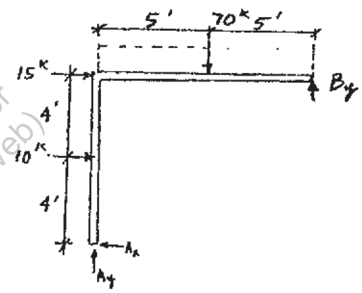
$B_y = 51\text{ k}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \qquad A_y + 51 - 70 = 0$

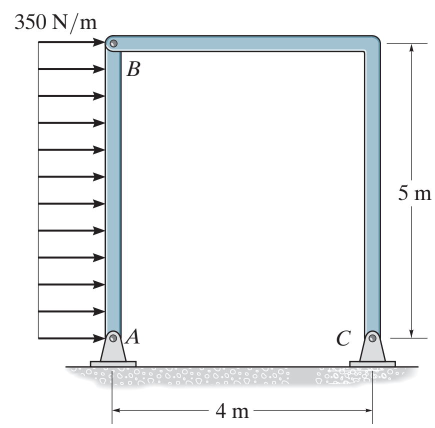
$A_y = 19\text{ k}$ **Ans.**

$+\leftarrow \Sigma F_x = 0; \qquad A_x - 10 - 15 = 0$

$A_x = 25\text{ k}$ **Ans.**



2–37. Determine the horizontal and vertical reactions at A and C of the two-member frame.



SOLUTION

Equations of Equilibrium. Member BC is a two force member, which is reflected in the FBD of member AB, Fig *a*. $\mathbf{F}_{BC}$ and $\mathbf{A}_x$ can be determined directly by writing the moment equations of equilibrium about A and B respectively.

$$\circlearrowleft + \Sigma M_A = 0; \quad F_{BC}\left(\frac{4}{\sqrt{41}}\right)(5) - 1750(2.5) = 0 \quad F_{BC} = 1400.68 \text{ N}$$

$$\circlearrowleft + \Sigma M_B = 0; \quad 1750(2.5) - A_x(5) = 0 \qquad A_x = 875 \text{ N} \qquad \textbf{Ans.}$$

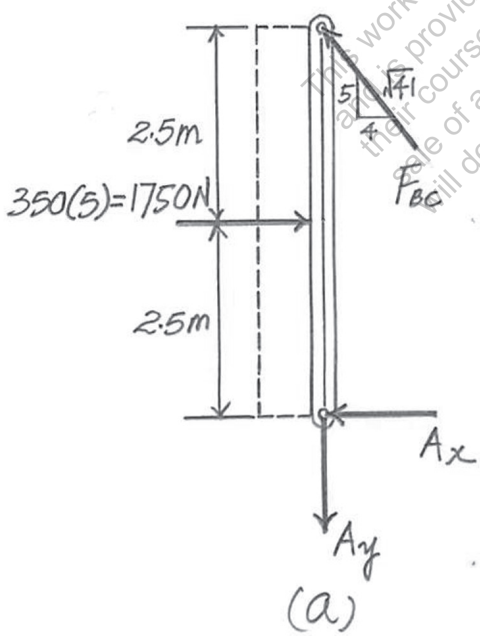
Write the force equation of equilibrium along y axis using the result of F_{BC},

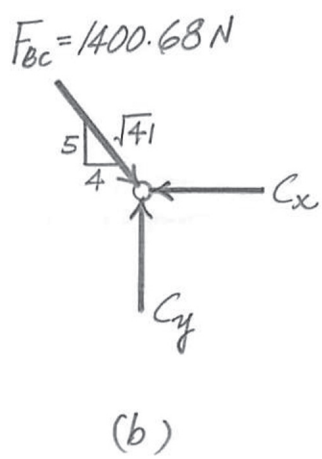
$$+\uparrow \Sigma F_y = 0; \quad (1400.68)\left(\frac{5}{\sqrt{41}}\right) - A_y = 0 \qquad A_y = 1093.75 \text{ N} = 1094 \text{ N} \quad \textbf{Ans.}$$

