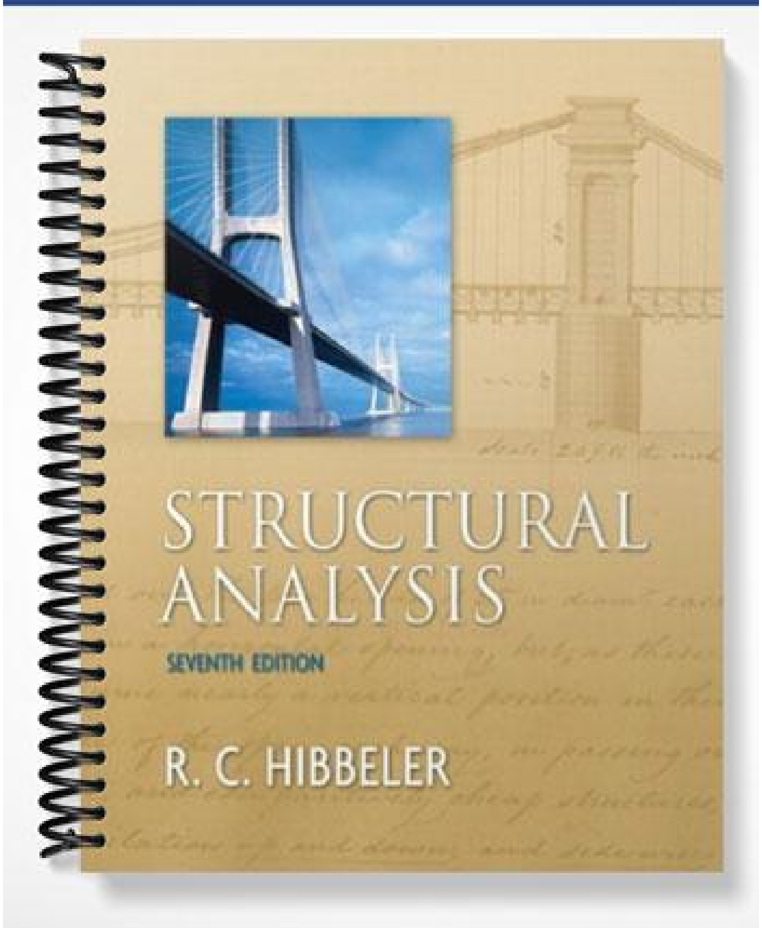
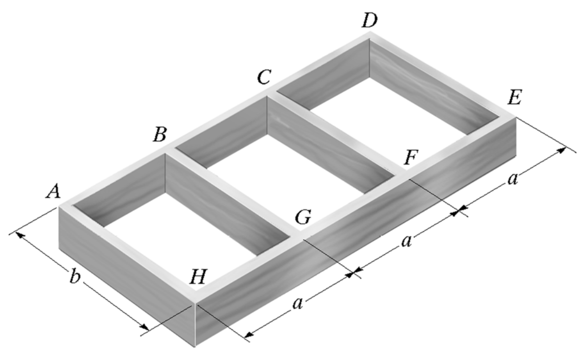
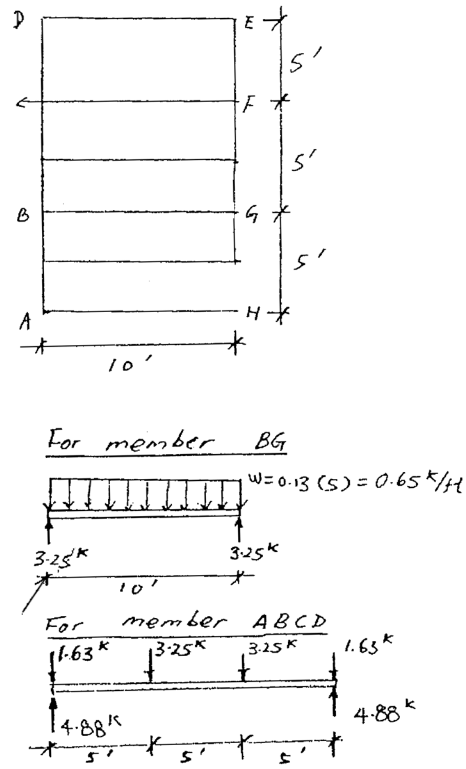
SOLUTIONS MANUAL



2–1. The frame is used to support a wood deck (not shown) that is to be subjected to a uniform load of 130 lb/ft^2. Sketch the loading that acts along members BG and $ABCD$. Take $b = 10$ ft, $a = 5$ ft.



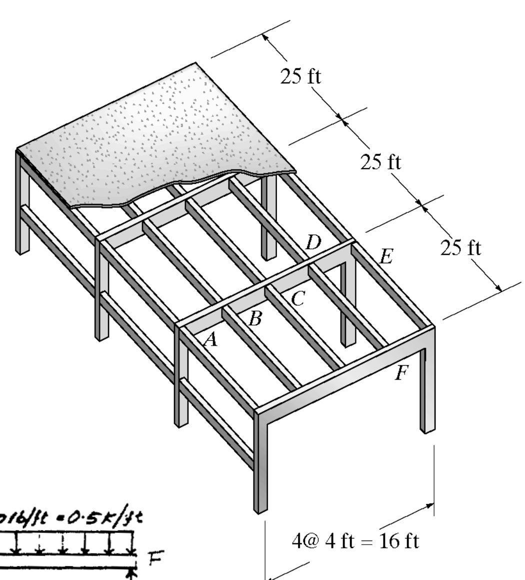
$b/a = 10/5 = 2 > 1.5$ (one-way slab)



For BG, $w = 0.65$ k/ft **Ans**

For $ABCD$, reactions are 4.88 k **Ans**

2–2. The roof deck of the single story building is subjected to a dead plus live load of 125 lb/ft^2. If the purlins are spaced 4 ft and the bents are spaced 25 ft apart, determine the distributed loading that acts along the purlin DF, and the loadings that act on the bent at A, B, C, D, and E.



$$\frac{L_2}{L_1} = \frac{25}{4} = 6.25 > 2$$

One-way slab.

Tributary load along DF = (125 lb/ft^2)(4 ft) = 500 lb/ft **Ans**

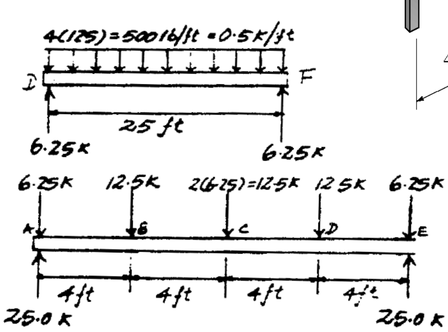
This load is also transferred to the bent from the other side of AE. Half the tributary loading acts at A and E.

At A and E:

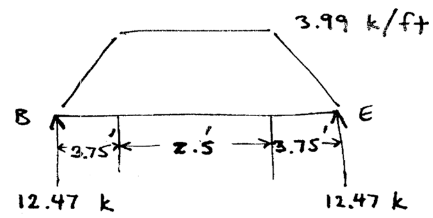
$F' = 6250 \text{ lb} = 6.25 \text{ k}$ **Ans**

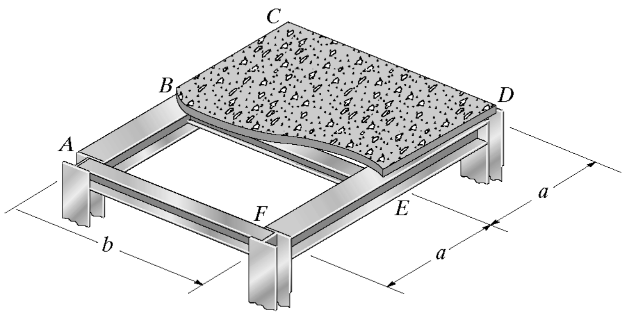
At B, C, D:

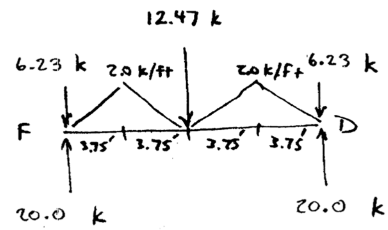
$F = 2(6250) = 12\,500 \text{ lb} = 12.5 \text{ k}$ **Ans**



2–3. The steel framework is used to support the 4-in. reinforced lightweight concrete slab that carries a uniform live loading of 500 lb/ft^2. Sketch the loading that acts along members BE and FD. Set $b = 10$ ft, $a = 7.5$ ft. *Hint:* See Table 1–3.

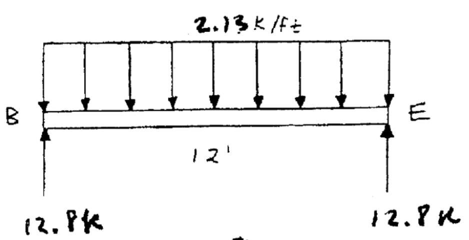


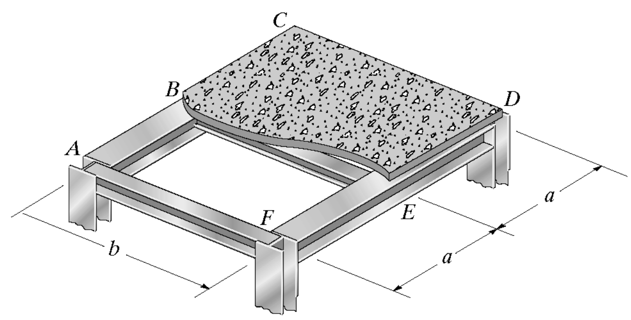


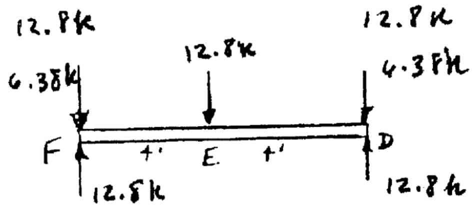


Reaction at B, 12.5 k;
Reaction at F, 20 k

***2–4.** Solve Prob. 2–3, with $b = 12$ ft, $a = 4$ ft.





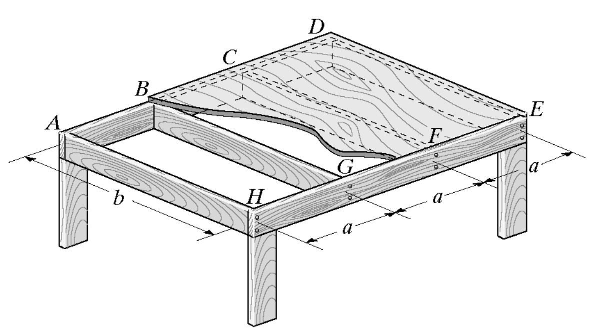


$DL = 8(4) = 32$ psf
$LL = 500$ psf
Total load $= 532$ psf

$$\frac{L_2}{L_1} = \frac{b}{a} = \frac{12}{4} = 3 > 2$$

One–way slab

2–5. The frame is used to support the wood deck in a residential dwelling. Sketch the loading that acts along members BG and $ABCD$. Set $b = 10$ ft, $a = 5$ ft. *Hint:* See Table 1–4.

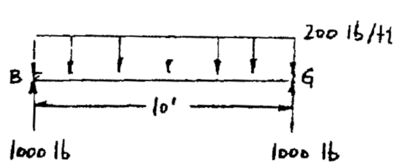


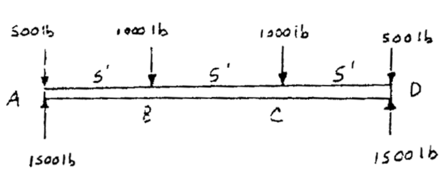
From Table 1-4
$LL = 40$ psf

$$\frac{L_2}{L_1} = \frac{b}{a} = \frac{10}{5} = 2$$

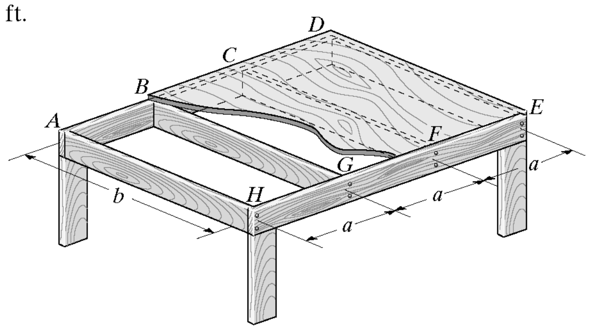
One–way slab

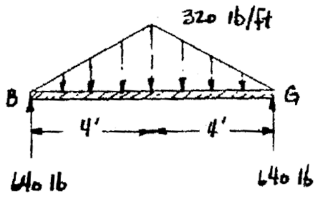
Reaction at A: 1500 lb **Ans**





2–6. Solve Prob. 2–5 if $b = 8$ ft, $a = 8$ ft.