Then consider the FBD of pin at C, Fig. *b*,

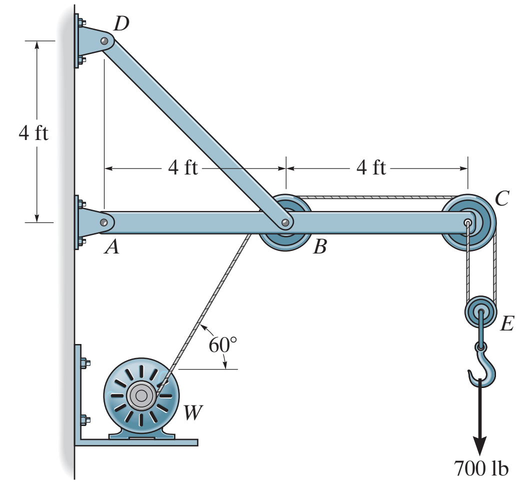
$$\xrightarrow{+} \Sigma F_x = 0; \quad 1400.68\left(\frac{4}{\sqrt{41}}\right) - C_x = 0 \qquad C_x = 875 \text{ N} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad C_y - 1400.68\left(\frac{5}{\sqrt{41}}\right) = 0 \qquad C_y = 1093.75 \text{ N} = 1094 \text{ N} \quad \textbf{Ans.}$$





2–38. The wall crane supports a load of 700 lb. Determine the horizontal and vertical components of reaction at the pins A and D. Also, what is the force in the cable at the winch W?

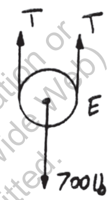


SOLUTION

Pulley E:

$+\uparrow\Sigma F_y = 0;\quad 2T - 700 = 0$

$T = 350\text{ lb}$ **Ans.**



Member ABC:

$\circlearrowleft +\Sigma M_A = 0;\quad T_{BD}\sin 45°\,(4) - 350\sin 60°(4) - 700(8) = 0$

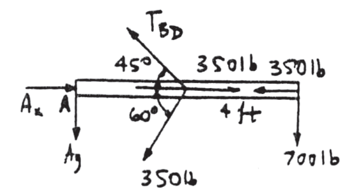
$T_{BD} = 2409\text{ lb}$

$+\uparrow\Sigma F_y = 0;\quad A_y + 2409\sin 45° - 350\sin 60° - 700 = 0$

$A_y = 700\text{ lb}$ **Ans.**

$\xrightarrow{+}\Sigma F_x = 0;\quad A_x - 2409\cos 45° - 350\cos 60° + 350 - 350 = 0$

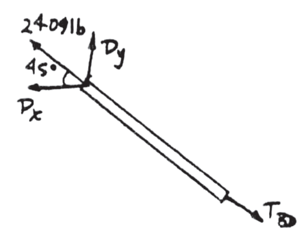
$A_x = 1.88\text{ k}$ **Ans.**



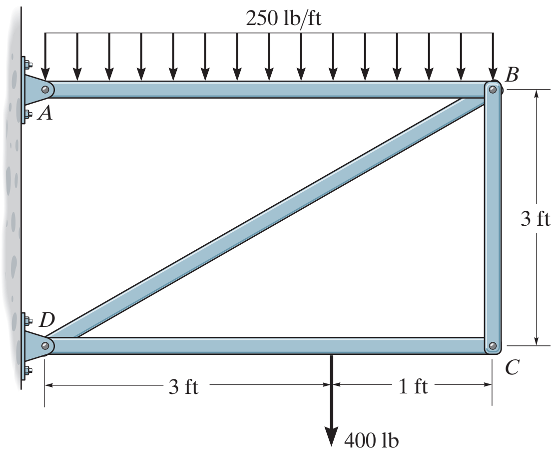
At D:

$D_x = 2409\cos 45° = 1703.1\text{ lb} = 1.70\text{ k}$ **Ans.**

$D_y = 2409\sin 45° = 1.70\text{ k}$ **Ans.**



2–39. Determine the horizontal and vertical force components that the pins support at A and D exert on the four-member frame.



SOLUTION

Equations of Equilibrium. First consider the FBD of member CD, Fig. a

$\circlearrowleft+\Sigma M_D = 0;\quad F_{BC}(4) - 400(3) = 0 \qquad F_{BC} = 300 \text{ lb}$

$\circlearrowleft+\Sigma M_B = 0;\quad 400(1) - D_y'(4) = 0 \qquad D_y' = 100 \text{ lb}$

$\xrightarrow{+}\Sigma F_x = 0;\quad D_x' = 0$

Next consider the FBD of member AB, Fig. b

$\circlearrowleft+\Sigma M_A = 0;\quad F_{BD}\left(\frac{3}{5}\right)(4) - 1000(2) - 300(4) = 0 \qquad F_{BD} = 1333.33 \text{ lb}$

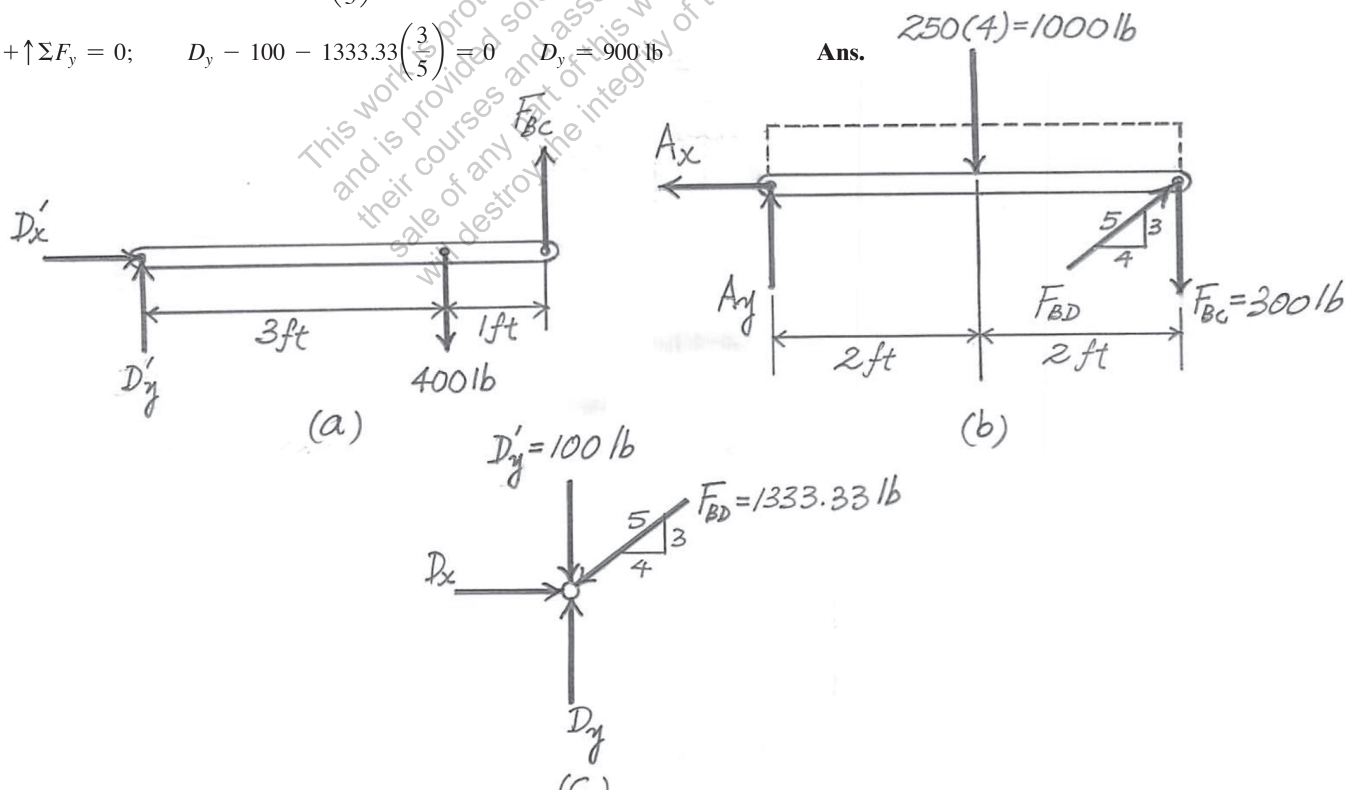
$\circlearrowleft+\Sigma M_B = 0;\quad 1000(2) - A_y(4) = 0 \qquad A_y = 500 \text{ lb}$ **Ans.**

$\xrightarrow{+}\Sigma F_x = 0;\quad 1333.33\left(\frac{4}{5}\right) - A_x = 0 \qquad A_x = 1066.67 \text{ lb} = 1067 \text{ lb}$ **Ans.**

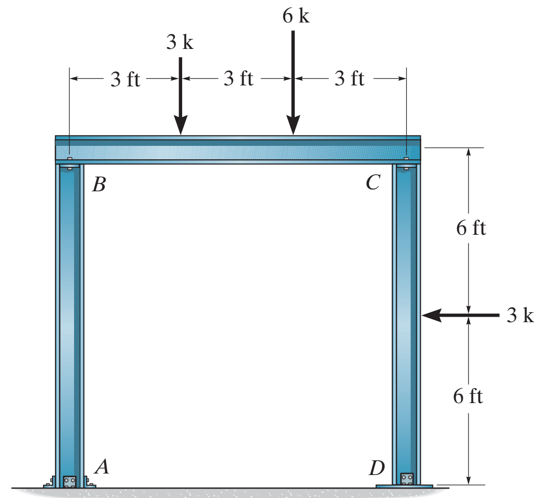
Finally consider the FBD of the pin at D, Fig. c