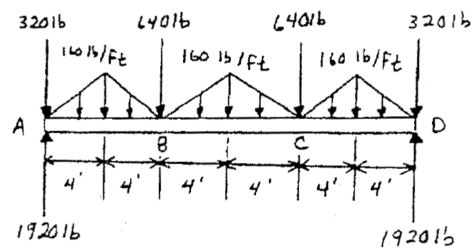


From Table 1–4

$LL = 40$ psf

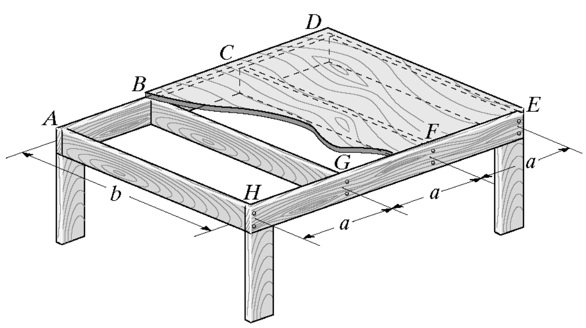
$\dfrac{L_2}{L_1} = \dfrac{b}{a} = \dfrac{8}{8} = 1 < 2$

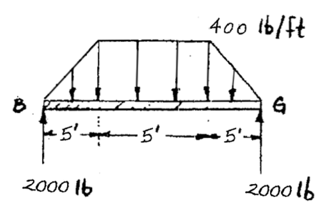
Two–way slab



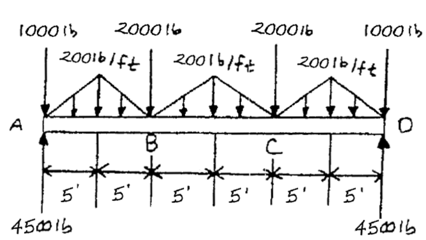
Reaction at A 1920 lb **Ans**

2–7. Solve Prob. 2–5 if $b = 15$ ft, $a = 10$ ft.



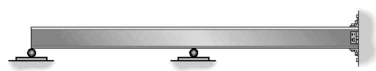


From Table 1–3,
$LL = 40$ psf
$b / a = 15/10 = 1.33<1.5$
Two–way slab

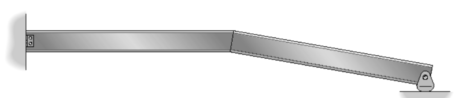


Reactions are 2000 lb and 4500 lb **Ans**

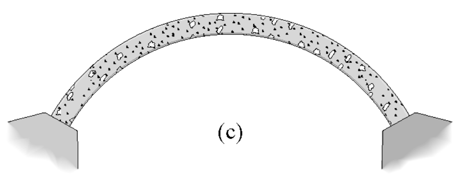
***2–8.** Classify each of the structures as statically determinate, statically indeterminate, stable, or unstable. If indeterminate, specify the degree of indeterminacy.



(a)



(b)



(c)

(d)

(a)

$r = 5, \quad n = 1$
$r > 3n$
$5 > 3(1)$

Indeterminate to 2°, Stable **Ans**

(b)

$r = 3, \quad n = 1$
$r = 3n$
$3 = 3(1)$
Determinate, Stable **Ans**

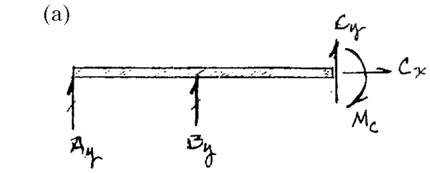
(c)

$r = 6, \quad n = 1$
$r > 3n$
$6 > 3(1)$
Indeterminate to 3°, Stable **Ans**

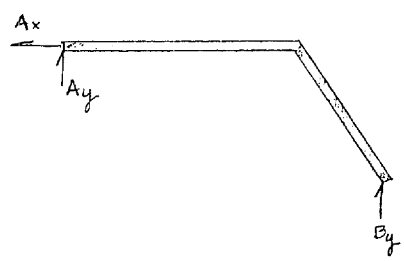
(d)

Unstable Concurrent Reactions **Ans**

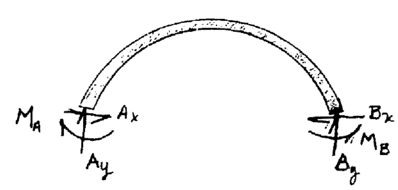
(a)



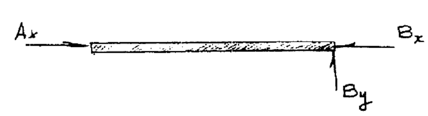
(b)



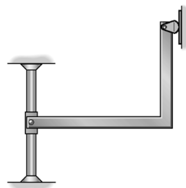
(c)



(d)

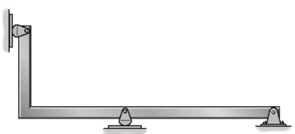


2–9. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.



(a)

(b)

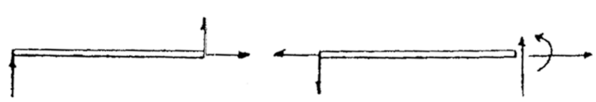


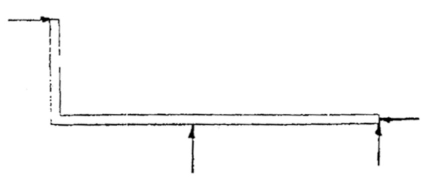
(c)

(d)

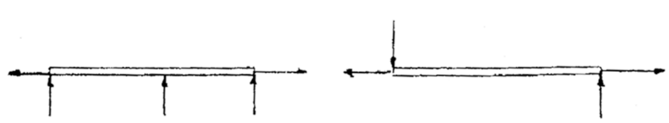
(a) Parallel reactions
Unstable. **Ans**

(b) $r = 3n$
$6 = 3(2)$
Statically determinate. **Ans**



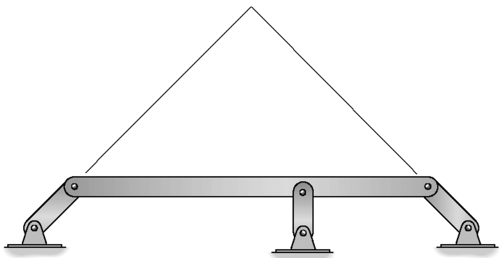


(c) $r > 3n$
$4 > 3(1)$
Statically indeterminate to 1° **Ans**



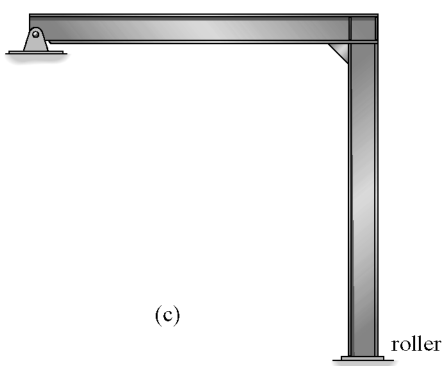
(d) $r > 3n$
$7 > 3(2)$
Statically indeterminate to 1°. **Ans**

2–10. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.

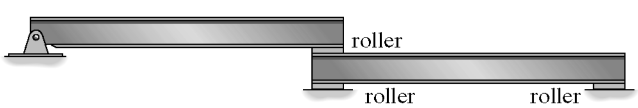


(a)

(b)



(c)



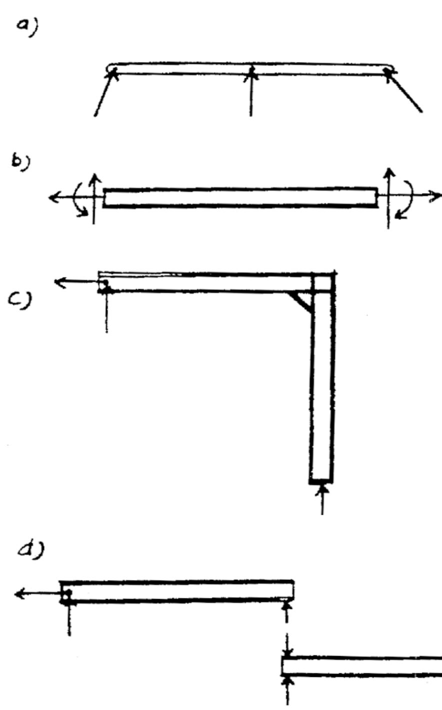
(d)

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

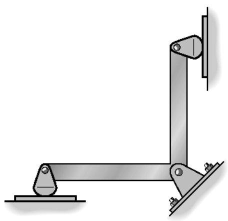
(b) $r = 6$ $\quad 3n = 3(1) = 3 < 6$
Indeterminate to 3° **Ans**

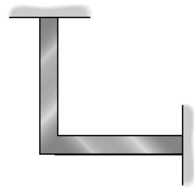
(c) $r = 3$ $\quad 3n = 3(1) = 3$
Statically determinate **Ans**

(d) Parallel reactions on lower beam
Unstable **Ans**



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


(a)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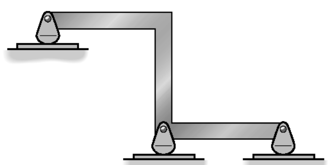

(b)

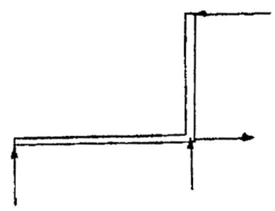

(d)

(a)

$r > 3n$

$4 > 3(1)$

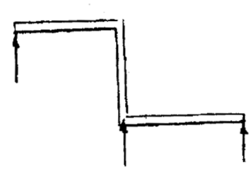
Statically indeterminate to 1° **Ans**



(b)

Parallel reactions

Unstable. **Ans**

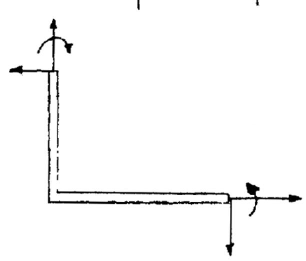


(c)

$r > 3n$

$6 > 3(1)$

Statically indeterminate to 3° **Ans**

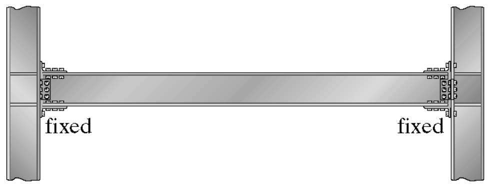


(d)

Parallel reactions

Unstable. **Ans**

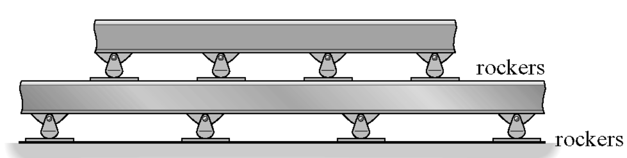
***2–12.** Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy. The supports or connections are to be assumed as stated.



(a)

(b)

(c)



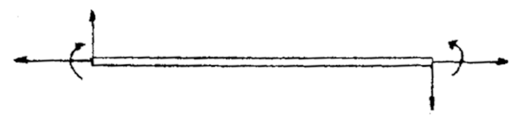
(d)

(a)

$r > 3n$

$6 > 3(1)$

Statically indeterminate to 3°. **Ans**

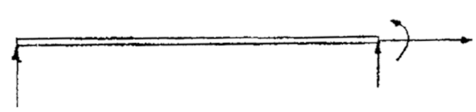


(b)

$r > 3n$

$4 > 3(1)$

Statically indeterminate to 1°. **Ans**



(c)

$r > 3n$

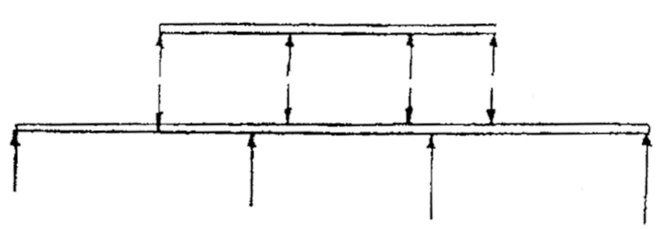
$4 > 3(1)$

Statically indeterminate to 1°. **Ans**

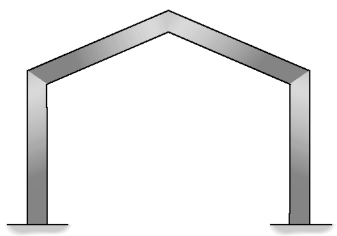
(d)

Parallel reactions.

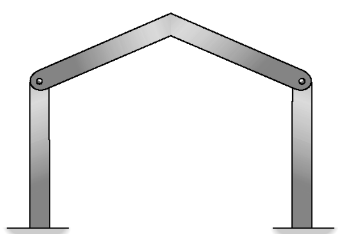
Unstable. **Ans**



2–13. Classify each of the structures as statically d minate statically indeterminate, or unstable. If indete nate, specify the degree of indeterminacy.