$\xrightarrow{+}\Sigma F_x = 0;\quad D_x - 1333.33\left(\frac{4}{5}\right) = 0 \qquad D_x = 1066.67 \text{ lb} = 1067 \text{ lb}$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad D_y - 100 - 1333.33\left(\frac{3}{5}\right) = 0 \qquad D_y = 900 \text{ lb}$ **Ans.**



***2–40.** Determine the reactions at the supports A and D. Assume A is fixed and B, C and D are pins.



SOLUTION

Equations of Equilibrium. First consider the FBD of member BC, Fig. a

$\circlearrowleft + \Sigma M_B = 0; \quad C_y(9) - 3(3) - 6(6) = 0 \quad C_y = 5.00 \text{ k}$

$\circlearrowleft + \Sigma M_C = 0; \quad 6(3) + 3(6) - B_y(9) = 0 \quad B_y = 4.00 \text{ k}$

$\xrightarrow{+} \Sigma F_x = 0 \quad B_x - C_x = 0 \qquad (1)$

Then consider the FBD of member CD, Fig. b

$\circlearrowleft + \Sigma M_C = 0; \quad D_x(12) - 3(6) = 0 \quad D_x = 1.50 \text{ k}$ **Ans.**

$\circlearrowleft + \Sigma M_D = 0; \quad 3(6) - C_x(12) = 0 \quad C_x = 1.50 \text{ k}$

$+\uparrow \Sigma F_y = 0; \quad D_y - 5.00 = 0 \quad D_y = 5.00 \text{ k}$ **Ans.**

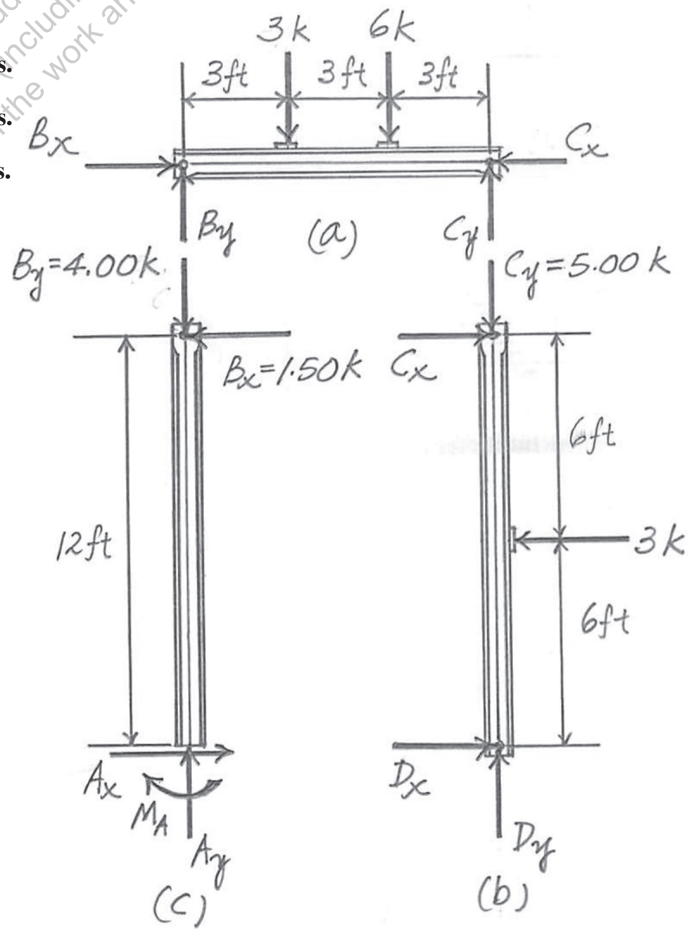
Then Eq (1) gives $B_x = 1.50 \text{ k}$