(a)



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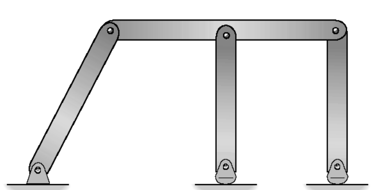
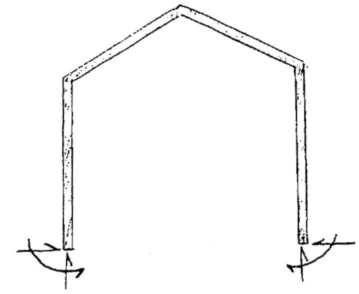


(c)

(a)



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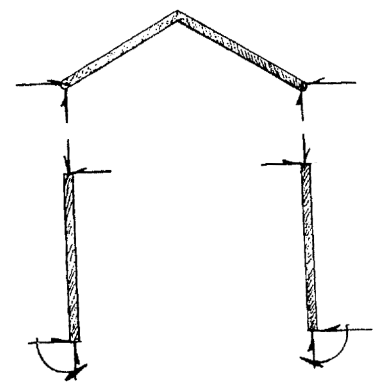
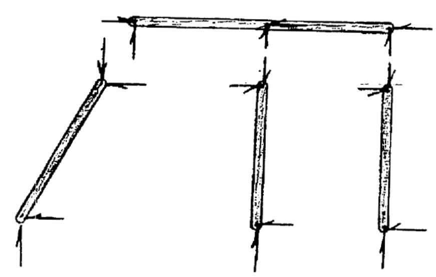


(c)



(a)

$r = 6, \quad n = 1$

$r > 3n$

$6 = 3(1)$

Indeterminanat to 3° **Ans**

(b)

$r = 10, \quad n = 3$

$r > 3n$

$10 = 3(3)$

Statically indeterminate to the 1° **Ans**

(c)

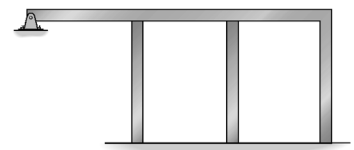
$r = 12, \quad n = 4$

$r = 3n$

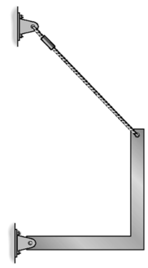
$12 = 3(4)$

Statically determinate **Ans**

2–14. Classify each of the frames as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy. All internal joints are fixed connected.



(a)



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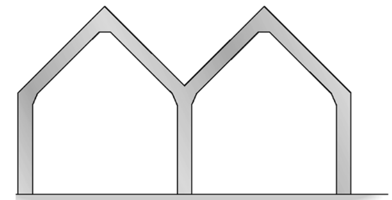

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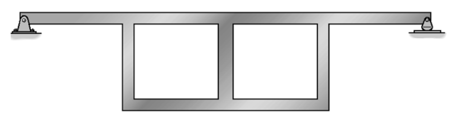

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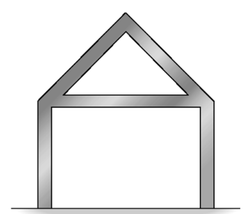
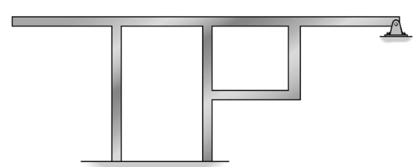


(e)



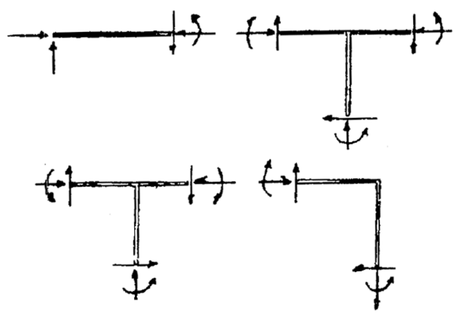
(f)

(a)

$r > 3n$

$20 > 3(4)$

Statically indeterminate to 8°. **Ans**

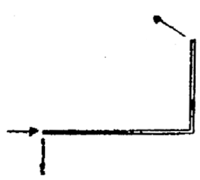


(b)

$r = 3n$

$3 = 3(1)$

Statically determinate. **Ans**

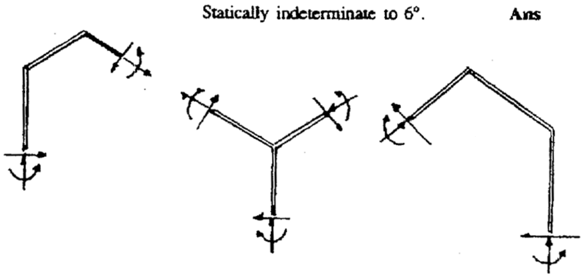


(c)

$r > 3n$

$15 > 3(3)$

Statically indeterminate to 6°. **Ans**

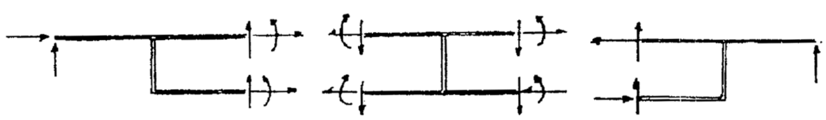


(d)

$r > 3n$

$15 > 3(3)$

Statically indeterminate to 6°. **Ans**

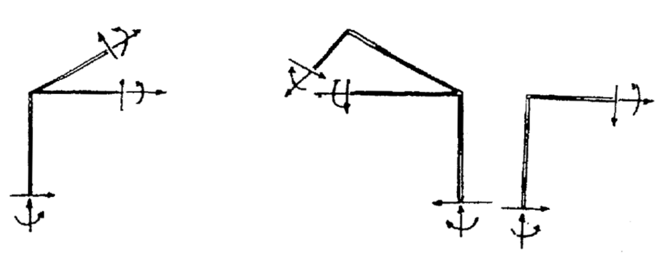


(e)

$r > 3n$

$12 > 3(2)$

Statically indeterminate to 6°. **Ans**

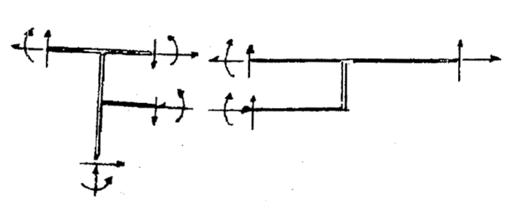


(f)

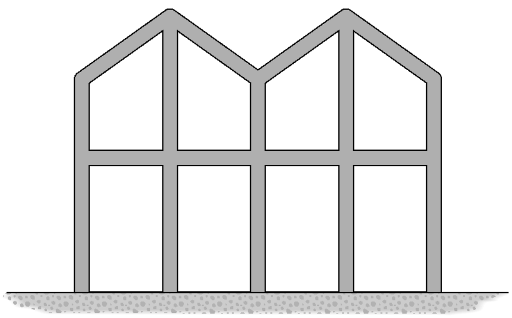
$r > 3n$

$17 > 3(3)$

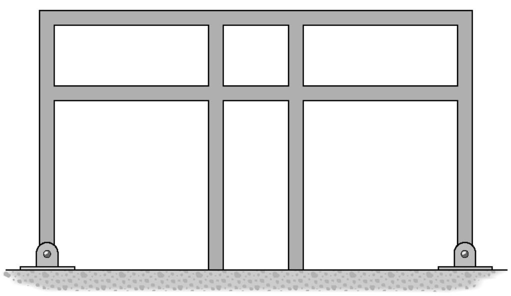
Statically indeterminate to 8°. **Ans**



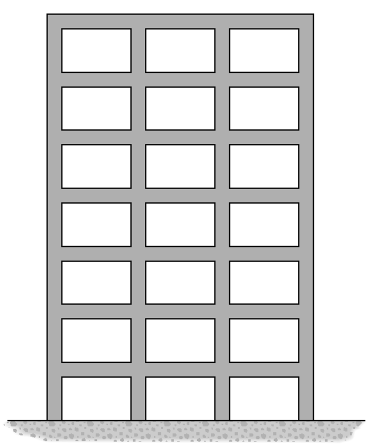
2–15. Determine the degree to which the frames are statically indeterminate. All internal joints are fixed connected.



(a)



(b)



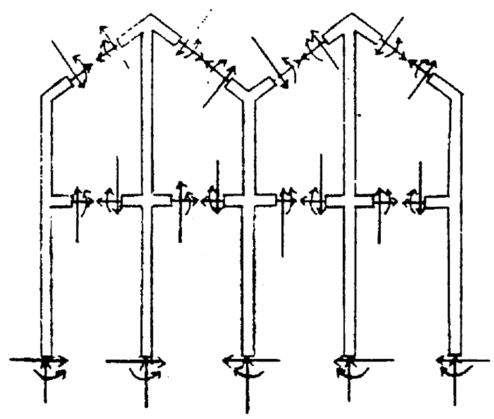
(c)

(a) Statically indeterminate to 24° **Ans**

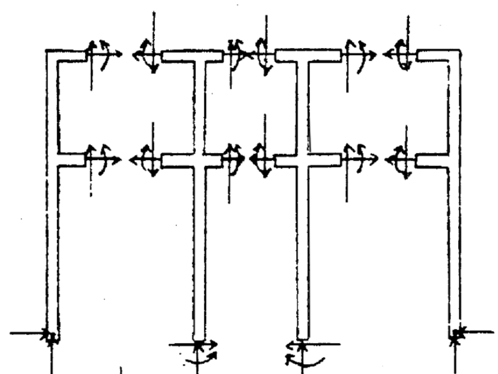
(b) Statically indeterminate to 16° **Ans**

Statically indeterminate to 63° **Ans**

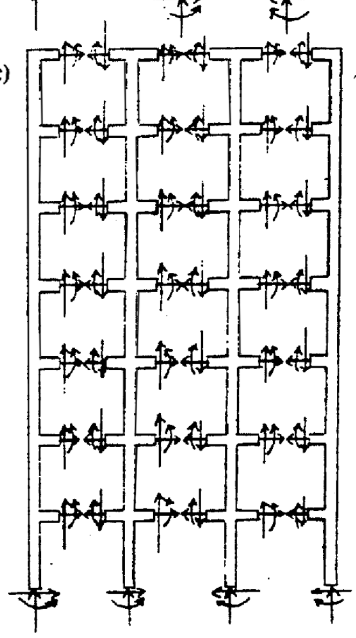
(a) 39 – 15 = 24°



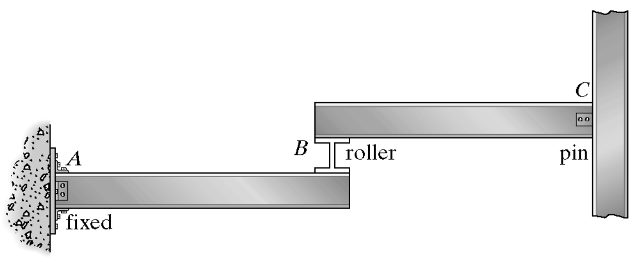
(b) 28 – 12 = 16°



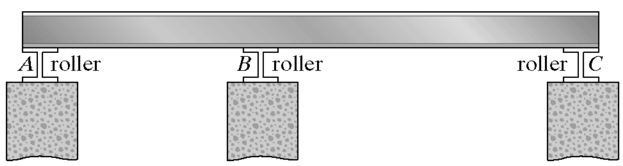
(c) 75 – 12 = 63°



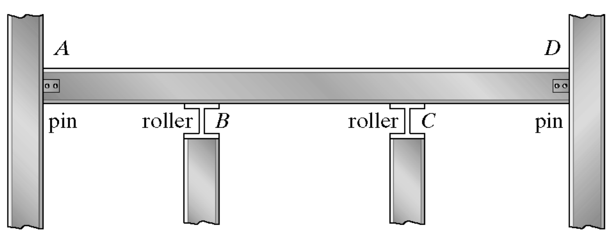
***2–16.** Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy. The supports or connections are to be assumed as stated.



(a)



(b)



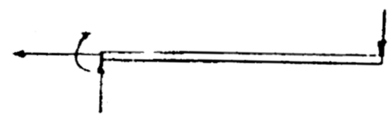
(c)

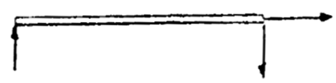
(a)

$r = 3n$

$6 = 3(2)$

Statically determinate. **Ans**

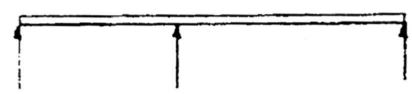




(b)

Parallel reactions

Unstable. **Ans**

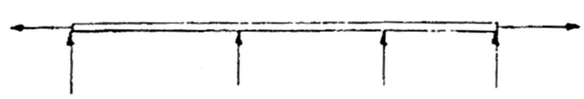


(c)

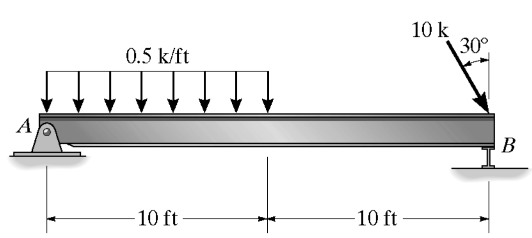
$r > 3n$

$6 > 3(1)$

Statically indeterminate to the 3°. **Ans**



2–17. Determine the reactions on the beam. The support at B can be assumed to be a roller. Neglect the thickness of the beam.



$\circlearrowleft + \Sigma M_A = 0;\; B_y(20) - 10\cos 30°(20) - 5(5) = 0$

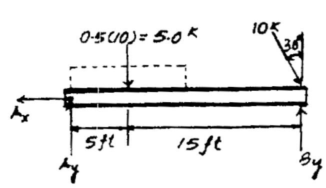
$B_y = 9.91 \text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0;\; A_y + 9.910 - 5 - 10\cos 30° = 0$

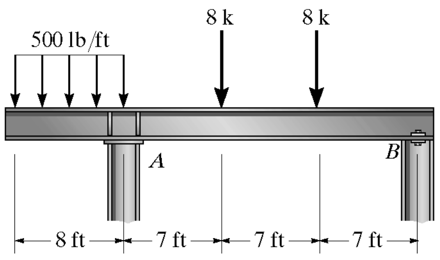
$A_y = 3.75 \text{ k}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\; -A_x + 10\sin 30° = 0$

$A_x = 5.00 \text{ k}$ **Ans**



2–18. Determine the reactions at the supports A and B. Assume A is a roller and B is a pin.