Finally consider the FBD of member AB, Fig. c

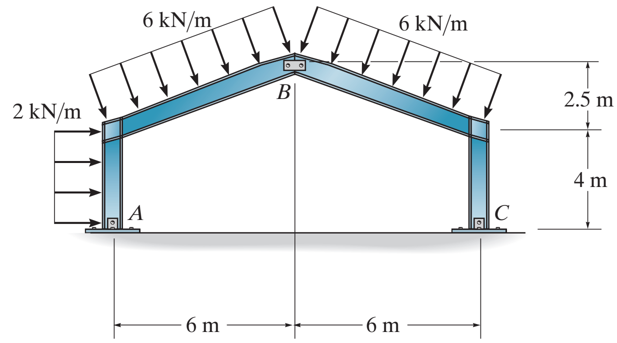
$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 1.50 = 0 \quad A_x = 1.50 \text{ k}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad A_y - 4.00 = 0 \quad A_y = 4.00 \text{ k}$ **Ans.**

$\circlearrowleft + \Sigma M_A = 0; \quad 1.50(12) - M_A = 0 \quad M_A = 18.0 \text{ k} \cdot \text{ft}$ **Ans.**



2–41. Determine the components of reaction at the pinned supports A and C of the two-member frame. Neglect the thickness of the members. Assume B is a pin.



SOLUTION

Equations of Equilibrium. Referring to the FBD of members AB and BC shown in Fig. a and b, respectively, we notice that $\mathbf{B}_x$ and $\mathbf{B}_y$ can be determined by solving simultaneously the moment equations of equilibrium written about A and C, respectively.

$$\circlearrowleft + \Sigma M_A = 0; \qquad B_x(6.5) + B_y(6) - (6)\left(\sqrt{42.25}\right)\left(\frac{2.5}{\sqrt{42.25}}\right)(5.25)$$

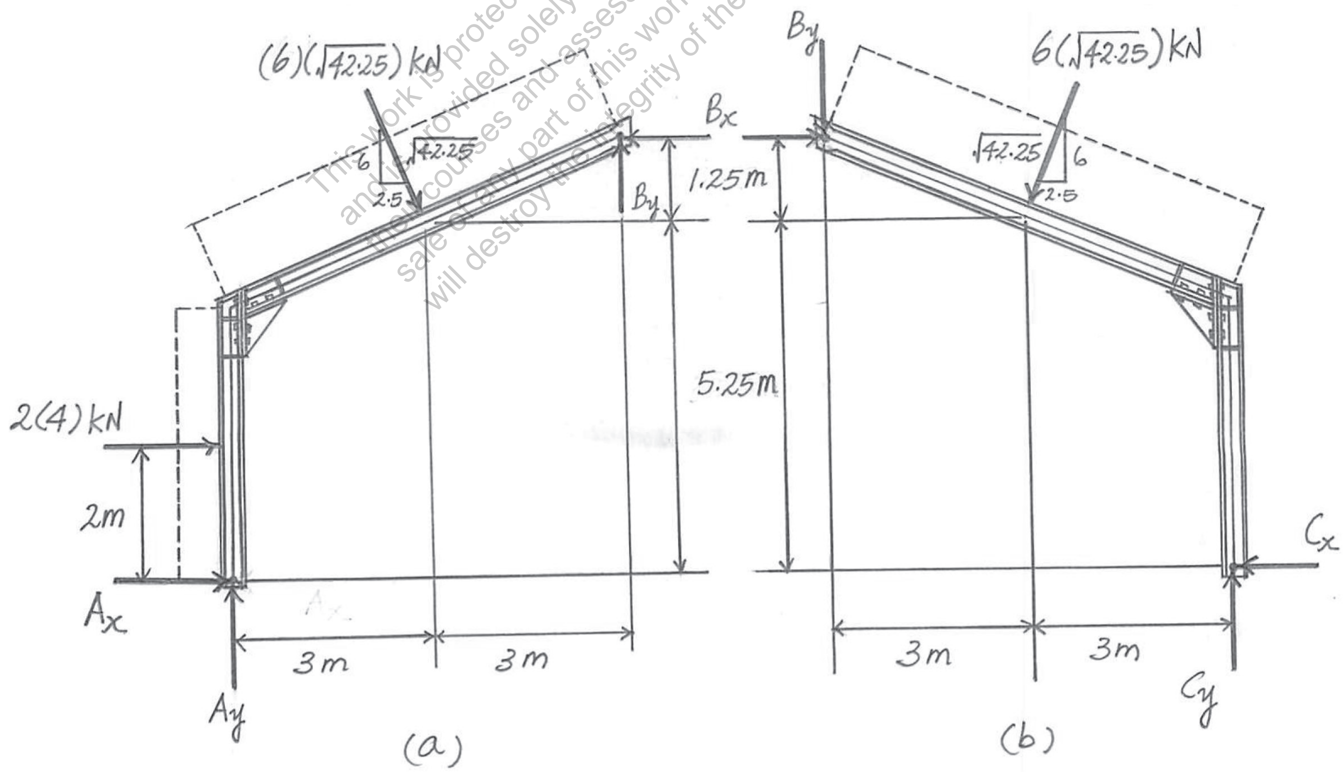
$$-(6)\left(\sqrt{42.25}\right)\left(\frac{6}{\sqrt{42.25}}\right)(3) - (2)(4)(2) = 0$$

$$6.5B_x + 6B_y = 202.75 \qquad (1)$$

$$\circlearrowleft + \Sigma M_C = 0; \qquad (6)\left(\sqrt{42.25}\right)\left(\frac{2.5}{\sqrt{42.25}}\right)(5.25) + (6)\left(\sqrt{42.25}\right)\left(\frac{6}{\sqrt{42.25}}\right)(3)$$

$$+B_y(6) - B_x(6.5) = 0$$

$$6.5B_x - 6B_y = 186.75 \qquad (2)$$



2–41. (Continued)

Solving Eq (1) and (2) yields

$$B_x = 29.96 \text{ k} \qquad B_y = 1.333 \text{ k}$$

Using these results and writing the force equation of equilibrium by referring to the FBD of member AB, Fig. a,

$$\xrightarrow{+} \Sigma F_x = 0; \qquad 2(4) + (6)\left(\sqrt{42.25}\right)\left(\frac{2.5}{\sqrt{42.25}}\right) - 29.96 + A_x = 0$$

$$A_x = 6.962 \text{ k} = 6.96 \text{ k} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad A_y + 1.333 - 6\left(\sqrt{42.25}\right)\left(\frac{6}{\sqrt{42.25}}\right) = 0$$

$$A_y = 34.67 \text{ k} = 34.7 \text{ k} \qquad \textbf{Ans.}$$

Referring to the FBD of member BC, Fig. b

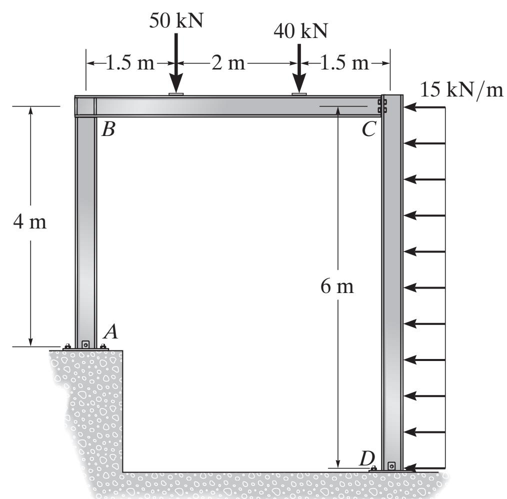
$$\xrightarrow{+} \Sigma F_x = 0; \qquad 29.96 - (6)\left(\sqrt{42.25}\right)\left(\frac{2.5}{\sqrt{42.25}}\right) - C_x = 0$$

$$C_x = 14.96 \text{ k} = 15.0 \text{ k} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad C_y - 1.333 - (6)\left(\sqrt{42.25}\right)\left(\frac{6}{\sqrt{42.25}}\right) = 0$$

$$C_y = 37.33 \text{ k} = 37.3 \text{ k} \qquad \textbf{Ans.}$$

2–42. Determine the horizontal and vertical components of reaction at A, C, and D. Assume the frame is pin connected at A, C, and D, and there is a fixed-connected joint at B.



SOLUTION

Member CD:

$\circlearrowleft + \Sigma M_D = 0; \quad -C_x(6) + 90(3) = 0$

$C_x = 45.0 \text{ kN}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0; \quad D_x + 45 - 90 = 0$

$D_x = 45.0 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad D_y - C_y = 0$ (1)

Member ABC:

$\circlearrowleft + \Sigma M_A = 0; \quad C_y(5) + 45.0(4) - 50(1.5) - 40(3.5) = 0$

$C_y = 7.00 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad A_y + 7.00 - 50 - 40 = 0$