$\curvearrowleft + \Sigma M_B = 0; \quad -A_y(21) + 8(7) + 8(14) + 4(25) = 0$

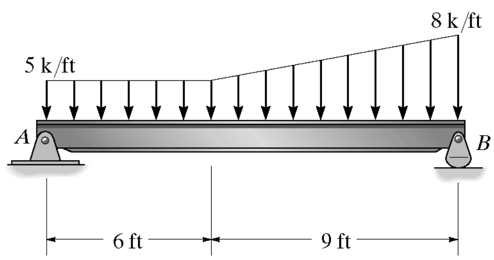
$A_y = 12.8 \text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad B_y + 12.76 - 4 - 8 - 8 = 0$

$B_y = 7.24 \text{ k}$ **Ans**

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

2–19. Determine the reactions on the beam.



$\curvearrowleft + \Sigma M_A = 0; \quad B_y(15) - 75(7.5) - 13.5(12) = 0$

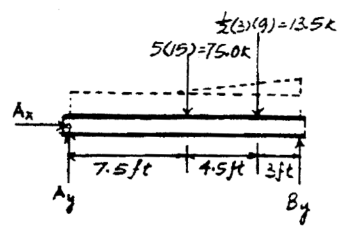
$B_y = 48.3 \text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y + 48.3 - 75 - 13.5 = 0$

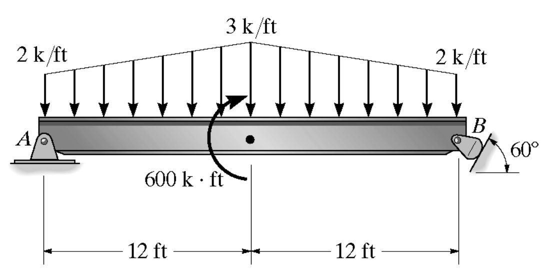
$A_y = 40.2 \text{ k}$ **Ans**

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

$A_x = 0$ **Ans**



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



$\curvearrowleft + \Sigma M_A = 0; \quad -60(12) - 600 + F_B \cos 60°(24)$

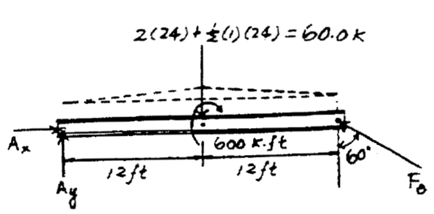
$F_B = 110.00 \text{ k} = 110 \text{ k}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad A_x - 110.00 \sin 60° = 0$

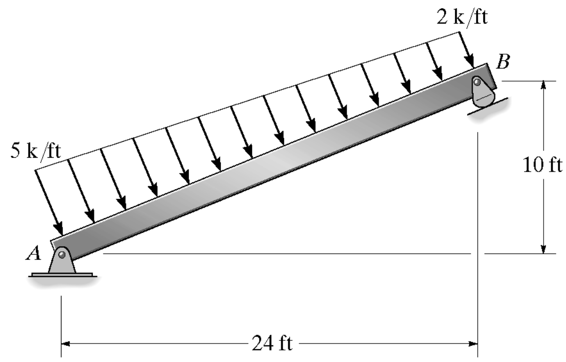
$A_x = 95.3 \text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y + 110.00 \cos 60° - 60 = 0$

$A_y = 5.00 \text{ k}$ **Ans**



2–21. Determine the reactions on the beam.



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

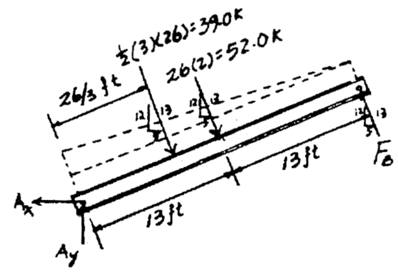
$F_B = 39.0\text{ k}$ **Ans**

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

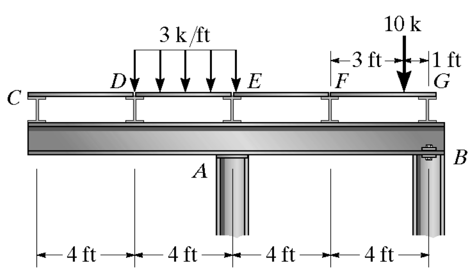
$A_y = 48.0\text{ k}$ **Ans**

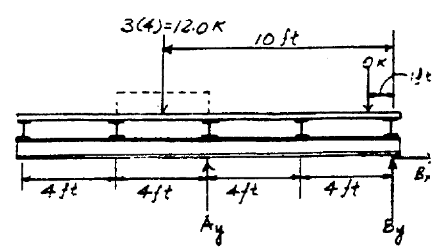
$$\xrightarrow{+} \Sigma F_x = 0;\; -A_x + \left(\frac{5}{13}\right)39 + \left(\frac{5}{13}\right)52 - \left(\frac{5}{13}\right)39.0 = 0$$

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



2–22. Determine the reactions at the supports A and B. The floor decks CD, DE, EF, and FG transmit their loads to the girder on smooth supports. Assume A is a roller and B is a pin.





Consider the entire system.

$$\circlearrowleft + \Sigma M_B = 0;\; 10(1) + 12(10) - A_y(8) = 0$$

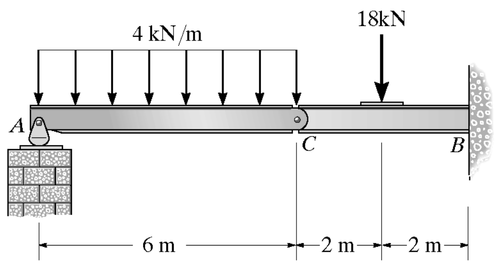
$A_y = 16.25\text{ k} = 16.3\text{ k}$ **Ans**

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

$$+\uparrow \Sigma F_y = 0;\; 16.25 - 12 - 10 + B_y = 0$$

$B_y = 5.75\text{ k}$ **Ans**

2–23. Determine the reactions at the supports A and B of the compound beam. There is a pin at C.



Section AC

$\circlearrowleft + \Sigma M_C = 0;\quad 24\text{ kN}(3\text{ m}) - A_y(6\text{ m}) = 0$

$A_y = 12\text{ kN}$

$+\uparrow \Sigma F_y = 0;\quad 12\text{ kN} - 24\text{ kN} + C_y = 0$

$C_y = 12\text{ kN}$

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

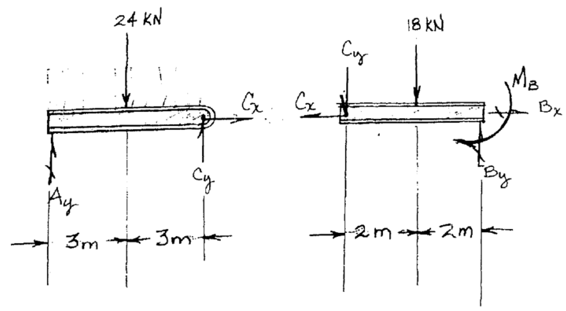
Section CB

$\circlearrowleft + \Sigma M_B = 0 \quad -M_B + 18\text{ kN}(2\text{ m}) + 12\text{ kN}(4\text{ m}) = 0$

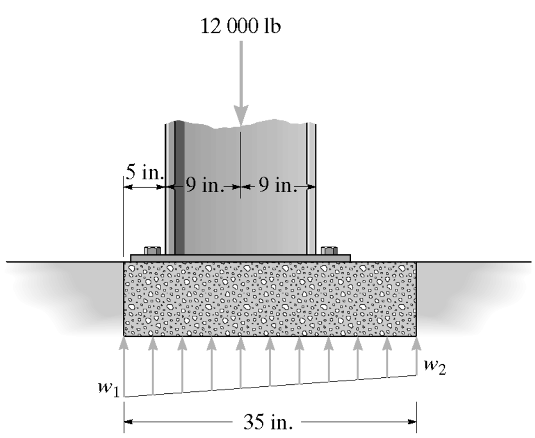
$M_B = 84\text{ kN}\cdot\text{m}$

$+\uparrow \Sigma F_y = 0;\quad -12\text{ kN} - 18\text{ kN} + B_y = 0$

$B_y = 30\text{ kN}$



***2–24.** The pad footing is used to support the load of 12 000 lb. Determine the intensities w_1 and w_2 of the distributed loading acting on the base of the footing for equilibrium.



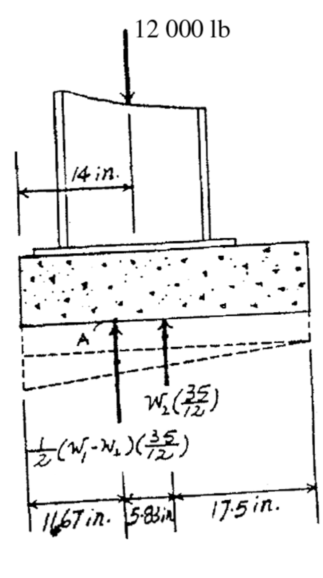
Equations of Equilibrium : The load intensity w_2 can be determined directly by summing moments about point A.

$$\circlearrowleft + \Sigma M_A = 0;\quad w_2\left(\frac{35}{12}\right)(17.5 - 11.67) - 12(14 - 11.67) = 0$$

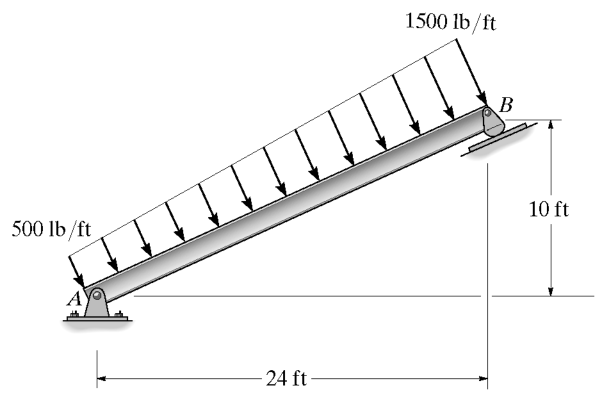
$$w_2 = 1.646\text{ kip/ft} = 1.65\text{ kip/ft} \qquad \textbf{Ans}$$

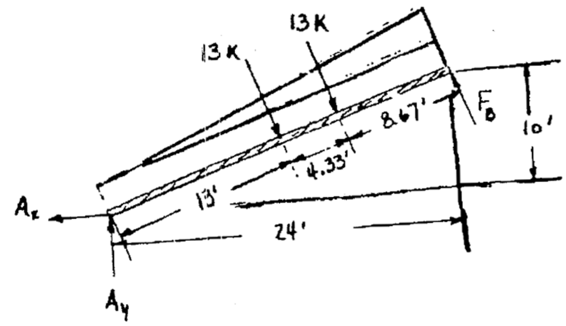
$$+\uparrow \Sigma F_y = 0;\quad \frac{1}{2}(w_1 - 1.646)\left(\frac{35}{12}\right) + 1.646\left(\frac{35}{12}\right) - 12 = 0$$

$$w_1 = 6.58\text{ kip/ft} \qquad \textbf{Ans}$$



2–25. Determine the reactions on the beam.





$\curvearrowleft + \Sigma M_A = 0;$ $\quad F_B(26) - 13(13) - 13(17.33) = 0$

$F_B = 15.17\text{ k} = 15.2\text{ k}$ **Ans**

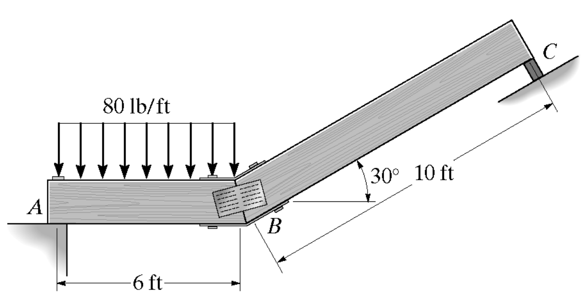
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -A_x + 26\left(\frac{10}{26}\right) - 15.17\left(\frac{10}{26}\right) = 0$

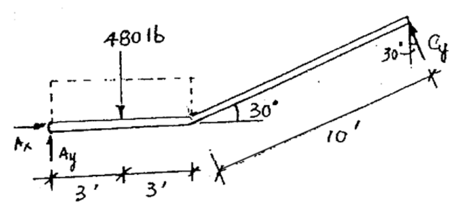
$A_x = 4.17\text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 26\left(\frac{24}{26}\right) + 15.17\left(\frac{24}{26}\right) = 0$

$A_y = 10.0\text{ k}$ **Ans**

2–26. Determine the reactions at the smooth support C and pinned support A. Assume the connection at B is fixed connected.





$+\Sigma M_A = 0;$ $\quad C_y(10 + 6\sin 60°) - 480(3) = 0$

$C_y = 94.76\text{ lb} = 94.8\text{ lb}$ **Ans.**

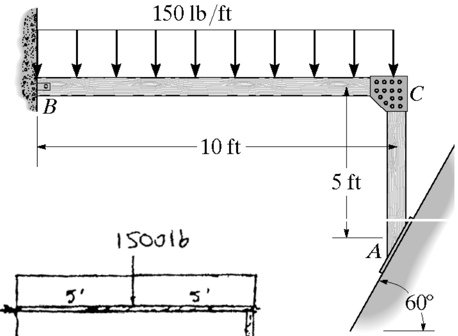
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad A_x - 94.76\sin 30° = 0$

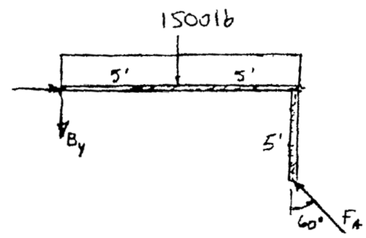
$A_x = 47.4\text{ lb}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y + 94.76\cos 30° - 480 = 0$

$A_y = 398\text{ lb}$ **Ans.**

2–27. Determine the reactions at the smooth support A and pin support B. The connection at C is fixed.





$\circlearrowleft + \Sigma M_B = 0$: $\quad -1500(5) + (F_A)(\cos 60^\circ)(10) - (F_A)(\sin 60^\circ)(5) = 0$

$F_A = 11{,}196.15 \text{ lb} = 11.2 \text{ k}$ **Ans**

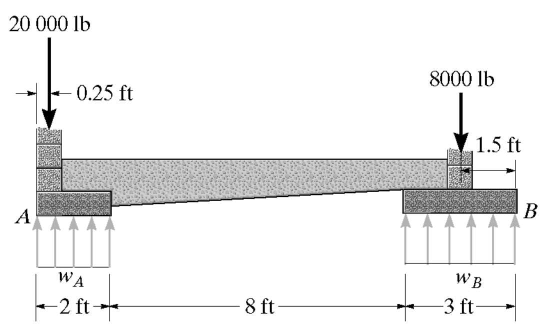
$\xrightarrow{+} \Sigma F_x = 0$: $\quad B_x - 11{,}196.15(\sin 60^\circ) = 0$

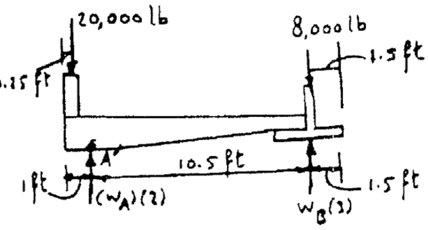
$B_x = 9.70 \text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0$; $\quad -B_y - 1500 + 11{,}196.15(\cos 60^\circ) = 0$

$B_y = 4.10 \text{ k}$ **Ans**

***2–28.** The cantilever footing is used to support a wall near its edge A so that it causes a uniform soil pressure under the footing. Determine the uniform distribution loads, w_A and w_B, measured in lb/ft at pads A and B, necessary to support the wall forces of 8000 lb and 20 000 lb.





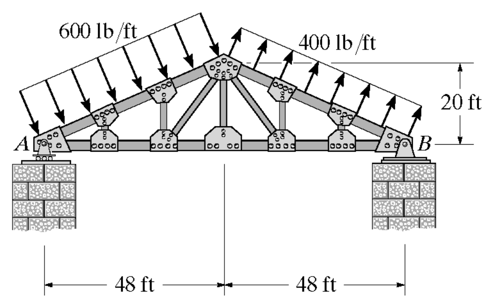
$\circlearrowleft + \Sigma M_A = 0$; $\quad -8000(10.5) + w_B(3)(10.5) + 20\,000(0.75) = 0$

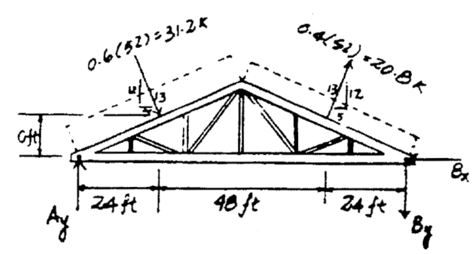
$w_B = 2190.5 \text{ lb/ft} = 2.19 \text{ kip/ft}$ **Ans**

$+\uparrow \Sigma F_y = 0$; $\quad 2190.5(3) - 28\,000 + w_A(2) = 0$

$w_A = 10.7 \text{ kip/ft}$ **Ans**

2–29. Determine the reactions at the truss supports A and B. The distributed loading is caused by wind.





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

$B_y = 5.117 \text{ kN} = 5.12 \text{ kN}$ **Ans**

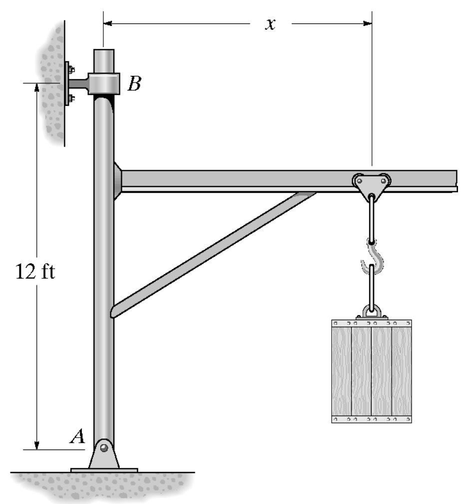
$+\uparrow \Sigma F_y = 0; \; A_y - 5.117 + \left(\frac{12}{13}\right)20.8 - \left(\frac{12}{13}\right)31.2 = 0$

$A_y = 14.7 \text{ kN}$ **Ans**

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

$B_x = 20.0 \text{ kN}$ **Ans**

2–30. The jib crane is pin-connected at A and supported by a smooth collar at B. Determine the roller placement x of the 5000-lb load so that it gives the maximum and minimum reactions at the supports. Calculate these reactions in each case. Neglect the weight of the crane. Require $4\text{ ft} \le x \le 10\text{ ft}$.

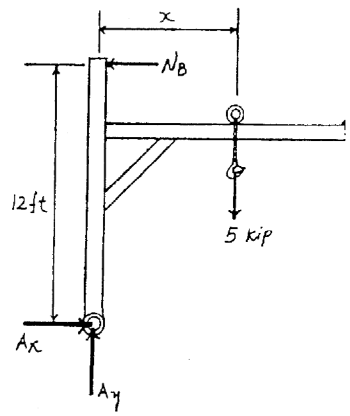


Equations of Equilibrium :

$\circlearrowleft + \Sigma M_A = 0; \quad N_B(12) - 5x = 0 \quad N_B = 0.4167x \quad [1]$

$+\uparrow \Sigma F_y = 0; \quad A_y - 5 = 0 \quad A_y = 5.00 \text{ kip} \quad [2]$

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 0.4167x = 0 \quad A_x = 0.4167x \quad [3]$



By observation, the **maximum support reactions** occur when

$x = 10$ ft **Ans**

With $x = 10$ ft, from Eqs.[1], [2] and [3], the **maximum support reactions** are

$A_x = N_B = 4.17$ kip $\quad A_y = 5.00$ kip **Ans**

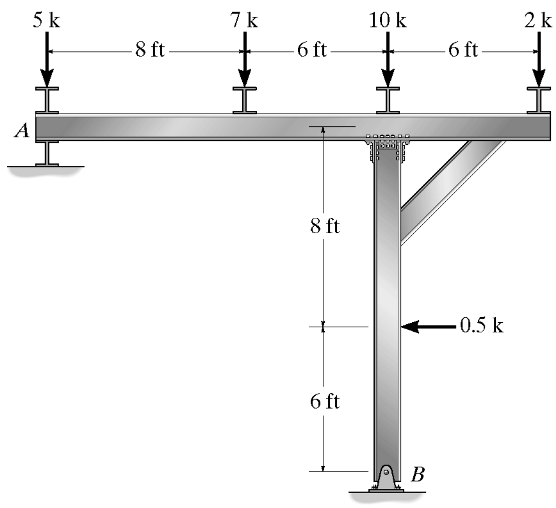
By observation, the **minimum support reactions** occur when

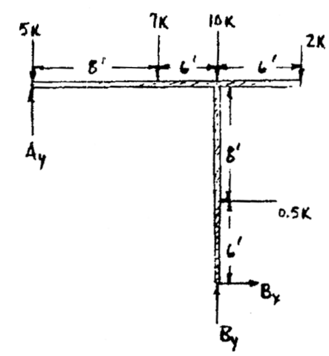
$x = 4$ ft **Ans**

With $x = 4$ ft, from Eqs.[1], [2] and [3], the **minimum support reactions** are

$A_x = N_B = 1.67$ kip $\quad A_y = 5.00$ kip **Ans**

2–31. Determine the reactions at the supports A and B of the frame. Assume that the support at A is a roller.





$\circlearrowleft + \Sigma M_B = 0; \quad -(0.5)(6) + (2)(6) - (7)(6) - (5)(14) + A_y(14) = 0$

$A_y = 7.36$ k **Ans**

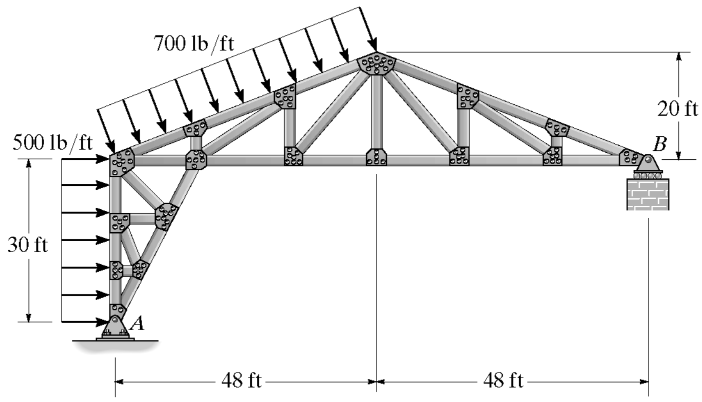
$+\uparrow \Sigma F_y = 0; \quad 7.36 - 5 - 7 - 10 - 2 + B_y = 0$

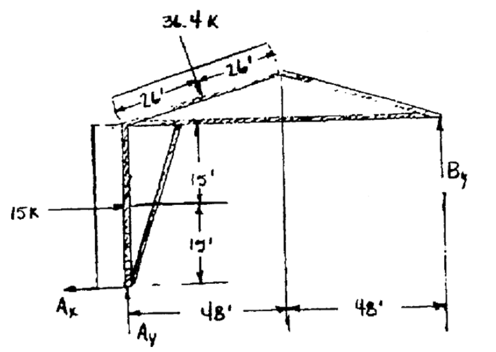
$B_y = 16.6$ k **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad -0.5 + B_x = 0$

$B_x = 0.500$ k **Ans**

***2–32.** Determine the reactions at the truss supports A and B. The distributed loading is caused by wind pressure.





700 lb/ft at 52 ft = 36,400 lb or 36.4 k

500 lb/ft at 30 ft = 15,000 lb or 15.0 k

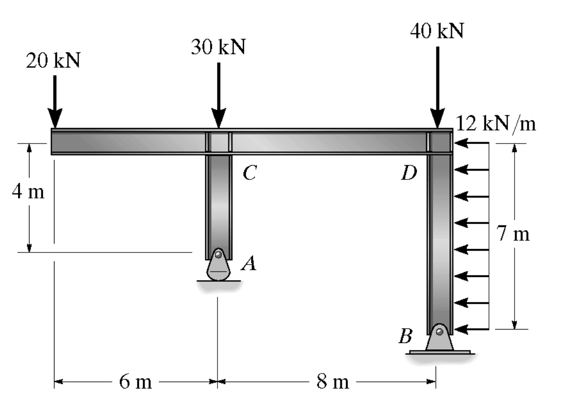
$\curvearrowleft + \Sigma M_A = 0;$ $\quad 96(B_y) - 24\left(\frac{48}{52}\right)(36.4) - 40\left(\frac{20}{52}\right)(36.4) - 15(15) = 0$

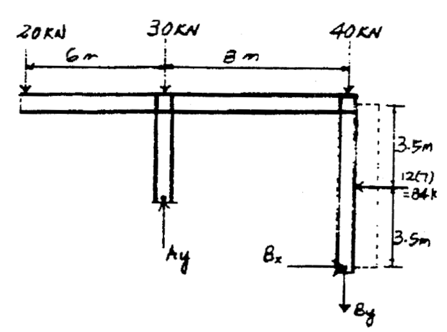
$B_y = 16.58\text{ k} = 16.6\text{ k}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 15 + \frac{20}{52}(36.4) - A_x = 0;\ A_x = 29.0\text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y + B_y - \frac{48}{52}(36.4) = 0;\ A_y = 17.0\text{ k}$ **Ans**

2–33. Determine the horizontal and vertical components of reaction at the supports A and B. The joints at C and D are fixed connections.





$\curvearrowleft + \Sigma M_B = 0;\ 20(14) + 30(8) + 84(3.5) - A_y(8) = 0$

$A_y = 101.75\text{ kN} = 102\text{ kN}$ **Ans**

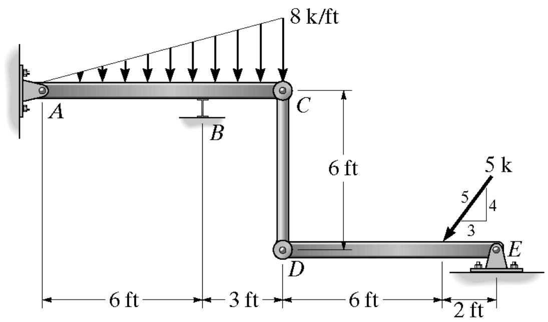
$\xrightarrow{+} \Sigma F_x = 0;\ B_x - 84 = 0$

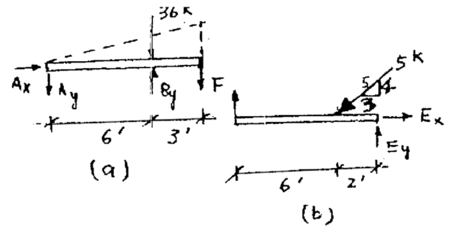
$B_x = 84.0\text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\ 101.75 - 20 - 30 - 40 - B_y = 0$

$B_y = 11.75\text{ kN}$ **Ans**

2–34. Determine the reactions at the supports A, B, and E. Assume the bearing support at B is a roller.