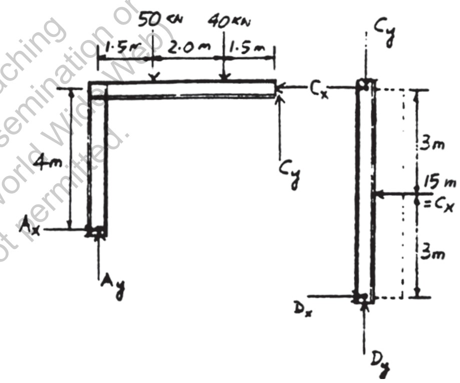
$A_y = 83.0 \text{ kN}$ **Ans.**

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 45.0 = 0$

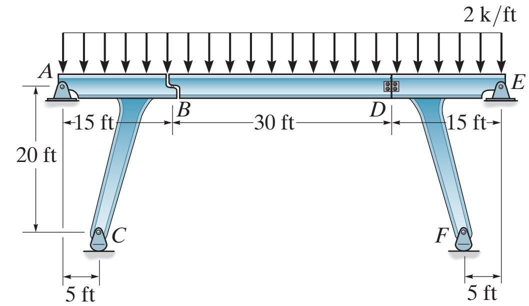
$A_x = 45.0 \text{ kN}$ **Ans.**

From Eq. (1).

$D_y = 7.00 \text{ kN}$ **Ans.**

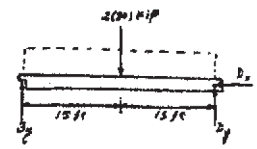


2–43. The bridge frame consists of three segments which can be considered pinned at A, D, and E, rocker supported at C and F, and roller supported at B. Determine the horizontal and vertical components of reaction at all these supports due to the loading shown.



SOLUTION

For segment BD:

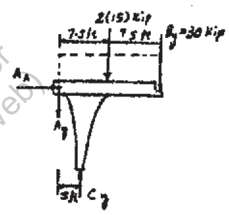


$\circlearrowleft+\Sigma M_D = 0;\quad 2(30)(15) - B_y(30) = 0 \quad B_y = 30\text{ kip}$ **Ans.**

$\xrightarrow{+}\Sigma F_x = 0;\quad D_x = 0$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad D_y + 30 - 2(30) = 0 \quad D_y = 30\text{ kip}$ **Ans.**

For segment ABC:

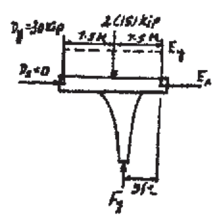


$\circlearrowleft+\Sigma M_A = 0;\quad C_y(5) - 2(15)(7.5) - 30(15) = 0 \quad C_y = 135\text{ kip}$ **Ans.**

$\xrightarrow{+}\Sigma F_x = 0;\quad A_x = 0$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad -A_y + 135 - 2(15) - 30 = 0 \quad A_y = 75\text{ kip}$ **Ans.**

For segment DEF:

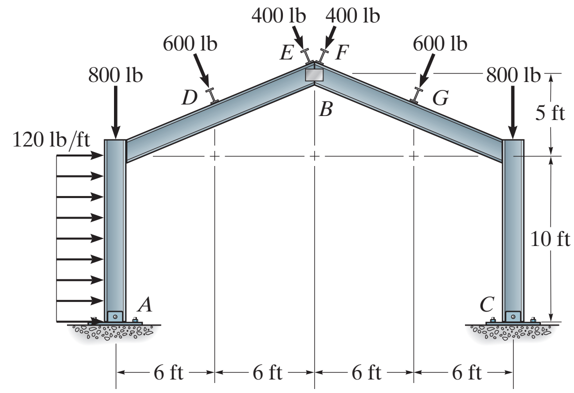


$\circlearrowleft+\Sigma M_g = 0;\quad -F_y(5) + 2(15)(7.5) + 30(15) = 0 \quad F_y = 135\text{ kip}$ **Ans.**

$\xrightarrow{+}\Sigma F_x = 0;\quad E_x = 0$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad -E_y + 135 - 2(15) - 30 = 0 \quad E_y = 75\text{ kip}$ **Ans.**

***2–44.** Determine the horizontal and vertical reactions at the connections A and C of the gable frame. Assume that A, B, and C are pin connections. The purlin loads such as D and E are applied perpendicular to the center line of each girder.