From *FBD* (*b*)

$+\Sigma M_E = 0;\ F(8) - 5\left(\frac{4}{5}\right)(2) = 0 \qquad F = 1.00\ \text{k}$

$+\uparrow \Sigma F_y = 0;\ E_y + 1.00 - 5\left(\frac{4}{5}\right) = 0 \qquad E_y = 3.00\ \text{k}$ **Ans.**

$\stackrel{+}{\rightarrow} \Sigma F_x = 0;\ E_x + 1.00 - 5\left(\frac{4}{5}\right) = 0 \qquad E_x = 3.00\ \text{k}$ **Ans.**

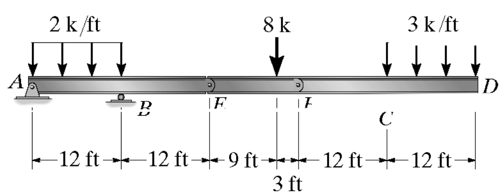
From *FBD* (*a*)

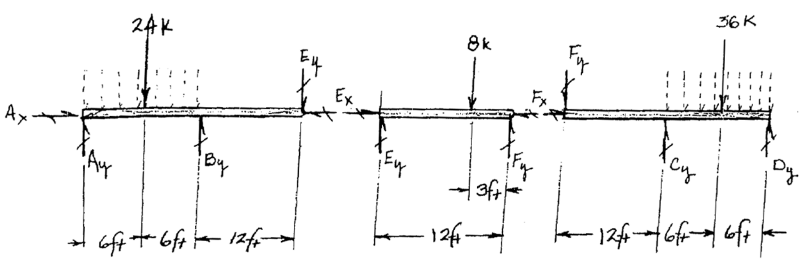
$+\Sigma M_A = 0;\ B_y(6) - 36(6) - 1.00(9) = 0 \qquad B_y = 37.5\ \text{k}$ **Ans.**

$+\downarrow \Sigma F_y = 0;\ A_y - 37.5 + 36 + 1.00 = 0 \qquad A_y = 0.50\ \text{k}$ **Ans.**

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

2–35. Determine the reactions at the supports A, B, C, and D.





Member *EF*:

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

$E_y = 2\ \text{k}$

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

$F_y = 6\ \text{k}$

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*:

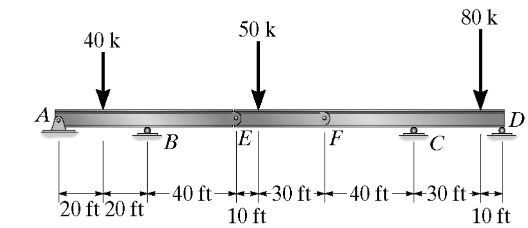
$\circlearrowleft + \Sigma M_D = 0; \quad 36\ \text{k}(6\ \text{ft}) - C_y(12\ \text{ft}) + (24\ \text{ft})(6\ \text{k}) = 0$

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

***2–36.** Determine the reactions at the supports for the compound beam. There are pins at A, E, and F.



Member DF:

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

Member EF:

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

$\circlearrowleft + \Sigma M_F = 0;\quad 50(30) - E_y(40) = 0$

$E_y = 37.5\text{ k}$

$+\uparrow\Sigma F_y = 0;\quad 37.5 + F_y - 50 = 0$

$F_y = 12.50\text{ k}$

Member DF:

$\circlearrowleft + \Sigma M_D = 0;\quad 80(10) - C_y(40) + 12.50(80) = 0$

$C_y = 45.0\text{ k}$ **Ans**

$+\uparrow\Sigma F_y = 0;\quad -12.50 + 45.0 + D_y - 80 = 0$

$D_y = 47.5\text{ k}$ **Ans**

Member AE:

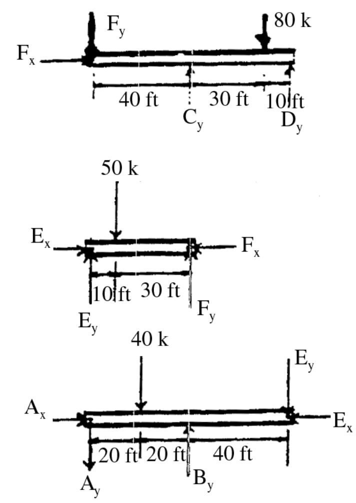
$\circlearrowleft + \Sigma M_A = 0;\quad -40(20) + B_y(40) - 37.5(80) = 0$

$B_y = 95.0\text{ k}$ **Ans**

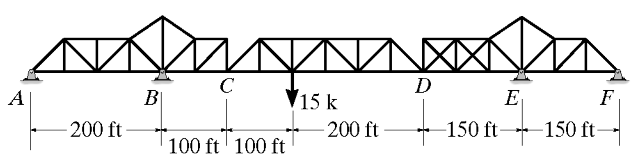
$\xrightarrow{+}\Sigma F_x = 0;\quad A_x = 0$ **Ans**

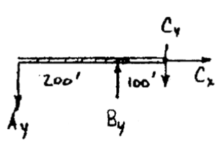
$+\uparrow\Sigma F_y = 0;\quad -A_y + 95.0 - 40 - 37.5 = 0$

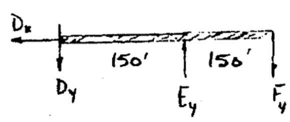
$A_y = 17.5\text{ k}$ **Ans**

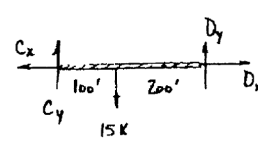


2–37. The construction features of a cantilever truss bridge are shown in the figure. Here it can be seen that the center truss CD is suspended by the cantilever arms ABC and DEF. C and D are pins. Determine the vertical reactions at the supports A, B, E, and F if a 15-k load is applied to the center truss.









Truss ABC:

$\circlearrowleft + \Sigma M_A = 0;\quad B_y(200) - 10(300) = 0$

$B_y = 15.0\text{ k}$ **Ans**

$+\uparrow\Sigma F_y = 0;\quad 15 - 10 - A_y = 0$

$A_y = 5.0\text{ k}$ **Ans**

Truss DEF:

$\circlearrowleft + \Sigma M_F = 0;\quad 5(300) - E_y(150) = 0$

$E_y = 10.0\text{ k}$ **Ans**

$+\uparrow\Sigma F_y = 0;\quad -5 + 10 - F_y = 0$

$F_y = 5.0\text{ k}$ **Ans**

Truss CD:

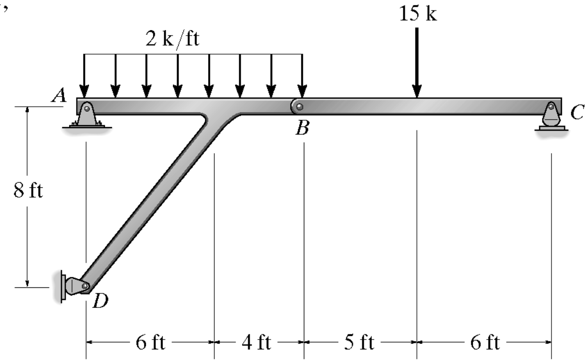
$\circlearrowleft + \Sigma M_D = 0;\quad 15(200) - C_y(300) = 0$

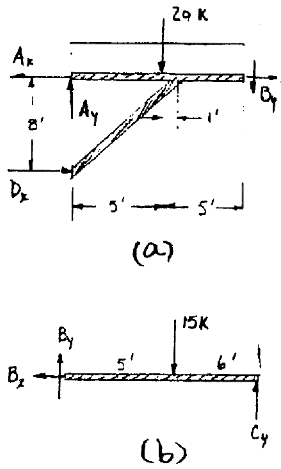
$C_y = 10.0\text{ k}$

$+\uparrow\Sigma F_y = 0;\quad -15 + 10 + D_y = 0$

$D_y = 5.0\text{ k}$

***2–38.** Determine the reactions at the supports A, C, and D.





From FBD(b):

$\circlearrowleft + \Sigma M_B = 0;$ $C_y(11) - 15(5) = 0$

$C_y = 6.82$ k **Ans**

$+\uparrow \Sigma F_y = 0;$ $B_y + 6.818 - 15 = 0$

$B_y = 8.182$ k

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

From FBD(a):

$\circlearrowleft + \Sigma M_A = 0;$ $D_x(8) - 8.182(10) - 20(5) = 0$

$D_x = 22.7$ k **Ans**

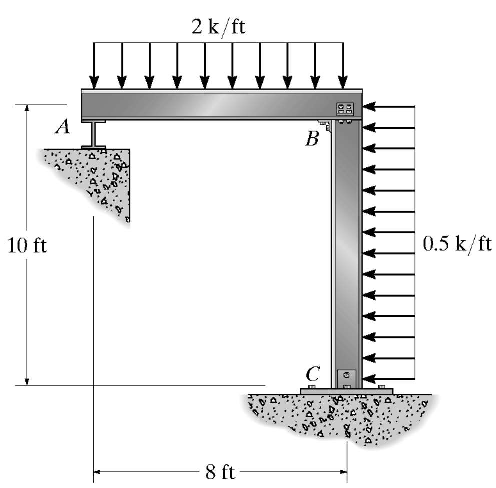
$+\uparrow \Sigma F_y = 0;$ $A_y - 20 - 8.182 = 0$

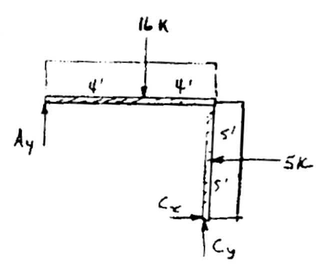
$A_y = 28.2$ k **Ans**

$\xleftarrow{+} \Sigma F_x = 0;$ $A_x - 22.73 = 0$

$A_x = 22.73 = 22.7$ k **Ans**

2–39. Determine the reactions at the supports A and C. Assume the support at A is a roller, B is a fixed-connected joint, and C is a pin.





$\circlearrowleft + \Sigma M_C = 0;$ $5(5) + 16(4) - A_y(8) = 0$

$A_y = 11.125 = 11.1$ k **Ans**

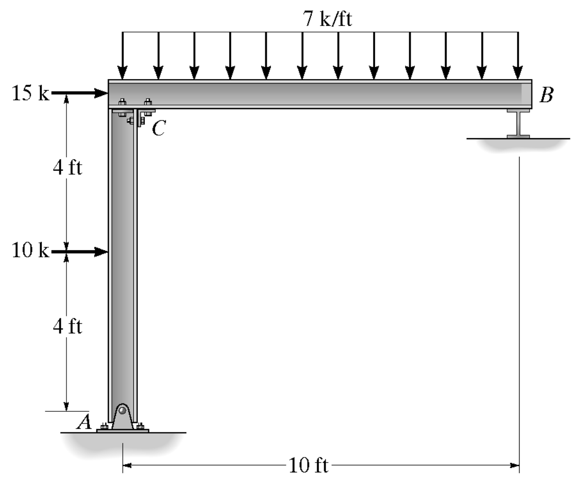
$+\uparrow \Sigma F_y = 0;$ $11.125 - 16 + C_y = 0$

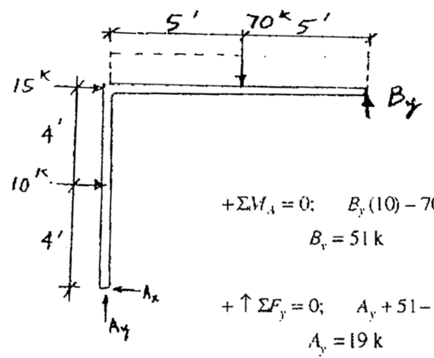
$C_y = 4.875 = 4.88$ k **Ans**

$\xrightarrow{+} \Sigma F_x = 0;$ $-5 + C_x = 0$

$C_x = 5.00$ k **Ans**

***2–40.** Determine the reactions at the supports A and B. Assume the support at B is a roller. C is a fixed-connected joint.





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

$B_y = 51$ k **Ans.**

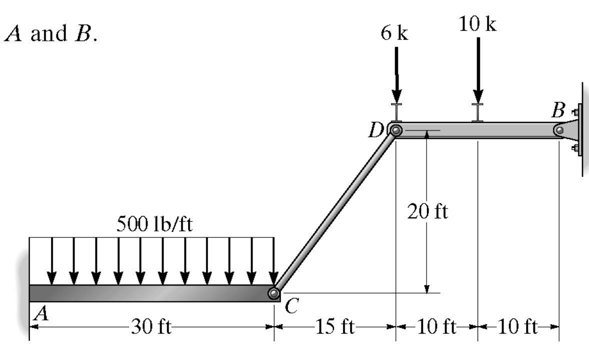
$$+\uparrow \Sigma F_y = 0; \quad A_y + 51 - 70 = 0$$

$A_y = 19$ k **Ans.**

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

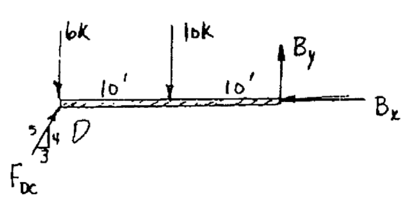
$A_x = 25$ k **Ans.**

2–41. Determine the reactions at the supports A and B.



Member DB :

$$\curvearrowleft + \Sigma M_B = 0; \quad F_{DC}\left(\frac{4}{5}\right)(20) - 6(20) - 10(10) = 0; \quad F_{DC} = 13.75 \text{ k}$$



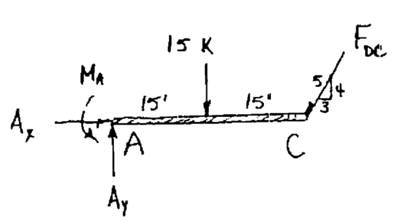
$$\xrightarrow{+} \Sigma F_x = 0; \quad -B_x + 13.75\left(\frac{3}{5}\right) = 0;$$

$B_x = 8.25$ k **Ans**

$$+\uparrow \Sigma F_y = 0; \quad B_y - 16 + 13.75\left(\frac{4}{5}\right) = 0;$$

$B_y = 5$ k **Ans**

Member AC :



$$\curvearrowleft + \Sigma M_A = 0; \quad 13.75\left(\frac{4}{5}\right)(30) + 15(15) - M_A = 0$$

$M_A = 555$ k·ft **Ans**

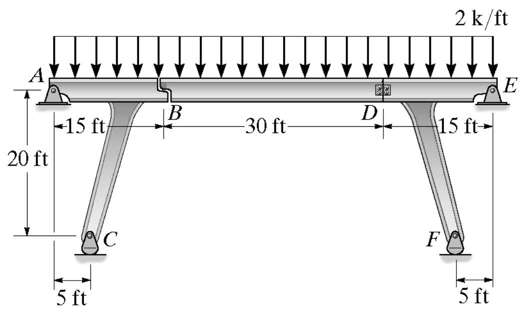
$$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 13.75\left(\frac{3}{5}\right) = 0$$

$A_x = 8.25$ k **Ans**

$$+\uparrow \Sigma F_y = 0; \quad A_y - 15 - 13.75\left(\frac{4}{5}\right) = 0$$

$A_y = 26.0$ k **Ans**

2–42. 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.

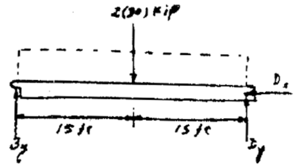


For segment BD :

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

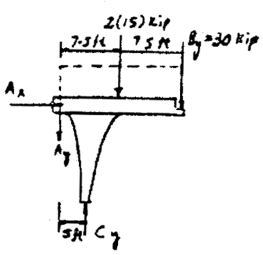


For segment ABC :

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

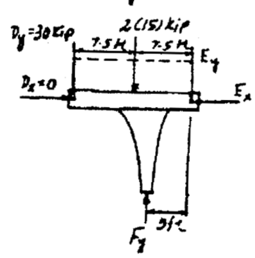


For segment DEF :

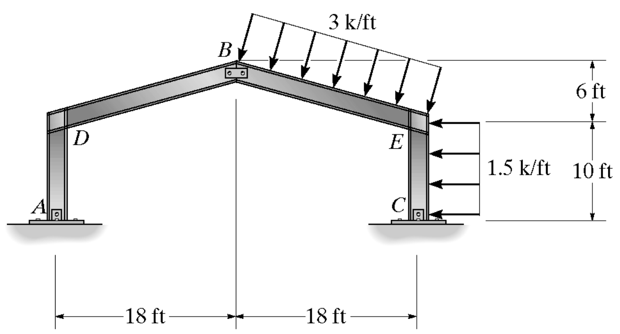
$\circlearrowleft +\Sigma M_E = 0;\quad -F_y(5) + 2(15)(7.5) + 30(15) = 0 \quad F_y = 135 \text{ kip}$ **Ans**

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

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



2–43. Determine the horizontal and vertical components at A, B, and C. Assume the frame is pin connected at these points. The joints at D and E are fixed connected.



$\circlearrowleft + \Sigma M_A = 0;\quad -18\text{ ft}(B_y) + 16\text{ ft}(B_x) = 0 \qquad (1)$

$\circlearrowleft + \Sigma M_C = 0;\quad 15\text{ k}(5\text{ ft}) + 9\text{ ft}(56.92\text{ k}(\cos 18.43°)) + 13\text{ ft}(56.92\text{ k}(\sin 18.43°))$

$- 16\text{ ft}(B_x) - 18\text{ ft}(B_y) = 0 \qquad (2)$

Solving Eq. 1 & 2

$B_x = 24.84\text{ k}$ **Ans**

$B_y = 22.08\text{ k}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad A_x = 24.84\text{ k} = 0$

$A_x = 24.84\text{ k}$

$+\uparrow \Sigma F_y = 0;\quad A_y - 22.08\text{ k} = 0$

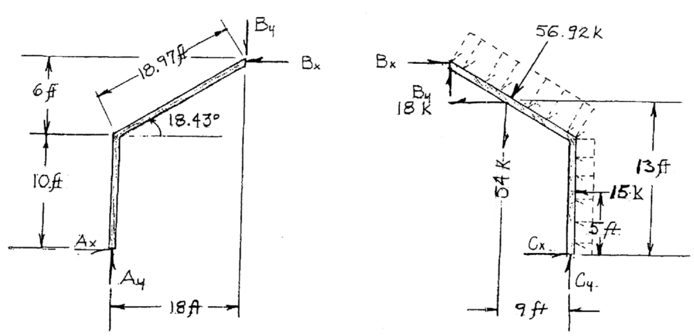
$A_y = 22.08\text{ k}$

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad C_x - 15\text{ k} - \sin(18.43°)(56.92\text{ k}) + 24.84\text{ k}$

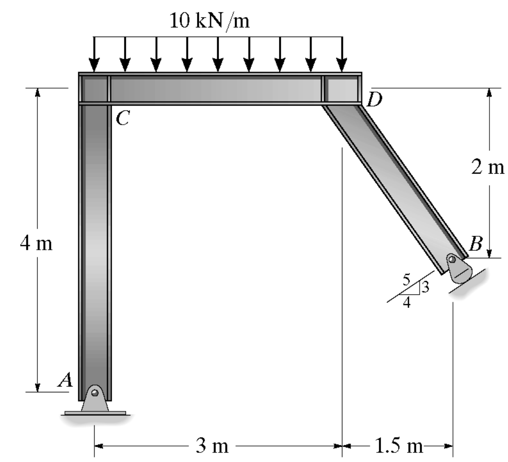
$C_x = 8.15\text{ k}$

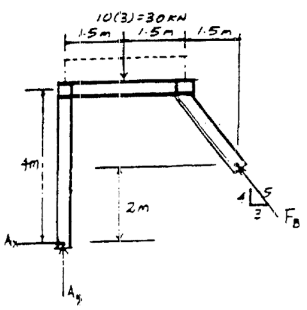
$+\uparrow \Sigma F_y = 0;\quad C_y + 22.08\text{ k} - \cos(18.43°)(56.92\text{ k}) = 0$

$C_y = 31.92\text{ k}$



***2–44.** Determine the reactions at the supports A and B. The joints C and D are fixed connected.





$$\curvearrowleft + \Sigma M_A = 0; \quad \frac{4}{5}F_B(4.5) + \frac{3}{5}F_B(2) - 30(1.5) = 0$$

$F_B = 9.375 \text{ kN} = 9.38 \text{ kN}$ **Ans**

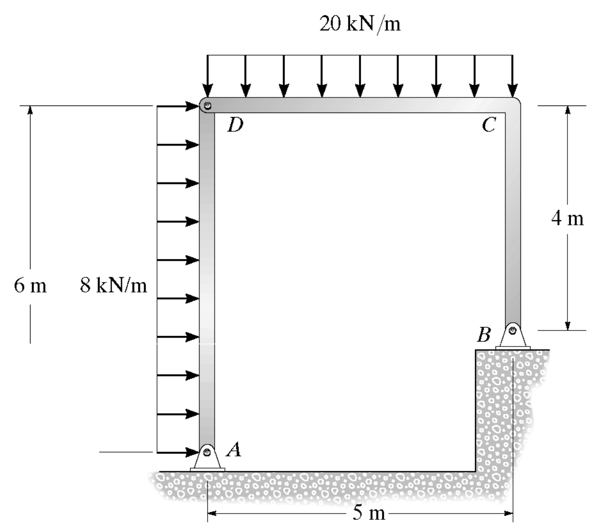
$$+\uparrow \Sigma F_y = 0; \quad A_y + \frac{4}{5}(9.375) - 30 = 0$$

$A_y = 22.5 \text{ kN}$ **Ans**

$$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - \frac{3}{5}(9.375) = 0$$

$A_x = 5.63 \text{ kN}$ **Ans**

2–45. Determine the horizontal and vertical components of reaction at the supports A and B.



Member AD:

$$\curvearrowleft + \Sigma M_A = 0;$$

$$-48 \text{ kN } (3 \text{ m}) + D_x(6 \text{ m}) = 0$$

$$D_x = 24 \text{ kN}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad 48 \text{ kN} - 24 \text{ kN} - A_x = 0$$

$$A_x = 24 \text{ kN}$$

Member DCD:

$$\curvearrowleft + \Sigma M_B = 0;$$

$$100 \text{ kN } (2.5 \text{ m}) - 24 \text{ kN } (4 \text{ m}) + D_y(5 \text{ m}) = 0$$

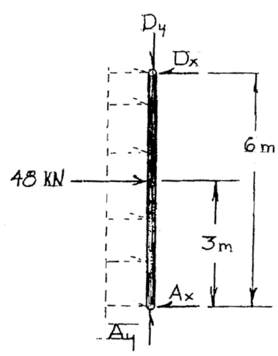
$$D_y = 30.8 \text{ kN}$$

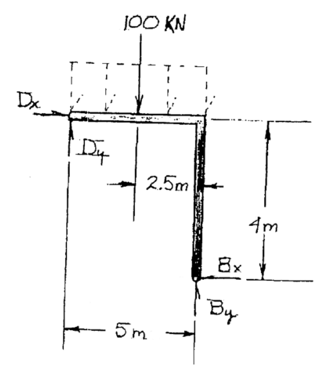
$$+\uparrow \Sigma F_y = 0; \quad 30.8 \text{ kN} - 100 \text{ kN} + B_y = 0$$

$$B_y = 69.2 \text{ kN}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad 24 \text{ kN} - B_x = 0$$

$$B_x = 24 \text{ kN}$$



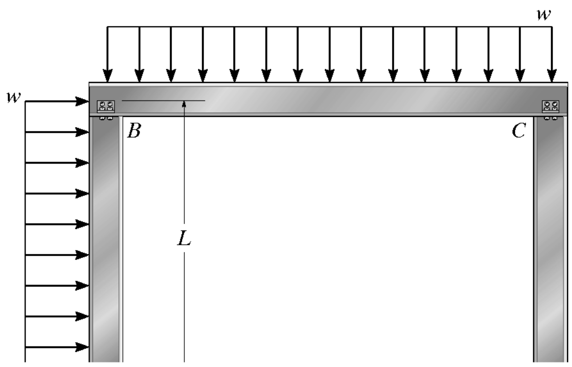


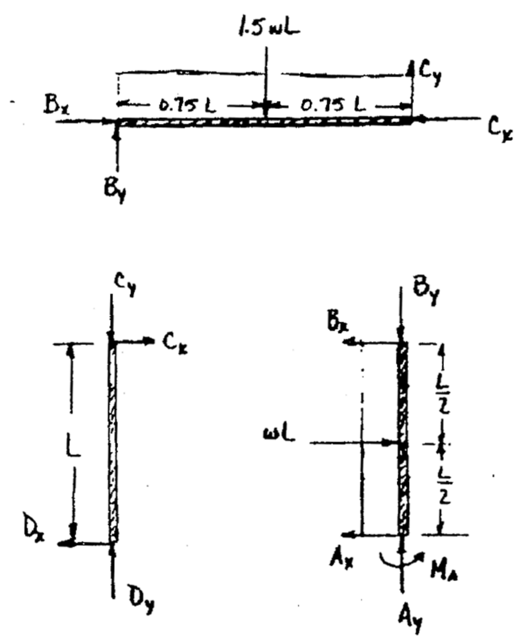
Member AD:

$$+\uparrow \Sigma F_y = 0; \quad -30.8 \text{ kN} + A_y = 0$$

$$A_y = 30.8 \text{ kN}$$

2–46. Determine the reactions at the supports A and D. Assume A is fixed and B and C and D are pins.