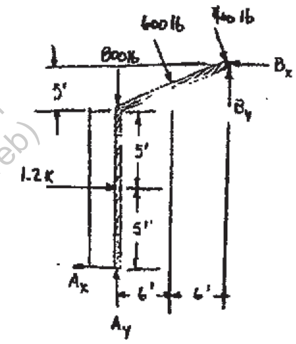
SOLUTION

Member AB:

$\zeta+\Sigma M_A = 0;\quad B_x(15) + B_y(12) - (1200)(5) - 600\left(\frac{12}{13}\right)(6) - 600\left(\frac{5}{13}\right)(12.5)$

$$-400\left(\frac{12}{13}\right)(12) - 400\left(\frac{5}{13}\right)(15) = 0$$

$$B_x(15) + B_y(12) = 18{,}946.154 \qquad (1)$$

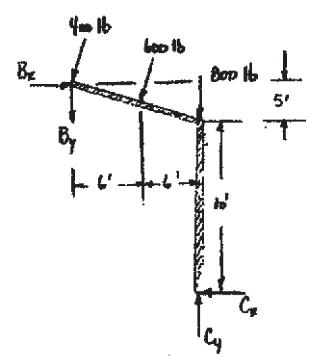


Member BC:

$\zeta+\Sigma M_C = 0;\quad -B_x(15) + B_y(12) + 600\left(\frac{12}{13}\right)(6) + 600\left(\frac{5}{13}\right)(12.5)$

$$400\left(\frac{12}{13}\right)(12) + 400\left(\frac{5}{13}\right)(15) = 0$$

$$B_x(15) - B_y(12) = 12{,}446.15 \qquad (2)$$



Solving Eqs. (1) and (2),

$$B_x = 1063.08 \text{ lb.} \qquad B_y = 250.0 \text{ lb}$$

Member AB:

$\xrightarrow{+}\Sigma F_x = 0;\quad -A_x + 1200 + 1000\left(\frac{5}{13}\right) - 1063.08 = 0$

$A_x = 522 \text{ lb}$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad A_y - 800 - 1000\left(\frac{12}{13}\right) + 250 = 0$

$A_y = 1473 \text{ lb}$ **Ans.**

Member BC:

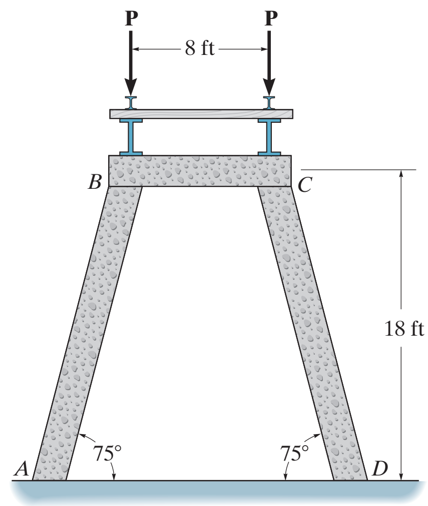
$\xrightarrow{+}\Sigma F_x = 0;\quad -C_x - 1000\left(\frac{5}{13}\right) + 1063.08 = 0$

$C_x = 678 \text{ lb}$ **Ans.**

$+\uparrow\Sigma F_y = 0;\quad C_y - 800 - 1000\left(\frac{12}{13}\right) - 250.0 = 0$

$C_y = 1973 \text{ lb}$ **Ans.**

2–1P. The railroad trestle bridge shown in the photo is supported by reinforced concrete bents. Assume the two simply supported side girders, track bed, and two rails have a weight of 0.5 k/ft and the load imposed by a train is 7.2 k/ft. Each girder is 20 ft long. Apply the load over the entire bridge and determine the compressive force in the columns of each bent. For the analysis assume all joints are pin connected and neglect the weight of the bent. Are these realistic assumptions?



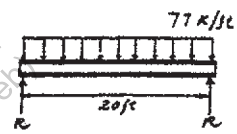
SOLUTION

Maximum reactions occur when the live load is over the entire span.

Load $= 7.2 + 0.5 = 7.7\ \mathrm{k/ft}$

$R = 7.7(10) = 77\ \mathrm{k}$

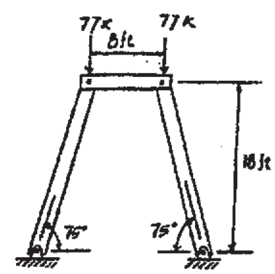
Then $\quad P = \dfrac{2(77)}{2} = 77\ \mathrm{k}$



All members are two-force members.

$\circlearrowleft + \Sigma M_B = 0; \quad -77(8) + F \sin 75°(8) = 0$

$F = 79.7\ \mathrm{k}$ **Ans.**



It is not reasonable to assume the members are pin connected, since such a framework is unstable. **Ans.**