Member BC:

$\curvearrowleft + \Sigma M_B = 0;$ $\quad C_y(1.5L) - (1.5wL)\left(\frac{1.5L}{2}\right) = 0$

$C_y = 0.75\,wL$

$+\uparrow \Sigma F_y = 0;$ $\quad B_y - 1.5wL + 0.75\,wL = 0$

$B_y = 0.75\,wL$

Member CD:

$\curvearrowleft + \Sigma M_D = 0;$ $\quad C_x = 0$

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

$+\uparrow \Sigma F_y = 0;$ $\quad D_y - 0.75wL = 0$

$D_y = 0.75\,wL$ **Ans**

Member BC:

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

Member AB:

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

$A_x = wL$ **Ans**

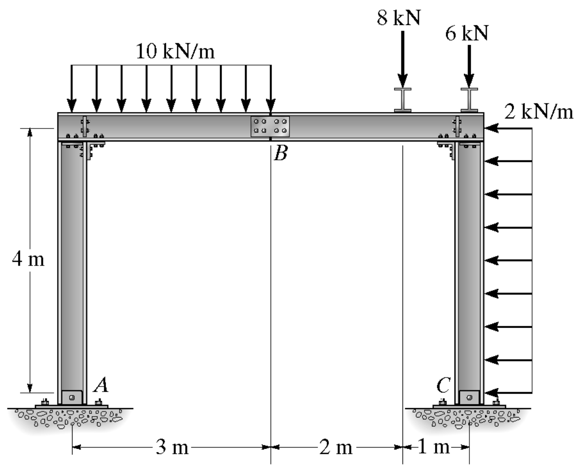
$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 0.75\,wL = 0$

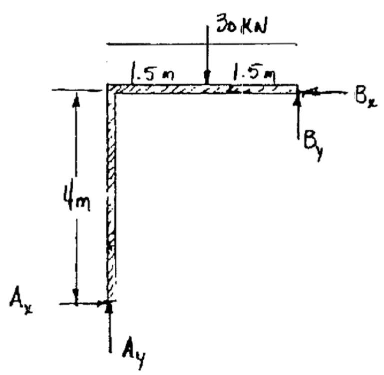
$A_y = 0.75\,wL$ **Ans**

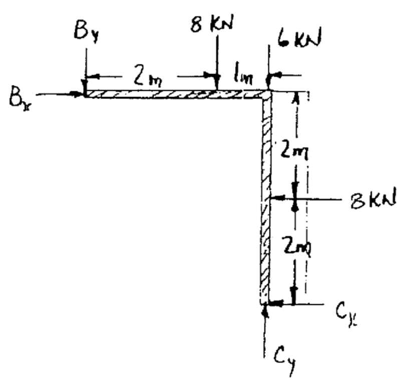
$\curvearrowleft + \Sigma M_A = 0;$ $\quad M_A - wL\left(\frac{L}{2}\right) = 0$

$M_A = \frac{wL^2}{2}$ **Ans**

2–47. Determine the reactions at the supports A and C. The frame is pin connected at A, B, and C and the two joints are fixed connected.







Member AB:

$\curvearrowleft + \Sigma M_A = 0;$ $\quad B_x(4) + B_y(3) - 30(1.5) = 0$

$B_x(4) + B_y(3) = 45 \qquad (1)$

Member BC:

$\curvearrowleft + \Sigma M_C = 0;$ $\quad -B_x(4) + B_y(3) + 8(2) + 8(1) = 0$

$-B_x(4) + B_y(3) = -24 \qquad (2)$

Solving Eqs. (1) and (2),

$B_x = 8.625$ kN, $\quad B_y = 3.5$ kN

Member AB:

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad A_x - 8.625 = 0$

$A_x = 8.62$ kN **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 30 + 3.5 = 0$

$A_y = 26.5$ kN **Ans**

Member CB:

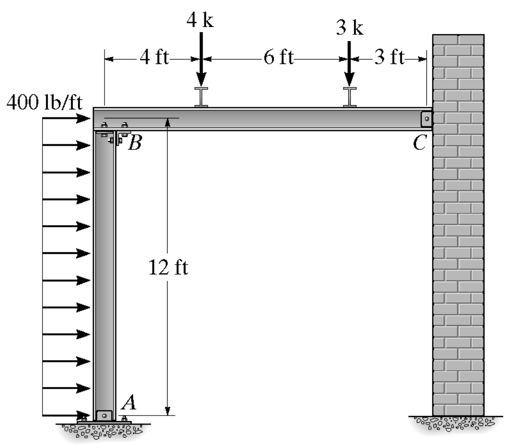
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -C_x - 8 + 8.625 = 0$

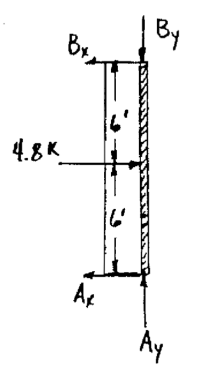
$C_x = 0.625$ kN **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad C_y - 6 - 8 - 3.5 = 0$

$C_y = 17.5$ kN **Ans**

***2–48.** Determine the horizontal and vertical components of force at the connections *A*, *B*, and *C*. Assume each of these connections is a pin.





Member AB :

$\circlearrowleft + \Sigma M_A = 0;$ $\quad B_x(12) - 4.8(6) = 0$

$B_x = 2.40 \text{ k}$ **Ans**

$\overset{+}{\leftarrow} \Sigma F_x = 0;$ $\quad A_x + 2.4 - 4.8 = 0$

$A_x = 2.40 \text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - B_y = 0 \quad (1)$

Member BC :

$\circlearrowleft + \Sigma M_C = 0;$ $\quad -B_y(13) + 4(9) + 3(3) = 0$

$B_y = 3.46 \text{ k}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad C_y + 3.462 - 4 - 3 = 0$

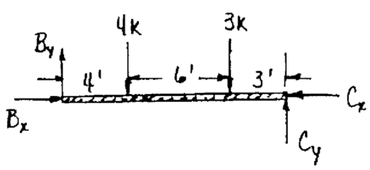
$C_y = 3.54 \text{ k}$ **Ans**

$\overset{+}{\leftarrow} \Sigma F_x = 0;$ $\quad C_x - 2.40 = 0$

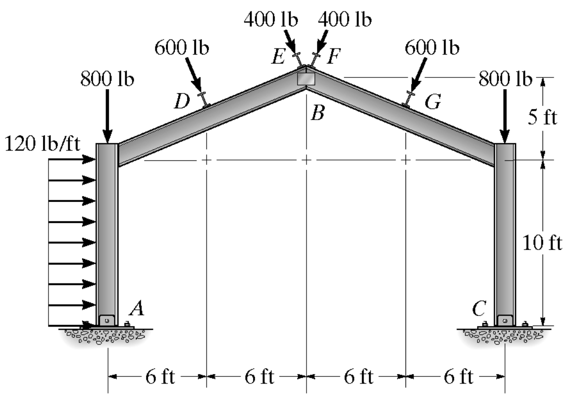
$C_x = 2.40 \text{ k}$ **Ans**

From Eq. (1),

$A_y = 3.46 \text{ k}$ **Ans**



2–49. 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.



Member AB :

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

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

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

Member BC :

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

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

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

Solving Eqs. (1) and (2),

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

Member AB :

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

$A_x = 522$ lb **Ans**

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

$A_y = 1473$ lb **Ans**

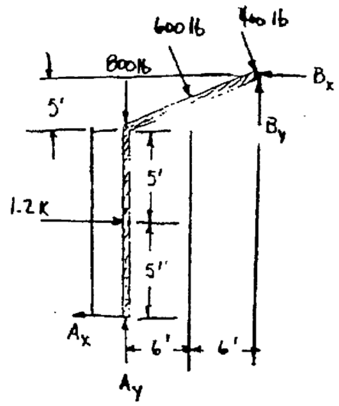
Member BC :

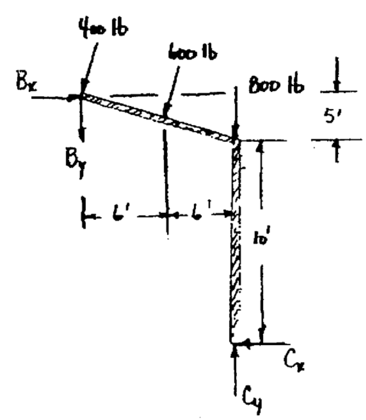
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -C_x - 1000\left(\frac{5}{13}\right) + 1063.08 = 0$

$C_x = 678$ lb **Ans**

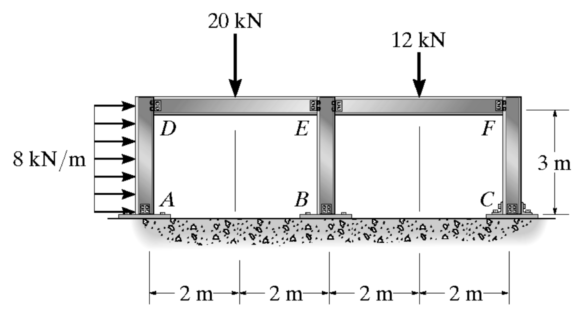
$+\uparrow \Sigma F_y = 0;$ $\quad C_y - 800 - 1000\left(\frac{12}{13}\right) - 250.0 = 0$

$C_y = 1973$ lb **Ans**





2–50. Determine the horizontal and vertical components of reaction at the supports A, B, and C. Assume the frame is pin connected at A, B, D, E, and F, and there is a fixed connected joint at C.



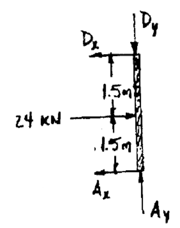
Member AD:

$\circlearrowleft + \Sigma M_A = 0;$ $\quad -24(1.5) + D_x(3) = 0$

$D_x = 12\text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -12 + 24 - A_x = 0$

$A_x = 12\text{ kN}$ **Ans**



Member DE:

$\circlearrowleft + \Sigma M_E = 0;$ $\quad 20(2) - D_y(4) = 0$

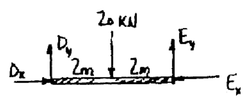
$D_y = 10\text{ kN}$

$+\uparrow \Sigma F_y = 0;$ $\quad E_y - 20 + 10 = 0$

$E_y = 10\text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -E_x + 12 = 0$

$E_x = 12\text{ kN}$



Member AD:

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 10 = 0$

$A_y = 10\text{ kN}$ **Ans**

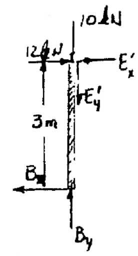
Member EF:

$\circlearrowleft + \Sigma M_E = 0;$ $\quad -12(2) + F_y(4) = 0$

$F_y = 6\text{ kN}$

$+\uparrow \Sigma F_y = 0;$ $\quad E_y' - 12 + 6 = 0$

$E_y' = 6\text{ kN}$



Member BE:

$+\uparrow \Sigma F_y = 0;$ $\quad B_y - 10 - 6 = 0$

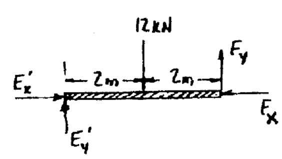
$B_y = 16\text{ kN}$ **Ans**

$\circlearrowleft + \Sigma M_B = 0;$ $\quad -12(3) + E_x'(3) = 0$

$E_x' = 12\text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -B_x + 12 - 12 = 0$

$B_x = 0$ **Ans**



Member EF:

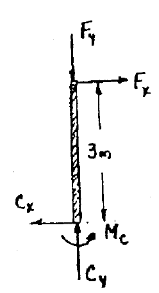
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 12 - F_x = 0;$

$F_x = 12\text{ kN}$

Member FC:

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 12 - C_x = 0;$

$C_x = 12\text{ kN}$ **Ans**



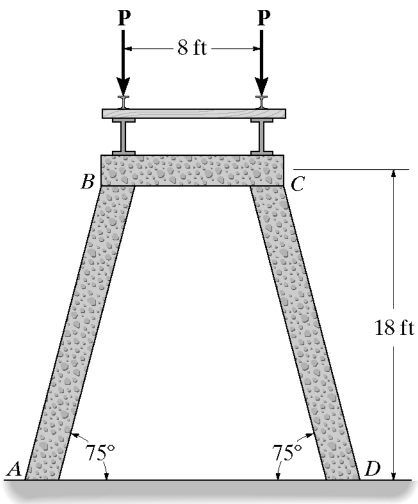
$+\uparrow \Sigma F_y = 0;$ $\quad C_y - 6 = 0$

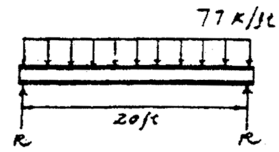
$C_y = 6\text{ kN}$ **Ans**

$\circlearrowleft + \Sigma M_C = 0;$ $\quad M_C - 12(3) = 0$

$M_C = 36\text{ kN}\cdot\text{m}$ **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 (see Fig. 1–11). 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?

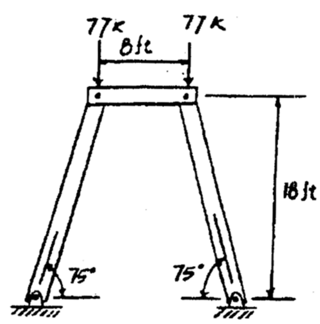




Maximum reactions occur when the live load is over entire span.

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

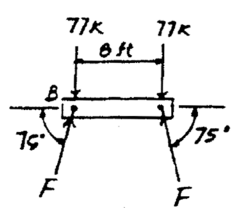
$R = 7.7(10) = 77 \text{ k}$



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

All members are two - force members.

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



$F = 79.7 \text{ k}$ **Ans**

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